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Curriculum for the joint
Master's Programme Mechatronics
of the Leopold-Franzens University of Innsbruck (LFUI) and
UMIT TIROL – Private University of Health Sciences and Technology

§ 1 Outline of the Joint Study Programme

(1) Mechatronics (deriving from Mechanical Engineering – Electronic Engineering) includes all approaches and techniques for developing systems, procedures, devices and products that are marked by the integration and interaction of mechanic, electronic and information-processing components. It is this integration of methods and techniques that makes it possible that the formerly independent technical specialist fields develop modern systems marked by high-level functionality, efficiency and productivity. This synthesis of the engineering science disciplines of Mechanical Engineering, Electrical Engineering and Informatics that are based on the natural science disciplines of Mathematics, Physics and Chemistry, reflects the interdisciplinary technological challenges of modern engineering processes and appliances and is a driving force for present and future product innovations.

(2) The joint Master's Programme in Mechatronics of the University of Innsbruck (LFUI) and the UMIT TIROL – Private University of Health and Life Sciences Technology is divided in a general education and a specialised education part according to no. 1 and 2. Students have to choose between the following specialist fields:

1. Industrial Mechatronics and Material Sciences (referred to as IMMS – German: IMW - hereafter) and
2. Biomedical Technology (BMT hereafter).

(3) Irrespective of the chosen field of specialisation, all students have to pass four compulsory modules covering 40 ECTS-Credits and two elective modules covering 10 ECTS-Credits.

(4) Students that choose the specialist field of IMMS have to pass two compulsory modules (15 ECTS-Credits) and five elective modules (25 ECTS-Credits).

(5) Students that choose the specialist field of BMT have to pass two compulsory modules (15 ECTS-Credits) and three elective modules (25 ECTS-Credits).

(6) The Master's Thesis is credited with 27.5 ECTS-Credits and the defence of the Master's Thesis, which concludes the study programme and takes place within the scope of the Compulsory Module "Defensio", is credited with 2.5 ECTS-Credits.

(7) The field of specialisation must be chosen at the time of registration for the course according to §7 para. 2 no. 1 to 2 or according to §7 para. 3 no. 1 to 2 and the Dean of Studies of the University of Innsbruck and the UMIT TIROL Study Management must be informed in writing of the choice.

The field of specialisation may only be changed if the responsible bodies of the two universities agree.

(8) One semester hour (h hereafter) equals the number of course units corresponding to the number of university weeks in the semester. A teaching unit has the duration of 45 minutes.

(9) For courses held at the UMIT TIROL the same regulations for the evaluation apply as at the University of Innsbruck.

§ 2 Qualification profile

(1) The joint Master's Programme in Mechatronics at the LFUI and the UMIT TIROL is part of the Engineering Studies. The degree of "Diplomingeneurin" or "Diplomingenieur" ("Dipl.Ing.") resp. that is earned with the conclusion of the study programme corresponds to the international "Master of Science" ("MSc").

(2) Within the scope of the Master's Programme in Mechatronics at the LFUI and the UMIT TIROL, students acquire knowledge built on the latest findings of the discipline. The engineering science study programme systematically combines research and doctrine and thus enables the students to undertake independent scientific research and to apply theories, methods and instruments in practice at the same time. Graduates acquire the following competences:

1. Natural science competence
   a) by gaining a profound knowledge of the basic principles and the methods used in natural science,
   b) by strengthening the ability of analytical, interdisciplinary and networked thinking and of critical reflection,
   c) by improving abstraction and modelling abilities;
2. Engineering competence
   a) by improving the understanding of contexts and problems of engineering science in theory and practice with advanced knowledge,
   b) by gaining subject-specific competence to make the graduates able to apply the basic knowledge of the core areas of the application-oriented subjects,
   c) by encouraging the creative potential for independently finding problem solutions for complex task of the engineering practice,
   d) by imparting strategies for independently developing solutions to new problem statements,
   e) by imparting knowledge of state-of-the-art IT, management and presentation methods,
   f) by improving problem awareness for a holistic view of mechatronic developments in a technical, economic and socio-ecological context;
3. Social competence
   a) by encouraging the ability to work in a team,
   b) by improving foreign language skills,
   c) by arising the interest in lifelong learning and to continue advanced education individually.

(3) Graduates of the Master's Programme of the LFUI and the UMIT TIROL can, thanks to their education, call on the competence fields listed above. They are qualified for jobs that demand an understanding, applying and developing of scientific findings and methods. Moreover, they are in particular qualified for leading positions in engineering and for subject-specific doctoral programmes which aim at independently researching and developing technical science.

(4) A central element of the Master's Programme in Mechatronics is its focus on sustainability and relevance of knowledge and skills. This is why the imparting of knowledge and competences of scientific methods is given priority to specialist user knowledge. Graduates have the competence to further develop their knowledge and understanding in the field of mechatronics autonomously, also for new and unfamiliar problems or within the scope of research contexts resp. They are especially qualified for demanding tasks in industry and business enterprises in the different fields of mechatronics and the related fields of mechanical engineering, material science, electronic

science, medical engineering etc. after brief training periods. There, the advantages of the university education's focus on basic and methodological competence take effect.

(5) The passing of special courses and projects in cooperation with industrial businesses reinforces the competence of using the acquired knowledge in practice and facilitates the graduates' passage to professional life.

(6) The research-oriented university education of the joint Master's Programme in Mechatronics at the LFUI and the UMIT TIROL is the basis for access to a vast occupational field in the area of mechatronics, from planning, developing and construction, to production, manufacturing, quality management to consulting. The occupational fields open to the graduates are correspondingly manifold. Typical occupational fields are: (i) employment with an industrial business in the area of machine, vehicle or plant engineering, with producers of electronic, medical technical, data processing or process control devices and employment with engineering offices, (ii) self-employed work as enterprisers or engineering consultants and (iii) working for educational and research institutions.

§ 3 Scope and duration

The Master's Programme in Mechatronics covers 120 ECTS-C and based on a workload of 30 ECTS-Credits per semester it has a duration of four semesters. One ECTS-Credit corresponds to a workload of 25 hours for the student.

§ 4 Types of courses and maximum number of students per course

(1) Lectures (VO)

1. Lectures aim at conveying the subject matter with oral presentations, explanations and with examples and demonstrations. Interaction of students and lecturer is aimed at.
2. This type of course encourages e.g. the understanding and integration of knowledge based on the latest developments of the discipline.
3. Lectures are courses without continuous performance assessment.

(2) Lecture tutorials (VU)

1. VU-type courses are a combination of lectures and tutorials, whereby the lecture and tutorial share can be adjusted flexibly depending on the requirements of the subject matter. Should it because of the number of participants be necessary to divide the group for the tutorial part, courses of the VU type have a share of 50% for the lecture part and 50% for the tutorial.
2. This course type similarly encourages the competences and skills listed in para. 1 and 2 no. 2.
3. VU courses are courses with continuous performance assessment.
4. The maximum number of participants for VU courses is usually 30, for practical training, laboratory or machine tutorials usually 15.

(3) Practical courses (PR)

1. Practical courses serve the acquisition of skills by working independently with laboratory equipment. They aim at encouraging practical use of scientific contents.
2. This course type encourages et al. the ability to work in a team, reliability, communication skills, structured working and professional competence in unfamiliar situations.
3. Practical courses are courses with continuous performance assessment.
4. The maximum number of participants is usually 15.

§5 Admission procedures for the admission to courses with a limited number of participants

The following criteria are considered for allocating places for courses with a limited number of participants:

1. Students, the study time of who would be prolonged without admission to the course, are given priority for admission.
2. If the criteria in no. 1 is not sufficient for regulating admission to a course, students, for whom it is compulsory to pass the course, come first, and students that attend the course as elective course second.
3. Should the criteria in no. 1 and no. 2 not suffice for regulating the admission to a course, the available places are drawn.

§6 Admission

(1) Precondition for being admitted to the joint Master's Programme in Mechatronics at the LFUI and UMIT TIROL is the conclusion of a subject-related BA Programme, a subject-related BA Study Programme of a College of Higher Education or a comparable study programme of an approved higher education institution at home or abroad.

(2) The conclusion of the joint BA Programme of Mechatronics at the LFUI and UMIT TIROL is in any case an eligible BA Study Programme.

(3) Admission of students is regulated by the respective responsible authority on both universities. The admission process based on the contract for setting up a joint programme will be published by the universities separately.

§ 7 Compulsory and elective modules

(1) Irrespective of the selected specialisation, the following four compulsory modules covering 40 ECTS-credits must be passed.

1.	**Compulsory Module 1: Mathematics and Information Theory**	**Univ.**	**h**	**ECTS-Credits**
a.	**VO Digital Signal Processing** Sampling theorem; basics of analogue/digital conversion; discrete Fourier transformation (DFT), fast Fourier transformation (FFT); data windows; z-transformation; basics of digital filers; synthesis FIR-filters: windowing, frequency sampling; synthesis IIR-filters: impulse variability model, bilinear transformation; digitalization of noise signals;	LFUI	2	3
b.	**VU Mechatronic Systems Control** Design of state controllers and state observers, derivation of the Kalman filter and its areas of application, realisation of digital controllers (criteria for selecting the controller, selection of sampling time, calculation algorithms, robust fixed-point and floating-point realisations), identification and estimation of system states, system diagnostics and their integration into fault-tolerant control of mechatronic systems;	UMIT TIROL	2	3
c.	**VU Mathematical Optimisation** Linear and convex optimisation, combinatorial optimisation, nonlinear optimisation (gradient-based and heuristic processes), optimal control of dynamic systems, inverse problems and data adaptation;	LFUI	2	3
	Total		**6**	**9**

	Learning Outcomes: Students are familiar with the mathematical basics of digital signal processing. They understand that the process of sampling in time is unlike an intuitive approach not connected to any loss of information. They know the effects and limiting factors connected to DFT spectral analysis. The students have the competence to design the control of mechatronic systems, to competently realize possible solutions for implementation and to complete the control through comprehensive system monitoring and diagnosis. Students have a profound understanding of mathematical concepts, tasks and methods of optimisation and optimal control. Students know and are able to apply the most important numerical procedures. Students have an overview of inverse problems, associated tasks, the most important numerical methods and questions of model adaptation.
	Prerequisites: none

2.	**Compulsory Module 2: Mechanics and Mechanical Engineering**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Design of Mechatronic Systems and Computer Aided Engineering (CAE)** Product life cycle; factors of the development of mechanic and mechatronic products; designs and structures of virtual products; overview of computer-aided engineering methods in construction and simulation; overview, classification and operating modes of mechatronic components and controls; CAE process chains in the development of mechatronic products; model making in computer-aided development; 3D-CAD construction; digital mock-up (DMU); N-body simulation; finite-element simulation (FEM); product data management (PDM); computer-aided design of a mechatronic system; verification of the concept with CAE methods;	LFUI	2	3
b.	**VU Strength of Materials and Mechanics of Materials** Strength theory (Tresca, Mises, Rankine), non-linear-elastic and anelastic material behaviour, elasto-plastic material behaviour and flow plasticity theory, bearing load ratings, principles of virtual working, stress concentration, linear-elastic fracture mechanics, cyclic stress;	LFUI	3	4
c.	**VU Mechanical Engineering and Construction Technology 2** Alternative construction and calculation of specified single elements: shaft-hub joints, joining (screwing, adhesive bonding, welding), storing as specified; free conceptual design: construction and calculation on a complete prototype group or a system as specified in the product specification (e.g. from the fields of robotics or medical technology);	LFUI	3	4
d.	**VU Dynamics of Machinery** Basics of the dynamics of machinery (assembly of machines, vibration isolation, vibration absorbers); basics of rotor dynamics; systems of generators, torsional vibration; basics of non-linear generators;	LFUI	3	4
	Total		**11**	**15**

	Learning Outcomes: Students have an advanced knowledge of and skills for designing mechatronic systems with computer-aided construction and interpretation methods. They understand the relations of product development and are able to apply CAD and CAE modules in the development process. Students possess advanced knowledge of and skills in linear and non-linear strength calculation of building elements under static and cyclic stress. Students have the skills to find solutions and alternatives for problems related to machine engineering, to assess them and to realize them in a constructive way. Students possess advanced knowledge of general machine assembly and vibration decoupling and can lay classic vibration absorbers. They understand the effects of imbalances in rotors and have a basic knowledge of the theory of oscillation, oscillator chains and non-linear oscillators.
	Prerequisites: none

3.	**Compulsory Module 3: Electrical Engineering**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Electromechanic Actuators** Advanced basics of electric machines, micromotors, linear and rotatory servo drives for controlling electro-mechanic actuators;	LFUI	2	3
b.	**VU Theoretical Electrical Engineering** Charges and electrostatic field; electricity and static current field; static magnetic field; time-dependent electro-magnetic field; induction and motion induction; electromotive force (e.m.f.); Maxwell‘s equations; retarded potentials; Coulomb gauge; Hertzscher’s dipole; transmission line theory; quadrupoles, skin-effect;	LFUI	3	4
	Total		**5**	**7**
	Learning Outcomes: Applying the theoretical basics in the area of electric machines, the students possess an advanced competence in the area of electrical engineering/drive engineering. Students have specialist knowledge in the area of vector analysis and are thus able to describe the electro-magnetic field. They are familiar with the physical/atomic basics of electrical engineering and understand the significance and importance of Maxwell’s equations.			
	Prerequisites: none			

4.	**Compulsory Module 4: Electrical Engineering and Informatics**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Digital Image Processing** Characteristics of digital images; histogram equalisation; filtering in the spatial domain; mathematical morphology; discrete Fourier transformation; deconvolution; wavelet transform; Radon transform; Hough transform; examples for application;	UMIT TIROL	2	3
b.	**VU Process Measurement Technology** Measurement of non-electrical quantities, principles of computer-aided measurement technology, basic structures of measurement systems (centralised and decentralised measurement systems, spatial distribution, synchronisation and computing power	UMIT TIROL	2	3

	requirements of processes); sensor technology in MES (sensor systems in automation technology, sensors in material measurement technology); data transfer to computer structures (principle, hardware, software); computer concepts in measurement systems and measured value acquisition using conventional and graphic-object-oriented programming;			
c.	**VO Embedded Systems** Architecture of embedded systems, sensors and actuators of embedded systems, specification languages, VHDL, real-time communication, field buses, CAN bus, CANopen, real-time operating systems, task management, middleware;	UMIT TIROL	2	3
	Total		**6**	**9**
	Learning Outcomes: Students are familiar with the types and characteristics of digital images and the basic spectrum of methods used for processing images in the typical application areas. Students are familiar with advanced methods of measurement technology and can design modern measurement systems for process measurement technology and use computer-aided measurement technology. Students know and apply the most important hardware and software components of embedded systems and real-time systems, are proficient in the most common specification languages for embedded systems, know the general requirements of embedded operating systems and understand the fundamental problems of real-time processing.			
	Prerequisites: none			

(2) If a specialisation in IMMS (IMW in German) is chosen, courses amounting to a total of 15 ECTS-Credits must be passed of the following two compulsory modules.

1.	**Compulsory Module 5: Industrial Mechatronics and Material Science 1**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Hydraulic and Pneumatic Power Drives** Structure and modes of operation of pumps and motors and their regulation; hydraulic transformers or energy saving; discussion of open and closed circuits with circuit diagrams; discussion of energy-efficient drives without throttles; discussion of oscillating and linear motors; special constructs for automation; telescopic cylinders – single- double-acting and with a constant process rate; basics of proportional and servo technology; differences and use of drives and regulators; discussions of problems of controlling differential cylinders with proportional valves; design of circuit diagrams; detecting and discussion of faulty drives; laying and calculating of machines; discussion of pneumatic sequence control systems with isolation of the control circuit and cyclic chain control with the help of circuit plans;	LFUI	2	3
b.	**VU Advanced Control** Design of control systems; 2-degree-of-freedom structure; disturbance observer and compensation; LQR design and Kalman filter; flatness-based design for simple nonlinear systems;	UMIT TIROL	2	3
	Total		**4**	**6**

	Learning Outcomes: Students possess, subject-specific for hydraulic and pneumatic drives, advanced knowledge and skills regarding regulated open and closed circuits of hydraulic and pneumatic systems. They have a profound knowledge of the uses of proportional and servo technology. They understand the correlation of electro-hydraulic and electro-pneumatic drives and controllers. The students possess the competence to design circuit diagrams and to calculate machines. They are able to analyse circuit diagrams. Students also have a deep understanding of classic control circuits and their practice-relevant extensions and methods of analysis and their time-discrete realisation. They are familiar with modern state space methods for linear systems and their extension to non-linear systems.
	Prerequisites: none

2.	**Compulsory Module 6: Industrial Mechatronics and Material Sciences 2**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Manufacturing Techniques 2** Advanced knowledge of the DIN 8580 manufacturing techniques with special focus on manufacturing of mechatronic and miniaturised components; introduction to industrial production and the corresponding manufacturing planning and cost planning;	LFUI	2	3
b.	**PR Industrial Mechatronics and Material Sciences – Laboratory** Interdisciplinary laboratory on themes attuned to the subject areas: design of mechatronic systems, electric drive technology and power electronics, control and automating technology, digital signal processing, mechanics, real-time systems and NanoLab - material analysis;	LFUI, UMIT TIROL	2	3
c.	**VU Material Engineering 1** Structure and mechanic characteristics of materials; alloyal structure of metal materials (crystallization, observing of thermodynamic stability, diffusion, precipitation reactions); stabilizing mechanisms; warmth treatments; fatigue; creepage; residual stress; steel for construction and machine engineering; synthetic materials and composite materials;	LFUI	2	3
	Total		**6**	**9**
	Learning Outcomes: The students have a detailed knowledge of the manufacturing processes that can be used for making mechatronic components. They are able to select suitable processes for specific tasks and to plan the manufacturing process for industrial production as well as to estimate the manufacturing cost. Students have practical skills in the field of mechatronics and are able to deal with and solve interdisciplinary tasks target-oriented by considering the sub-disciplines and their interactions. They are able to independently study the lab documents and to independently approach the tutorial with professional guidance. Students have an advanced knowledge of the structure of materials and of their mechanical characteristics. With regards to metallic materials, they are familiar with the micro-structures that are the result of alloys and warmth treatments and with their characteristics. Thanks to their deep understanding of the metallographic mechanisms regarding the mechanical characteristics like strength, deformability, creepage or fatigue, students are able to assess an individual load situation appropriately and to develop strategies for solving the problems. They			

	also have an advanced knowledge of the different materials, from simple steel for construction or machine engineering, tool steel to synthetic materials and complex compound materials.
	Prerequisites: none

(3) If a specialisation in BMT is selected courses covering a total of 15 ECTS-credits must be passed of the following two compulsory modules.

1.	**Compulsory Module 7: Biomedical Technology**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Medical Physics and Biophysics** X-ray, computed tomography (CT), magnetic resonance imaging (MRI), sonography, nuclear medicine, radiation biophysics, bionics, molecular biophysics, membrane systems, membrane proteins, molecular machines, bio-signal transduction;	UMIT TIROL	2	3
b.	**VU Clinical Medicine** General pathology, overview of the individual specialist fields of clinical medicine, individual pathologies and basics of diagnostics and therapy;	UMIT TIROL	2	3
	Total		**4**	**6**
	Learning Outcomes: Students know the basic anatomic structure of the human body and can name the parts. They understand basic physiological correlations and have a command of the basic medical terminology for naming anatomic and physiological terms. They understand basic medical contexts (pathologies, diagnosis and therapy approaches) and are able to understand medical specialist conversation.			
	Prerequisites: none			

2.	**Compulsory Module 8: Biomedical Technology 2**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Biomedical Imaging** Imaging, basic characteristics and types of biomedical images, histogram equalisation, local filters in the domain of space, mathematical morphology, geometric transformation, interpolation, segmentation, classification, visualisation; application fields in diagnostics, therapy and medical technology;	UMIT TIROL	2	3
b.	**VU Biomedical Technology - Laboratory** ECG-amplifier, recording and interpreting standard ECGs, cardiac pacemakers, biomedical sensors; ultrasound and sonographic applications (US principles, A-, B-, M-mode, 3D-US, foetal pulse detectors); high-frequency technology, transmission line theory, Smith-diagram, adaptation, filtering, □/4-transformation, measurement of scattering parameters (S-matrix), skin-effect; neurostimulators, functional electrical stimulation (FES), transcutaneous transmission of data and energy, cochlear implants;	LFUI, UMIT TIROL	2	3

c.	**VO Bioelectric Signals** Bioelectrical modelling and simulation, current applications of electrical and neurostimulation (cochlear and vestibular implants, deep brain stimulation, functional electrical stimulation); cryoablation, technical assistance systems (pacemakers, defibrillators);	UMIT TIROL	2	3
	Total		**6**	**9**
	Learning Outcomes: Students have a command of the basic methods of creating, editing, analysing and visualising biomedical image data. Students are able to assess possibilities and limits of biomedical systems and components. They have the competence to independently study laboratory documents and to independently carry out the laboratory exercises under professional guidance. They know about the basic physiological principles and methods, concepts and systems of biomedical technology and their practical use in electro-cardiology, biomedical sensor systems and technical assist systems.			
	Prerequisites: none			

(4) Irrespective of the chosen field of specialisation, the Compulsory Module "Defensio" covering 2.5 ECTS-credits that finalises the studies must be passed in addition to the Master's Thesis.

	Compulsory Module 9: Defence of the Master's Thesis (Defensio)	**Univ.**	**h**	**ECTS-Credits**
	Oral defence of the Master's Thesis before of an examination board;	LFUI, UMIT TIROL	-	2.5
	Total		**-**	**2.5**
	Learning Outcomes: Reflection of the Master's Thesis in the overall context of the Master's Programme of Mechatronics; Emphasis is on theoretic understanding, methodological foundations, imparting of results of the Master's Thesis and presentation skills.			
	Prerequisites: positive evaluation of all compulsory modules and the required optional modules, plus the Master's Thesis.			

(5) If IMMS (IMW in German) is the chosen field of specialisation, courses covering a total of 25 ECTS-credits have to be passed of the following optional modules.

1.	**Elective Module 1: Industrial Mechatronics and Material Sciences 3**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Robotic Systems** Components of robotic systems, collaborative robots, collision avoidance, system architecture, gripping, robot learning, artificial intelligence in robotics, mobile robots, navigation, modular robots, robot operating system (ROS);	LFUI	2	2.5
b.	**VU Power Electronics and Electrical Drives** Semiconductor devices and basic circuits of power electronics, power amplifiers, line commutation inverters, chopper converters, electromagnetic tolerance of power electronics;	LFUI	2	2.5

c.	**VU Surface Technology** PVD (physical vapour deposition or vacuum or thin film technology) process technologies as modern industrial engineering techniques for functionalization of surfaces; manufacturing of thin for application in the field of mechanical engineering, tools, optics, electronics, motorcars; materials and material characteristics of thin films; technical plasmas for supporting the manufacturing processes and for influencing the surface features;	LFUI	2	2.5
d.	**VU Optimisation of Material Engineering** Multi-scale concept; experimental characterisation (NanoLab) and scale changes; methods of optimization; bionics; computer-based design of new materials;	LFUI	2	2.5
e.	**VU Robotics 2** Advanced knowledge of the different robot systems (serial, parallel and rolling robots); singularities, dynamics, route planning, collision avoidance;	LFUI	2	2.5
f.	**VU Technical Logistics** Introduction to industrial logistics and the technical problems faced in a business environment; material handling engineering (consignment, transport and sorting systems); identification and localization of goods (RFID-systems, 2D-codes); methods of material handling systems, especially material handling analyses, depiction of work sequences with flow diagrams and function charts and the corresponding planning methods to be applied; dimensioning and calculation of logistics facilities; case studies;	LFUI	2	2.5
g.	**VU Industrial Mechatronics and Materials Science 1 – Specialization:** Courses on special module-relevant topics are offered alternately;	LFUI, UMIT TIROL	2	2.5
	Total Courses covering 5 ECTS-credits have to be passed from the courses listed from a to g.		**4**	**5**
	Learning Outcomes: Students have the competences and skills for innovatively designing mechatronic systems. They can resort to an advanced basic knowledge in the area of technical engineering, material sciences and power electronics and can develop innovative solution and application approaches for technical problems in relevant industrial areas, assess their suitability for application and eventually constructively imply the measures.			
	Prerequisites: none			

2.	**Elective Module 2: Industrial Mechatronics 1**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Systems with Locally Distributed Parameters** Concept of the distributed-parametric system; description by partial differential equations; modelling of locally distributed systems; characterization of partial differential equations; approximation by systems with locally concentrated parameters; control design for distributed-parametric systems;	UMIT TIROL	2	2.5

b.	**VU Regulation of Non-Linear Systems** Mathematical models of non-linear systems, fundamental differences of the behaviour of linear and non-linear systems: existence and uniqueness of the solutions, chaos, finite exhaust time, rest positions, limit cycles and general invariant fields of the state space, Lyapunov-stability, exponential stability, Lyapunov functions and Lyapunov-based control, backstepping and differential geometrical techniques: input, output and state stability, exact linearisation, flat systems and flatness-based control;	UMIT TIROL	2	2.5
c.	**VU Robot Control** Robots in industry, structure and overview of robot controls and their programming, forming of kinematic and kinetic models for serial robots, mathematics of the motion of rigid bodies, rotations, translations, homogenous transformations, direct and inverse kinematics, die Denavit-Hartenberg-convention, Jacobi-matrices, dynamics of link drives and controllers, robot dynamics, multivariable systems and motion control, impedance control, exact linearization of equations of motions of serial robots, planning of paths and trajectories;	UMIT TIROL	2	2.5
d.	**VU Industrial Mechatronics 1 – Advanced:** Alternatingly courses on special module-relevant themes, e.g. applied automatization, optimized filtering, robust and optimised control are offered;	LFUI, UMIT TIROL	2	2.5
	Total Courses covering a total of 5 ECTS-Credits have to be passed from the courses listed from a. to d.		**4**	**5**
	Learning Outcomes: Students have an advanced understanding of the theme complex of automation and control, which is vital to the functional design of mechatronic systems. Additionally, to their basic knowledge of this specialist area the students are able to use advanced methods for system modelling, analysis and synthesis and to apply them in a targeted and innovative way.			
	Prerequisites: none			

3.	**Elective Module 3: Industrial Mechatronics 2**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Bioenergy** Basics of biological waste treatment, generating of renewable energies from organic waste, conditioning and possible uses of biogas and mechatronic systems used for those purposes; if possible in cooperation with an industrial business;	LFUI	2	2.5
b.	**VU Converter Technology** Rectifiers, inverted rectifiers, frequency inverters, circuit feedback, power factor correction, thermal stress and cooling, safety technology, field-oriented control of induction machines;	LFUI	2	2.5
c.	**VU Thermofluid Dynamics** Basic terms of technical thermo-dynamics, fluid dynamics and thermal transfer (heat conduction and convection); similitude theory, dimensionless parameters, kinematics of fluids, continuity equation, Navier-Stokes-equations,	LFUI	2	2.5

	Euler equation of movement, Bernoulli-equation, application of Bernoulli's equation, one-dimensional transient flows; flows with friction, laminar and turbulent flows, flow processes with thermal transfer, basics of fluid flow engines; introduction to CFD;			
d.	**VU Industrial Mechatronics 2 – Advanced:** Alternatingly courses on special module-relevant themes, e.g. electric systems engineering, multi-body dynamics, structure dynamics are offered;	LFUI, UMIT TIROL	2	2.5
	Total Courses covering 5 ECTS-credits have to be passed from the courses listed from a. to d.		**4**	**5**
	Learning Outcomes: Students have an advanced knowledge of industrial applications of mechatronic systems and are able to implement them on the basis of practical examples. They are familiar with complex, interconnected mechatronic processes, their subject-specific principles and selected fields of application that are relevant to industry and thanks to the research-oriented doctrine they are able to approach the development and implementation of independent, innovative approaches towards the solution of problems.			
	Prerequisites: none			

4.	**Elective Module 4: Material Sciences 1**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Composites** Manufacturing, laying and designs of composite structures; material science: fibre materials, matrix materials, core materials; manufacturing technique: draping, weaving, automated fibre placement etc; hand-lamination technology; autoclave method, infusion and injection technology etc; elastic behaviour of composites; fracture behaviour of composites; joining technology (mechanic, adhesive bonding); composite building techniques;	LFUI	2	2.5
b.	**VU Lightweight Design** Concepts and strategies of lightweight design, design principles, criteria for selecting the materials, lightweight design potential of isotropic and anisotropic lightweight design structures, structural mechanics basics of lightweight design, structure optimisation, reliability proofs;	LFUI	2	2.5
c.	**VU Material Engineering 2** Durability and fracture mechanics; fracture behaviour and types of fracture; residual stress and its effect on metallic materials; mechanisms of corrosion and corrosion prevention; chemical resistant steel (austenites, duplex steel etc.); introduction to high performance materials (ni-base superalloys, titan etc.);	LFUI	2	2.5
d.	**VU Material Sciences 1 – Advanced:** Alternatingly courses on special module-relevant themes, e.g. special materials and technologies, materials in mechatronics – electronic components, materials in mechatronics – precision engineering are offered;	LFUI	2	2.5

	Total Courses covering 5 ECTS-credits have to be passed from the courses listed from a. to d.	**4**	**5**
	Learning Outcomes: Students have an advanced knowledge of mechatronic systems and their applications and are thus able to select and optimise the material and structure of mechatronic components for a specific application. Thanks to their advanced understanding of mechanic and material science theories, they are able to provide innovative solutions.		
	Prerequisites: none		

5.	**Elective Module 5: Material Sciences 2**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU ASIC-Design** Design of integrated digital and analogue circuits, steps in the design process of an ASIC, available electronic components on an IC, manufacturing steps for an ASIC, circuit layout of analogue and digital circuits, influence of the circuit layout on the electrical properties, methods for verifying an ASIC, electrostatic discharge (ESD), latch up, assembly and connection technology;	LFUI	2	2.5
b.	**VU Human-Machine-Systems** Aspects of the design and evaluation of human-machine systems (HMS), approaches to the design of technical systems and interfaces, basic principles of human information processing and biomechanics, design of workplaces, analysis of humans as system components, methods for the ergonomic evaluation of HMS, classification of advanced methods of human-machine systems technology;	LFUI	2	2.5
c.	**VU Industry 4.0** Network and cloud technology, software and control technologies, human-machine interaction, humans in I4.0, sensor systems, industrial robotics, sensor systems, localisation and location-based services, machine learning, simulation and programming technologies;	LFUI	2	2.5
d.	**VU Material Sciences 2 – Advanced:** Alternatingly courses on special module-relevant themes, e.g. treating of special and new materials, computer-aided methods of product development and manufacturing, tool machines are offered;	LFUI	2	2.5
	Total Courses covering 5 ECTS-credits have to be passed from the courses listed from a. to d.		**4**	**5**
	Learning Outcomes: Students have an advanced knowledge of and skills in the area of material sciences and industrial mechatronics. They are familiar with the physical basics, the manufacturing processes and techniques and can realistically assess their possible applications for the problems in questions, select appropriate techniques and apply them, as well as develop new ones.			
	Prerequisites: none			

(6) If BMT is the chosen field of specialisation, courses covering 25 ECTS-credits of the following three optional modules have to be passed.

1.	Elective Module 6: Biomedical Technology 3	Univ.	h	ECTS-Credits
a.	**VU Biostatistics** Problems of descriptive statistics, probabilities and distributions, formulating and testing of hypothesis, evaluation, comparison of statistic values, regression and correlation, biologic applications, biostatistical software;	UMIT TIROL	2	2.5
b.	**VO Basics of Biomechanics** Biomechanic basics of the musculoskeletal system, the cardiovascular system and the respiratory system; forces of the musculoskeletal system; fluid dynamics (blood) in the heart, lung, arteries and veins;	UMIT TIROL	2	2.5
c.	**VO Technical Principles of Active and Passive Implantable Systems** Overview and classification of different implants; technical basics of energy supply/energy management; methods for energy-efficient circuits; communication interfaces and how they work for implants;	LFUI	2	2.5
	Total Courses covering 5 ECTS-Credits have to be passed from the courses listed from a to d.		**4**	**5**
	Learning Outcomes: Students have a deep understanding of theoretical and practical aspects of several application areas of biomedical technology. They have an advanced knowledge of the methods as a basis for acquiring advanced knowledge in related areas of medical technology. The students are familiar with complex, interrelated bio-mechatronic processes and apply this knowledge for special developmental tasks in this area.			
	Prerequisites: none			

2.	Elective Module 7: Biomedical Technology 4	Univ.	h	ECTS-Credits
a.	**VU Development and Approval in Medical Technology** European safety strategy, Medical Device Regulation, Medical Devices Act, structure of the standards system, medical devices and their classification, certification of medical devices, medical devices from the manufacturer's perspective, medical devices from the operator's perspective, software as a medical device, quality management in medical technology;	UMIT TIROL	2	2.5
b.	**VO Biological Regulation** Introduction to the mathematical description of physiological systems, model formation, basic principles of biological regulation: basic terms, models and classification, exchange processes and mathematical description, general system-analytic reflection of physiological regulatory circuits, sensors and receptors, regulation of the blood chemistry and the nervous system, temperature regulation, blood pressure regulation, regulation of	UMIT TIROL	2	2.5

	the circulatory system, regulation of the respiratory system, metabolism and energy rate;			
c.	**VU Electrical and Neurostimulation** Fundamentals of electro- and neurophysiology; electro cardiology - basic principle, modelling and simulation; electroencephalography - basic principle, modelling, brain-computer interface; biopotential electrodes; bio signal amplifiers; methods of bio signal processing and analysis	UMIT TIROL	2	2.5
d.	**VU Advanced Methods of Medical Image Analysis** Modelling and simulation of form and structure changes, registration methods (point- and intensity-based), model-based segmentation, analysis and classification; applications in diagnostics and therapy, especially in surgery, radiation therapy and pathology;	UMIT TIROL	2	2.5
e.	**VU Materials in Mechatronics – Medical Technology** Biocompatible organic and inorganic materials; methods for determining biocompatibility; absorbable materials; polymers; metals; ceramic materials;	LFUI	2	2.5
f.	**VU Biomedical Technology 4 – Advanced:** Alternatingly courses on special module-relevant themes, e.g. special themes of biomedical technology, microscopic techniques are offered;	LFUI, UMIT TIROL	2	2.5
	Total Courses covering a total of 10 ECTS-credits have to be passed from the courses listed in a. to f.		**8**	**10**
	Learning Outcomes: Students have an advanced knowledge of and skills in biomedical technology and are able to put these in practice in the area of system development. They are familiar with complex biomechanical processes and acquire independent solutions for the development of components, devices and systems of medical technology based on the research-focused doctrine.			
	Prerequisites: none			

3.	**Elective Module 8: Biomedical Technology 5**	**Univ.**	**h**	**ECTS-Credits**
a.	**VU Molecular Biological Methods for Diagnostics and Therapy** fundamental knowledge of cell biology, biochemistry and molecular biology; detailed knowledge of essential analytical laboratory methods (basic molecular biology techniques and high-throughput procedures); basic knowledge of procedures for data analysis and quantitative assessment of diagnostic markers and procedures;	LFUI	2	2.5

b.	**VU Biomedical Modelling and Simulation** Introduction to modelling and simulation, spatial and temporal discretization; special applications of numeric methods for solving ordinary and partial ODEs, Finite-Difference-Method (FDM), Finite-Elements-Method (FEM), iterative solution procedures, convergency studies; physical relations of biomedical models and systems; concrete models like e.g. Hodgkin-Huxley-model, characteristics of models and systems, linearization, model validation, tutorial with Matlab/Simulink;	UMIT TIROL	2	2.5
c.	**VU Data Mining in Biomedicine** Statistic principles, data preparation (data transformation, integration, selection of attributes), classification (quality measures, validation, binary logistic regression, K-NN, Bayes, decision trees, SVM, neuronal networks, ensemble methods), clustering (k-means, EM-algorithm, density-based methods, hierarchic methods), clustering in high-dimensional data;	UMIT TIROL	2	2.5
d.	**VU eHealth** Concepts, definitions and terms; basic decision and financing structures in the Austrian health sector; concepts of electronic files: electronic health files, electronic patient files etc.; standardisation of information systems (et al. IHE, DICOM, HL7, CDA etc.); information system architectures; electronic health files in Austria and Europe: concepts and architectures; data safety; legal principles of eHealth; quality of the electronic files;	UMIT TIROL	2	2.5
e.	**VU Hospital Information Systems** Modules and functionality of hospital information systems, types of architecture, static modelling with 3LGM, integration of heterogenous information systems (data integration, semantic integration etc.), communication standards (HL7, DICOM, CDA), electronic patient file, site visits, HL7-interface tutorial;	UMIT TIROL	2	2.5
f.	**VU Biomedical Technology 5 – Advanced:** Alternatingly courses on special module-relevant themes, e.g. molecular-biological methods for diagnostics and therapy, system biology are offered;	UMIT TIROL	2	2.5
	Total Courses covering 10 ECTS-credits have to be passed from the courses listed from a to f.		**8**	**10**
	Learning Outcomes: Students have an advanced knowledge of biomedical technology and informatics and can assess the possible use of relevant devices and software for targeted applications of medical technology. They are familiar with the methods for analysing, designing and developing special applications in medical technology and informatics and to independently develop the required problem solutions.			
	Prerequisites: none			

(7) Irrespective of the selected field of specialisation, courses covering 10 ECTS-credits have to be passed from the following two elective modules.

1.	Elective Module 9: Advanced Mechatronics	Univ.	h	ECTS-Credits
a.	**VU Adaptive and Intelligent Control Systems** Decision processes, performance measures, stability, neuronal networks, genetic algorithms;	LFUI	2	2.5
b.	**VU Computer-Vision** Geometric principles, transformation groups, 3D-scene geometry, camera geometry, diction of features in images: edges, corners, SIFT-features, epipolar geometry, reconstruction of 3Dinformation from image pairs and series, motion detection in image series, shape from shading;	UMIT TIROL	2	2.5
c.	**VU Electronic Speech Recognition** Principles of digital speech signal processing, features of a speech signal, recognition of individual words, recognition of continuous speech (verification, identification), fields of application of speech processing, experimental research;	UMIT TIROL	2	2.5
d.	**VU Fuzzy-Methods** Principles of fuzzy quantities and fuzzy numbers, fuzzy-logics, fuzzy-inference system, analysis and processing of fuzzy data, arithmetics of fuzzy numbers, fuzzy-input-output models, draft of fuzzy regulators;	LFUI	2	2.5
e.	**VO RF-Engineering** Transmission line theory; solving of the wave equation – wave functions; S-parameters; Smith-diagram; parallel waveguides; hollow conductors; microstrip lines; band filters, LC-oscillators; quartz oscillators:	LFUI	2	2.5
f.	**VO Information Theory** Principles of the information theory acc. to Shanning; information content, entropy; channel capacity; channel coding; mutual information analysis; coding acc. to Huffman; features of technical codes; cyclic redundancy check (CRC); cyclic codes; Galois fields; principles of cryptography; trapdoor functions; public-key systems (knapsack systems, RSA);	LFUI	2	2.5
g.	**VU Microelectronics** Behaviour of modern field-effect transistors and their modelling, advanced topologies for current mirrors, reference sources, circuit topologies for low supply voltages, functionality of simulation programs for analogue integrated circuits;	LFUI	2	2.5
h.	**VU Physical Principles of Semiconductor Devices** Binding model: intrinsic conduction, impurity conduction; electrical features: drift current, diffusion current, conductibility; energyband model, pn-junction, diode, bipolar construction elements, MOSFET, memory cells, techniques of bulding elements engineering;	LFUI	2	2.5
i.	**VU Signals and Systems** Continuous control Fourier, Hilbert and Laplacet transformation; LTI-systems; convolution; causality and stability; transfer function; analogous filters (e.g. Butterworth filter, Bessel filter);	LFUI	2	2.5

	sigmadelta-modulation; spread spectrum systems (satellite communication)			
j.	**VU Advanced Mechatronics – Selected Topics:** Alternatingly courses on special module-relevant themes, e.g. antennas, production measurement technology, software design are offered;	LFUI, UMIT TIROL	2	2.5
	Total Courses covering a total of 5 ECTS-credits have to be passed from the courses listed in a. to j.		**4**	**5**
	Learning Outcomes: Students have an advanced knowledge and skills in different specialist fields of mechatronics. They have the competence to independently address complex problems of advanced mechatronics in methodological appropriate way and to develop innovate problem solutions.			
	Prerequisites: none			

2.	**Elective Module 10: Additional Qualifications**	**Univ.**	**h**	**ECTS-Credits**
	Courses covering a total of 5 ECTS-credits; one course can be passed in the area of "Equality and Gender". Also courses from other Master's Programmes of the LFUI and UMIT TIROL can be passed. It is also recommended to attend courses that encourage competences for imparting knowledge of the subjects. Suitable courses are in particular: Introduction to Economics and Management (LFUI) Foreign Language 2 (LFUI) Gender Aspects in Technology 2 (LFUI) IT-Project Management (UMIT TIROL) Standards and Rules in Mechatronics (UMIT TIROL) Patent- and Copyright (LFUI) Social Competences 2 (LFUI) Mechatronics Practice 2 (UMIT TIROL) To attend the seminar "Mechatronics Practice 2" proof of an appropriate practical experience covering 160 working hours is required.	LFUI, UMIT TIROL	-	5
	Total Courses covering 5 ECTS-credits must be passed.		**-**	**5**
	Learning Outcomes: Students have the qualification to get involved in a scientific discourse in a constructive, responsible and gender-sensitive way that also goes beyond the boundaries of their specialist discipline.			
	Prerequisites: The course requirements specified in the respecitive Curriculum must be met.			

§ 8 Master's Thesis

(1) In the Master's Programme of Mechatronics a Master's Thesis covering 27.5 ECTS-Credits must be written. The Master's Thesis is a scientific piece of work that serves as proof that the students are able to independently deal with a scientific theme in a methodologically and thematically responsible way.

(2) The theme of the Master's Thesis is to be taken from an area of Mechatronics.

(3) Students may suggest a theme for their Master's Thesis themselves or select from given themes.

(4) The Master's Thesis must be handed in at the university the main supervisor belongs to. The thesis must be submitted in writing and in the electronic form specified by the responsible authority of the respective university.

§ 9 Examination regulations

(1) Before the start of the semester, the course instructor shall inform the students about the assessment criteria and assessment standards and shall specify one of the assessment methods mentioned in paragraphs 2 to 5.

(2) An exam takes place at the end of the course to assess the performances of each lecture of a compulsory or optional module. Examination method: written and/or oral examination.

(3) Tutorials and practical courses of a compulsory or optional module are courses with continuous performance assessment all through the course.

(4) Lecture-tutorials of optional and compulsory modules are courses with continuous performance assessment for the tutorial part and a final examination at the end of the course for the lecture part of the course. Examination method: tutorial: continuous performance assessment; lecture: written and/or oral examination.

(5) Seminars of compulsory and optional modules are courses with continuous performance assessment and a final examination at the end of the course. Examination method: continuous performance assessment and written and/or oral examination.

(6) A compulsory module is passed with the positive evaluation of all required courses of the respective module.

(7) Elective modules are passed with the positive evaluation of all courses required for reaching the amount of ECTS-credits according to §7 para. 5 to 7.

(8) Requirements for registering for the Master's Thesis is the successful completion of the compulsory modules 1 and 2 acc. to §7 para. 1, no. 1 and 2.

(9) According to the cooperation agreement for realizing the joint Master's Study Programme for Mechatronics with the UMIT TIROL University of 8 March 2013, the defense of the Master's Thesis must be made at the university where it was written. The defense is an oral examination in front of an examination board of three persons. The examination board must consist of persons from both universities, who are chosen according to the respective effective regulations of the University of Innsbruck.

§10 Academic degree

Graduates of the joint Master's Programme of Mechatronics, of the Leopold-Franzens University of Innsbruck and UMIT TIROL – Private University of Health and Life Sciences Technology earn the academic degree of "Diplom-Ingenieurin" or "Diplom-Ingenieur" abbreviated as "Dipl.-Ing." or "DI" resp.

§11 Coming into force

(1) This curriculum comes into force on 1 October 2013.

(2) The changes to the curriculum in the version of the University of Innsbruck Bulletin of 27 June 2024, Issue 79, No. 890 come into force on 1 October 2024 and are to be applied to all students.