University
of Ljubljana

Faculty
of Mechanical Engineering

Aškerčeva 6
1000 Ljubljana
Slovenia

APPLICATION FOR APPROVAL OF LEVEL 1
UNIVERSITY STUDY PROGRAMME:

MECHANICAL ENGINEERING
RESEARCH AND DEVELOPMENT PROGRAMME

Ljubljana, November 2007

APPLICATION FOR APPROVAL OF LEVEL 1 UNIVERSITY STUDY PROGRAMME:

MECHANICAL ENGINEERING – RESEARCH AND DEVELOPMENT PROGRAMME

AT THE FACULTY OF MECHANICAL ENGINEERING, UNIVERSITY OF LJUBLJANA
(accreditation of the study programme)

1. Applicant Institution and Substantiation of the Application

1.1. Applicant Institution's Details

The application is submitted by the Faculty of Mechanical Engineering (UL FME) at the University of Ljubljana.

Applicant's address:
University of Ljubljana
Faculty of Mechanical Engineering
Aškerčeva 6
1000 Ljubljana

Applicant's contact persons:
Prof. Jožef Duhovnik, Dean of the Faculty
and
Prof. Boris Štok, Vice Dean for the Bologna reform

Faculty of Mechanical Engineering – Overview

The Faculty of Mechanical Engineering (UL FME) is a member of the University of Ljubljana. With 50,000 students, it is the third largest University in Europe. The Faculty of Mechanical Engineering has been engaged in education, research and technical activities for over 60 years. The milestones of its development are shown in the table bellow:

A short history of studying mechanical engineering on the university level in Ljubljana:

1919	The University of Ljubljana is established and university courses in mechanical engineering begin
1940	The Faculty of Mechanical Engineering building is completed
1950	An 8-semester study programme is set up.
1960	Department of Mechanical Engineering at the Technical Faculty develops into the independent Faculty of Mechanical Engineering as a member of the University of Ljubljana
1994/95	Beginning of higher professional studies at the Faculty of Mechanical Engineering
21. 12. 1994	Date of establishment, according to court register
1998/99	Beginning of a 9-semester university study programme

Source: Internal archives

The Faculty of Mechanical Engineering creates and disseminates knowledge that enables our students and research business partners to take a competitive part in the international environment.

Our vision is to become the most important education and research institution with the highest international education and research standards in the area of mechanical engineering in Slovenia, Central and South-eastern Europe, which should make our institution, our graduates and research work interesting for Slovenian as well as international economies and research and development institutions.

Educational, scientific, research and technical activities are performed by 18 education and research units – Chairs – in 34 laboratories.

The Faculty of Mechanical Engineering is managed by its bodies:
- Dean,
- Senate,
- Academic Assembly
- the member's Students Council

The Faculty is led, represented and presented by its Dean. The Faculty has vice deans for the following areas: a vice dean for educational activities – university and doctoral programmes, a vice dean for educational activities – higher professional studies, a vice dean for science and research activities, a vice dean for the Bologna reform and a vice dean for new constructions projects.

Functioning of the Faculty is supported by organisational units: secretarial office, financial and accounting services, student matters office, human resources office, international co-operation office, technical maintenance, library, computer centre and publishing.

The Faculty of Mechanical Engineering carries out undergraduate and postgraduate mechanical engineering study programmes.

The following programmes are being carried out by the Faculty in the 2007/08 academic year:
1 higher professional study programme MECHANICAL ENGINEERING as a full-time study (locations: Ljubljana and Novo mesto) and a part-time study (locations: Ljubljana, Nova Gorica and Celje),
1 university study programme MECHANICAL ENGINEERING as a full-time study in Ljubljana,
5 specialist study programmes MECHANICAL ENGINEERING in Ljubljana, as follows:
- Maintenance technologies management
- Design and development technology
- Production management
- Energy management
- Process engineering

1 postgraduate study programme MECHANICAL ENGINEERING in Ljubljana.

Tables 1.1.1 and 1.1.2 show the main figures on the number of students and graduates during the period between 2002 and 2007

Table 1.1.1: Number of students during the last five years (without candidates for graduation)

Study programme (s.p.)	2003/04	2004/05	2005/06	2006/07	2007/08
higher professional s.p. - full-time	814	845	875	927	989
higher professional s.p. - part-time	28	61	100	134	177
university s.p. - full-time	638	670	705	794	892
specialist s.p. - part-time	0	33	31	15	12
postgraduate s.p. - full-time	89	95	80	85	101
Total	1.569	1.704	1.791	1.955	2.171

Source: Internal archives

Table 1.1.2: Number of graduates during the last five years

Programme	2002	2003	2004	2005	2006
higher professional s.p. - full-time	83	85	111	95	93
higher professional s.p. - part-time	94	89	63	30	16
university s.p. - full-time	76	112	49	75	49
specialist s.p. - part-time	0	0	0	0	0
postgraduate s.p. - full-time	31	33	23	28	22
Total	284	319	246	228	180

Source: Internal archives

On November 12, 2007, the Faculty of Mechanical Engineering had 328 employees, whose structure is presented in Table 1.1.3. below. Education and research work also involves external partners.

Table 1.1.3: Number and structure of FME's employees during the last five years

Profile	2003	2004	2005	2006	2007
Higher education teachers	59	57	55	54	55
Instructors and assistants	78	77	77	75	72
Research and science associates	47	52	60	63	65
Technical staff	48	44	44	41	43
PhD students	34	34	31	35	40
Professional services	57	53	53	53	53
Total	**323**	**317**	**320**	**321**	**328**

Source: Internal archives

Table 1.1.4: Number of FME's part-time employees and those working on a contract basis during the last five years

Profile	2003	2004	2005	2006	2007
Part-time education staff	2	3	3	5	5
Part-time research staff	14	16	20	25	27
Education staff on a contract basis	15	14	15	15	10
Research staff on a contract basis	0	0	0	0	2
Total	**31**	**33**	**38**	**45**	**44**

Source: Internal archives

1.2. A Short Substantiation of the Application

The Faculty of Mechanical Engineering carries out undergraduate and postgraduate mechanical engineering study programmes. With the reform of the programme in the light of the Bologna reform, it plans to update its study programmes, adjust them to the needs of the economy and to expand international co-operation through students and education staff mobility. With the new Undergraduate University Study Programme **Mechanical Engineering** – **Research and Development Programme** (abbreviation **ME-RDP**, mainly used in tables) the Faculty replaces the existing 9-semester university programme Mechanical Engineering in its first part. It covers and upgrades the contents of roughly six semesters of the existing programme.

With this programme, the goal is to provide a good educational basis for the areas of study, such as development of new products, production engineering, power engineering environmental engineering, process engineering, new technologies and materials, mechatronics and road safety. The extent and exact titles will be defined in the announcement of Level 2 study programme **Mechanical engineering** – **Research and Development Programme**.

Needs of the economy and research institutions require fast and effective adjustments of higher education to modern science and technology trends as well as formation of specialists who will be able to become directly involved in the industrial work, science and research activities and development activities. Manufacturing and mechanical engineering contribute the largest part of Slovenia's exports. In order to achieve its goal, the Faculty has designed a study programme to educate development, evaluation, manufacturing and maintenance staff in the mechanical engineering area in its broadest sense. Particular emphasis will be on a rational use of materials, proper designing of building blocks, machines and apparatus, efficient use of energy and environmental acceptability.

Mechanical engineering is closely connected with other technical and industrial fields, such as electrical engineering, metallurgy, civil engineering, mining, traffic...

Trends on the global market require a very rapid development of knowledge and technologies, which should be followed by the Faculty's education activities. This study programme is based on positive experience from the past, on current know-how needs and on the expected development of mechanical engineering. As such, it is comparable with similar study programmes on other European universities. The proposed Level 1 University Study Programme covers the entire range of mechanical engineering skills.

The study programme reform began with a research and analysis of the needs and expectations of the industry in 2003. The working group for the reform of the study programme opted for a three-level system 3+2+3. Activities, related to formation of the study programme finished on November 14, 2007, when the proposed study programme was confirmed by the Faculty Senate. The working group membership and the Faculty Senate meeting involved also representatives of the FME's Students Council. Representatives of some larger Slovenian companies, professional associations and Chamber of Commerce and Industry also took an active part in preparing the reformed study programme.

The reformed programme, which follows the goals of the Bologna reform, represents a considerable update of the existing teaching content, it improves the optimality and involvement of students into the education process and introduction of modern teaching methods.

The main goal of the reformed Undergraduate University Study Programme **Mechanical engineering** – **Research and Development Programme** is to qualify the professional for solving efficiently and productively complex research and development problems and mechanical engineering tasks. In this phase of the study, the emphasis is on acquiring fundamental knowledge that provides for a high degree of students' interdisciplinary knowledge while at the same time providing them with a good basis for studying on Level 2 – the master study programme.

The Level 1 of mechanical engineering university study has therefore two main goals: to offer fundamental knowledge and fundamental professional knowledge and to emphasise interdisciplinarity of mechanical engineering, motivating students to continue the research and development oriented study. With its internationally recognised references, the existing education staff ensures a suitable basis for successful realisation of the study programme, based on solid academic foundations and detailed fundamental knowledge as well as on advanced methodology of educational activities in the research environment with suitable laboratory equipment. The credibility of the programme is based on participation of the education staff in international scientific and research activities, published articles, patents, conferences and international interdisciplinary co-operation.

A graduate of the Level 1 University Study Programme **Mechanical engineering** – **Research and Development Programme** will become a professional with a comprehensive knowledge of mechanical engineering and will be employable in companies and institutions, involved in mechanical engineering in the broad sense. Currently, the demand for mechanical engineering graduates exceeds the supply of suitable specialists. With the acquired fundamental knowledge, the graduate will be able to successfully continue studying any Level 2 study programme in Slovenia or abroad, directly or indirectly related to mechanical engineering.

The Faculty of Mechanical Engineering plans to take a step by step approach to implementation of new study programmes, meaning that the first generation of students should enter Year 1 of the university undergraduate programme in the 2008/09 academic year.

2. Level 1 Undergraduate University Study Programme

2.1. Substantiation of Fundamental Programme Objectives and General Course-Specific Competences

2.1.a. The Fundamental Programme Objectives

The main objectives of Level 1 Undergraduate University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** are as follows:

- To follow national economy's as well as students' requirements and requests to acquire the necessary competences that would provide direct employability after the end of studying. In line with this, it should provide a graduate with
  - broad and basic engineering skills, especially quality mechanical engineering skills and thus adequate employability,
  - solid fundamental knowledge and understanding of a wide range of mechanical engineering topics,
  - necessary skills to continue studying on the postgraduate level – Level 2.
  - broad mechanical engineering knowledge and skills, making him or her capable of linking different areas together in an interdisciplinary way.
- To follow the principles of the Bologna declaration, the European University Association EUA, the European Federation of National Engineering Associations FEANI and the German Accreditation Agency ASIIN. Through improved optionality and mobility, it should provide European comparable knowledge and employment qualifications of its graduates. In line with that:
  - a graduate should get the education, comparable with similar study programmes in Central and Western Europe,
  - the credits assessed certificate of accomplished study requirements makes it possible for a student to change for another similar undergraduate study programme in Slovenia or abroad
  - with conditions for migrations across study programmes, with the education work methods, encouraging continuous studying, and with the tutoring system, conditions for students' smooth migrations are provided.

2.1.b. General Competences, Acquired Through the Programme

After completing Level 1 undergraduate university study programme **MECHANICAL ENGINEERING – Research and Development Programme**, the graduate will have the following general competences:

- The ability to define, understand and creatively solve professional challenges.
- Development of creative, analytical and synthetic thinking.
- Development of professional responsibility and ethics.
- Professional communication and writing communication skills, including the use of foreign technical language.
- The ability to use information and communication technology.
- The ability to use the acquired knowledge to solve professional engineering problems independently.
- The ability to find sources, make critical judgement of information, upgrade the acquired skills independently and further develop the knowledge on various specific areas of engineering.
- The ability for teamwork and establishing interdisciplinary partnerships.
- Following safety, functional, economic and environmental principles at their work.
- Respecting the engineering code.

2.1.c. Course-Specific Competences, Acquired Through the Programme

After completing Level 1 undergraduate university study programme **MECHANICAL ENGINEERING** – **Research and Development Programme**, the graduate will have the following course-specific competences:

- Mastery of basic theoretic skills, fundamental to the technical aspect of mechanical engineering.
- Mastery of basic professional mechanical engineering skills and the fundamental complementary sciences (metallurgy, informatics and organisational sciences).
- Having basic engineering competence, which allows him/her to carry on studying on Level 2.
- The ability to acquire new knowledge and skills independently.
- A Level 1 graduate is able to perform easier development, engineering and professional organisational tasks as well as to solve individual well-defined engineering tasks.
- Specific competences are described in work plans for each course.

2.2. International Comparability of the Programme

The proposed programme **MECHANICAL ENGINEERING – Research and Development Programme** follows the principles of the European University Association, http://www.eua.be (EUA), and particularly the principles of the German Accreditation Agency for Degree Programmes in Engineering, Informatics, Natural Sciences and Mathematics (ASIIN), http://www.asiin.de, and its requirements and principles for the accreditation of the programmes, specified in the document, called Information for Universities, Requirements and Procedural Principles for the Accreditation and Reaccreditation of Bachelor's and Master's Degree Programmes in Engineering, Architecture, Informatics, the Natural Sciences and Mathematics, 08/12/2006, and course specific criteria for mechanical engineering, specified in the document, called TC1- Mechanical Engineering and Process Engineering, 08/12/2006 (Annex 3a).

Designing the programme, we took account of the basic principles of the European Federation of National Engineering Associations, http://www.feani.org (FEANI), particularly the criteria and guidelines, specified in the European Accredited Engineer (EUR-ACE) and European Engineering Professional Card (ENGCARD) programmes, which might include 3.5 million European engineers.

Four comparable international mechanical engineering programmes are presented and analysed below.

Similar foreign study programmes (name of programme, institution, country, website)	**1. Name of the programme:** **Génie mécanique** **Institution:** **École Polytechnique Féderale Lausanne (EPFL), Faculté des Sciences et Techniques de l'Ingénieur,** **Country:** **Switzerland** **Website:** http://sti.epfl.ch/ **Acronym:** **EPFL (Lausanne)** **Programme details:** **Annex 3b** **2. Name of the programme:** **Bachelorstudiengang Maschinenwesen** **Institution:** **Technische Universität München (TUM), Fakultät für Maschinenwesen,** **Country:** **Germany** **Website:** http://www.mw.tum.de/ **Acronym:** **TUM (München)** **Programme details:** **Annex 3c** **3. Name of the programme:** **Bacheloropleiding werktuigbouwkunde (Bachelor of Science Mechanical Engineering)** **Institution:** **Technische Universiteit Delft (TU Delft), Faculteit Werktuigbouwkunde, Maritieme Techniek en Technische Materiaalwetenschappen,** **Country:** **The Netherlands** **Website:** http://www.3me.tudelft.nl/ **Acronym:** **TU Delft (Delft)** **Programme details:** **Annex 3d** **4. Name of the programme:** **Bachelorstudiengang Maschinenbau** **Institution:** **Rheinisch Westfälischen Technische Hochschule Aachen (RWTH), Fakultät für Maschinenwesen,** **Country:** **Germany** **Website:** http://www.maschinenbau.rwth-aachen.de/ **Acronym:** **RWTH (Aachen)** **Programme details::** **Annex 3e**

Table 2.2.1 International Comparability of the Proposed Programme

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
2.2.a. Comparability of the Proposed Study Programme's Concept and Its Formal and Contents Structure with Foreign Programmes					
name of programme:	MECHANICAL ENGINEERING – Research and Development Programme	mechanical engineering	mechanical engineering	mechanical engineering	mechanical engineering
type of programme:	University – Level 1 (Bachelor)	University – Level 1 (Bachelor)	University – Level 1 (Bachelor)	University – Level 1 (Bachelor)	University – Level 1 (Bachelor)
contents:	**Fundamental sciences – compulsory general (43 ECTS):** Mathematics 1, Mathematics 2, Mathematics 3, Physics, Numerical Methods, Numerical Modelling Methods **Engineering sciences:** See more detailed description of this thematic set in the next indent.	**Fundamental sciences (56 ECTS):** Mathematics, Physics, Chemistry, Geometry, Probability and Statistics, Numerical Analysis **Engineering sciences (73-85 ECTS):** Materials, Informatics, Statics, Structures Mechanics, Thermodynamics and Power Engineering, Electrical Engineering, Continuum Mechanics, Electronics, Dynamic Systems, Automatics, Non-compressible Fluids Mechanics, Finite Elements Method, Vibrations, Solid Bodies Mechanics, Heat and	**Fundamental sciences (285P/ 135V hours):** Mathematics, Experimental Physics, Experimental Chemistry **Engineering sciences (480P/255V hours):** Mechanics, Electrical Engineering, Materials, Programming, Thermodynamics and Heat Transfer, Control, Mechanics of Fluids	**Fundamental sciences (21 ECTS):** Mathematics, Probability and Statistics **Engineering sciences (57 ECTS):** Statics, Strength, Dynamics, Materials, Thermodynamics, Modelling and Control, Discrete Systems Simulations, Non-linear Mechanics, Electrical Engineering, Process Technology, Signals Analysis, Heat and Substance Transfer	**Fundamental sciences (33 ECTS):** Mathematics, Chemistry, Physics, Numerical Mathematics **Engineering sciences (78 ECTS):** Mechanics, Thermodynamics, Electrical Engineering, Electronics, Materials, Measurements, Mechanics of Fluids, Simulations, Heat and Substance Transfer, Control Technology

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
		Substance Transfer, Finite Differences and Volumes Method, Compressible Fluids Mechanics			
	Fundamental mechanical engineering courses – compulsory specialised (93 ECTS) Within the proposed programme structure, the cumulative total of »Fundamental mechanical engineering courses – compulsory specialised« takes account of the »Engineering sciences« courses as well as »Fundamental mechanical engineering courses« Statics and Kinematics, Descriptive Geometry and Technical Documentation, Energy and Environment, Strength of Materials, Engineering Materials 1, Space Modelling and Representation, Thermodynamics, Engineering Materials 2, Machine Elements 1, Fluid Mechanics, Heat Transfer, Machine Elements 2,	**Fundamental mechanical engineering courses (21 do 33 ECTS):** Introduction to Mechanical Engineering, Mechanical Rotation Transfer Systems, Transformatio, Concepting Methods, Manufacturing Technologies, Electrical Machinery, Measurement Technology, Introduction to Turbine Machines	**Fundamental mechanical engineering courses (135P/120V):** Fundamentals of Production, Technical Drawing and Computer Aided Drawing, Fundamentals of Product Development, Machine Elements.	**Fundamental mechanical engineering courses (13 ECTS):** Systems Design, Manufacturing Technologies, Delphi Programming	**Fundamental mechanical engineering courses (21 ECTS):** Introduction to Mechanical Engineering, Machines Design, Informatics in Mechanical Engineering, Introduction to CAD

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
	Manufacturing Technologies 1, Project Management, Measurement Techniques, Design Methodology, Tribology **Specialised mechanical engineering courses – Elective specialised (32 ECTS):** Rigid Body Dynamics, Fluid Dynamics, Product Conception and Development, Energy Machines and Apparatus, Manufacturing Technologies 2, Polymer Science, Fundamentals of Mechatronics, Technical Acoustics, Internal Environment, Hydraulics and Pneumatics, Production Engineering, Laser Systems	**Specialised mechanical engineering courses (0 ECTS):**	**Specialised mechanical engineering courses (540 hours):** Dependant on the Selection of Module (29 Available Modules): for example: Trains of Mechanisms, Electric Actuators, Manufacturing Technologies, Transport Technology, Tribology of Gear Pairs, Finite Elements Method, Vehicles Dynamics, Transformation, Simulation of Multimass Systems, Flow Machines CFD, Numerical Simulation of The Real Flow, Turbulent Flows, Cast, Precision Mechanics	**Specialised mechanical engineering courses (30 ECTS; minor modul with required courses to be selected):** Structures Materials, Fundamentals of Design, Design in Practice, Practical Engineering Tools, Dimensioning, Selection of Manufacturing and Assembly Processes Electricity and Magnetism, Java Programming, Physics of Fluids, Informatics-Mathlab, Solid Bodies Mechanics, Modelling Techniques, Numerical Solving of Differential Equations Materials in Art and Design, Mechanics of Materials, Joining Materials, Materials Production, Recycling Engineering Materials, Materials Performance	**Specialised mechanical engineering courses (30 ECTS; modul with required courses to be selected; 1 elective)** Measurement Technology and Quality Assurance, Manufacturing Technologies, Machine Tools, Design Methodology, Electromechanical Drives, Combustion, Thermodynamics Compounds, Development of Processes and Products in the Process Technology, Machining Non-Metallic Materials, Mechatronic Systems in Mobile Machines, Materials in Mobile Machines

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
	Laboratory and project work (0 ECTS): Included in the compulsory and elective specialised courses	**Laboratory and project work (10 ECTS):** Design projects	**Laboratory and project work (240 ur):** Practicians	**Laboratory and project work (43-54 ECTS):** Projects	**Laboratory and project work (10 ECTS):** Project work (6 weeks)
	Economic and management courses (3 ECTS): Fundamentals of quality assurance, Business economics	**Economic and management courses (ECTS):** See below	**Economic and management courses (30P ur):** Fundamentals of economics	**Economic and management courses (3 ECTS):** Business economics	**Economic and management courses (6 ECTS):** Quality, projects and human resources management, Business operations
	Humanities and social sciences, languages, physical education (0 ECTS):	**Humanities and social sciences (including economic courses), languages, physical education (12 ECTS):** Elective courses and seminars and studio work (industrial design)	**Humanities and social sciences, languages, physical education (30 hours):** Elective courses: such as Industrial design, the role of technology in the society	**Humanities and social sciences, languages, physical education (0 ECTS):**	**Humanities and social sciences, languages, physical education (3 ECTS):** Communication and organisation
	Practical work (5 ECTS): Study programme does not include compulsory practical training but the student can opt for professional training, amounting to 5 ECTS, which corresponds to a 3-week guided practical work in an industrial or research environment, resulting in a project work.	**Practical work (0 ECTS):**	**Practical work (18 weeks):** Industrial design practical training, taking 18 weeks (it includes 6 weeks of industrial practical training, required before enrolment).	**Practical work (0 ECTS):**	**Practical work (14 ECTS):** Industrial practical training (14 weeks) in the 7th semester. Before enrolment, a 6-week practical work is required. Altogether, 20 weeks.

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
	Final thesis (0 ECTS): Not applicable.	**Final thesis (0 ECTS):** Not applicable.	**Final thesis (15 weeks):** BSc work takes 1 semester (15 weeks)	**Final thesis (9 ECTS):** BSc thesis	**Final thesis (15 ECTS):** BSc work takes 10 weeks
2.2.b. Comparability of Access Opportunities and Admission Requirements					
	Year 1 University Study Programme MECHANICAL ENGINEERING – Research and Development Programme can be entered by anyone who has: A – passed the matura exam, B – passed the vocational education final exam in any of the secondary schools and the exam in one of the matura courses: Mechanics, Physics, Mathematics, Computing, Electrical Engineering or a foreign language; the selected subject must not be one of those that the candidate has taken as part of the vocational education final exam, C – completed any of the 4-year secondary school programmes. In case of restricted enrolment: candidates in items A and C will be selected on the basis of: - grade point average of the matura or final exam: 60%	Without the entrance examination: - passed the matura exam in Switzerland (type A, B, C, D, E) and new matura exams and canton matura exams, recognised by the federal authorities. -Bakalaureat from EU members states (+ states from the free trade area) with marks 70% or above in Mathematics, Physics, Chemistry and mother tongue or another modern language. With the entrance examination: - Swiss matura exam without federal recognition. Depending on the matura, it is necessary to sit for partial or full entrance examinations. - all others are required to take partial or full entrance examination.	Before enrolment, a minimum 6-week industrial practical training is required. Its duration counts towards the required 18-week practical training that should be completed before BSc graduation. A secondary school programme should be completed, together with the Abitur maturity examination. If marks of the selected subjects (Mathematics, Physics, mother tongue) as part of this exam are above the average, the student can enter the programme directly. In case the marks are lower, an interview is necessary and enrolment is allowed on its basis. Foreign students need the German language certificate. In case the secondary school final examination is not equivalent to German	An adequate secondary school final examination, which means either matura or bakalaureat. In case the secondary school final examination is not suitable (recognised), entrance examination is required. Knowing the Dutch language is also required, which is proved by passing the examination.	German citizenship and German education: passed general maturity examination Abitur or a suitable final examination Before enrolment, a 6-week practical training of pre-defined tasks and the so-called self assessment, made on-line with a special computer programme. Foreigners also need the German language certificate.

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
	of points - grade point average in third and fourth year: 40% of points. Candidates in item B will be selected on the basis of: - grade point average of vocational education final exam: 40% of points - grade point average in third and fourth year: 40% of points - result of a matura subject: 20% points.		Abitur, entrance examination is required.		
2.2.c. Comparability of the Duration of Study, Promotion, Completion of Study and Acquired Degrees					
duration of study	3 years (6 semesters)	3 years (6 semesters)	3 years (6 semesters)	3 years (6 semesters)	3.5 years (7 semesters)
promotion	A detailed description is in item 4.9. The student can enter the next year if he or she fulfils all the requirements, prescribed by the curriculum, and accumulates 60 ECTS credits. Exceptional conditions of promotion are given in item 4.9. FME currently has an established tutoring and mentoring system.	Studying is divided into the basic ("propédeutique"; 2 semesters) part and the bachelor part (4 semesters). In order to advance from Year 1 to Year 2, the "propédeutique" exam, amounting to 60 ECTS credits, should be passed with at least the average mark (»moyenne«, which means 4 on a 6-grade scale). If the mark is lower, the student must repeat the grade.	Studying is divided into two parts (basic and main): the basic one takes 4 semesters and the main one 2 semesters. Passing examinations in the basic part is divided into two blocks. The first block (five examinations from the prescribed courses) should be passed no later than in the third semester.	Promotion is fairly free in terms of examinations dates. The system allows a number of exceptions, confirmed by a relevant commission for each student.	First dates to sit for exams are proposed. An exam should be passed no later than within two months of the proposed date. Otherwise, the student loses the right to sit for the exam. If the student does not accumulate at lest 20 ECTS within two months of the proposed date, he or she should attend the so-called exam counselling.

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
completion of study:	The student completes the study when all requirements in the amount of 180 ECTS credits are fulfilled.	The student should accumulate 180 ECTS credits. It earns him/her the temporary bachelor diploma, which enables studying on EPFL's level 2 or elsewhere but no employment (it is not a vocational certificate)	The required examinations passed, industrial practical training and BSc work completed.	180 ECTS credits, including BSc work	210 ECTS credits, including practical training and BSc work
title:	Diplomirani/-a inženir/-ka strojništva (UN), abbreviated to dipl. inž.str. (UN), which corresponds to the BSc (Bachelor of Science) degree	The student acquires the so-called temporary Bachelor diploma (Bachelor-Zwischendiplom), but not a professional title.	Bachelor of Science (also Bachelor of Science TUM)	Bachelor of Science	Bachelor of Science RWTH Aachen University
2.2.d Comparability of Types and Methods of Study					
methods of study:	full-time and part-time study	full-time study	full-time study	full-time study	full-time study
forms of study:	lectures, seminars, laboratory work, project work, examinations	lectures, seminars, laboratory work, project work, examinations	lectures, seminars, laboratory work, project work, apprenticeships, industrial practical training, examinations	lectures, seminars, laboratory work, project work, examinations	lectures, seminars, laboratory work, project work, apprenticeships, industrial practical training, examinations
share of optionality:	Total optionality within the programme: 44 ECTS (24,4•%), out of which elective specialised courses: 32 ECTS (17,7•%) and elective general courses: 12 ECTS (6,6•%)	34 ECTS (19%); it includes different forms of project work. Out of the elective specialised courses, the 6th semester student can pick up courses with the aggregate value of 12 ECTS. They can either belong exclusively to the Engineering sciences group, exclusively to the	(30%): the student picks up a module (from the range of 29 modules), amounting to 660 hours. Courses within the module are compulsory and elective from the offered range. Supposing that the choice of a module makes the courses within the module elective, too, the share of optionality is	30 ECTS (17%); with a minor-modul, the student picks up courses with the aggregate value of 30 ECTS. Courses within the module are compulsory. All courses within the module are specialised mechanical engineering programmes.	30 ECTS (14%); with a module (from the range of 7 modules), the student picks up courses, amounting to 30 ECTS. Subjects within the module are compulsory, 1 is elective. The module is elective, while out of the courses within the module (the module's courses are

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
		Fundamental mechanical engineering courses group or both. Other elective activities are from the humanities, social and economic sciences group and from the profession, in the form of project work.	around 30%. A module consists of courses (around 65%), ranging from engineering sciences (such as the Numerical simulations module) to specialised mechanical engineering courses (such as the Manufacturing technologies module). 30% of the module consist of apprenticeship. 5% of hours are elective activities from Humanities and social sciences.		from the specialised mechanical engineering group) only one has a share of 20% (this one also belongs to the specialised mechanical engineering group). With a share of 60% (18 ECTS engineering sciences courses), the air transport module is an exception.
ECTS number:	180 ECTS	180 ECTS	The programme has no ECTS	180 ECTS	210 ECTS
status of programme:	proposed programme	introduced in the 2003/2004 academic year	introduced in the 2005/2006 academic year and updated in 2008/2009	introduced in the 2005/2006 academic year	introduced in the 2007/2008 academic year
2.2.e. Opportunities for Including the Programme in International Partnership (Mobility) and Common European Higher Education Area					
	The programme is presented in Slovenian language. Parts of lectures and exercises are given in English. Courses are assessed with ECTS credits, which facilitates international exchange and serves as a basis for attending part of the study abroad, within programmes, such as Erasmus-Socrates and other student exchange programmes.	The program is presented mostly in the French language (some courses are available also in German). Second and third year courses are assessed with ECTS credits, which facilitates international exchange and serves as a basis for attending part of the study abroad.	The programme is presented in the German language. Courses are not assessed with ECTS credits, which makes international exchange more difficult. However, the faculty has concluded bilateral agreements with European universities to take part in the student exchange programmes.	The programme is presented in the Dutch language. Courses are assessed with ECTS credits, which facilitates international exchange and serves as a basis for attending part of the study abroad.	The programme is presented in the German language. Courses are assessed with Leistungspunkte points, which correspond to ECTS credits. It facilitates international exchange and serves as a basis for attending part of the study abroad.

	UL FME (Ljubljana)	EPFL (Lausanne)	TUM (München)	TU Delft (Delft)	RWTH (Aachen)
2.2.f. Substantiation of Differences Between the Proposed and Foreign Programmes in Terms of Specific National Needs					
	The study programme is comparable with the compared foreign programmes. Along with the comparable extent of fundamental compulsory courses, the emphasis is on a large volume of fundamental specialised courses as a result of a specific situation in Slovenia, which requires wide knowledge of different engineering fields. Optionality is very extensive and covers basic principles of the Bologna reform. Comparing the programmes, differences in the contents, work methods and conditions for promotion to the next year and completion of study are not substantial.	A characteristic feature of the EPFL programme is a substantial extent of theoretical fundamental courses while the extent of specialised mechanical engineering subjects is small. The programme does not end with a diploma work and industrial practical training is also not necessary.	In terms of contents, the programme is similar to other compared programmes but it has not been officially verified as a reformed Bologna programme. An 18-week practical training and a diploma work are part of the programme.	The key feature of the TU Delft programme is a substantial volume of project work, amounting to over 40 ECTS. The system allows a number of exceptions, confirmed by a relevant commission for each student. The programme ends with a diploma work; practical training is not planned.	The programme takes 7 semesters to complete and it amounts to 210 ECTS. It is very similar to the proposed programme. This programme includes 6-week practical training and a 10-week period for the completion of the diploma work.
2.2.g. Compliance with EU Regulations for Regulated Professions					
	This programme does not educate for a regulated profession.	This programme does not educate for a regulated profession.	This programme does not educate for a regulated profession.	This programme does not educate for a regulated profession.	This programme does not educate for a regulated job.

2.2.a Comparability of the Concept and Formal and Contents Structure

The compared programmes are Level 1 mechanical engineering programmes. They are in line with European higher education guidelines and they follow the Bologna declaration. The programmes include contemporary mechanical engineering topics. The presented and compared programmes of the selected universities are 3-year (6-semester) programmes, amounting to 180 credits (ECTS), with the exception of RWTH Aachen, whose 3.5-year (7-semester) programme amounts to 210 ECTS.

The presented programmes are characterised by their division into homogeneous groups:

- Fundamental sciences
- Engineering sciences
- Fundamental mechanical engineering courses
- Specialised mechanical engineering courses
- Economic and management courses
- Humanities and social sciences, languages, physical education
- Practical work
- Final thesis

In all programmes, fundamental sciences, engineering sciences and fundamental mechanical engineering courses prevail in the first four semesters, which are followed by specialised and elective courses in the fifth and sixth semester.

Differences between the topics of fundamental and engineering sciences are almost non-existent but they appear in specialised mechanical engineering topics, whose selection is wider at TUM, TU Delft and RWTH universities. We believe that this is so due to the number of students and characteristic features of Slovenian economic area.

2.2.b Comparability of Access Opportunities and Admission Requirements

All direct admission programmes (i.e. without the entrance examinations) require completed secondary school and national matura examination while the German universities' programmes also require a 6-week industrial practical training. Foreign prospective students of the presented foreign programmes need a certificate of the national language of the university concerned and the matura should be recognised by the university which the candidate is entering. In all other cases, the entrance examination is required.

2.2.c Comparability of the Duration of Study, Promotion, Completion of Study and Acquired Titles

The presented programmes take three years (6 semesters, except RWTH, which takes 7 semesters). All programmes are based on continuous studying, where most of the requirements of one year should be fulfilled before advancing to the next year. The only exception is TU Delft, where promotion largely depends on the promotion commission's decision in case of derogation from formal conditions.

All programmes lead to the BSc (Bachelor of Science) title or another equivalent title, in accordance with national legislations. There is a difference in the case of EPFL, where students are granted a document that enables them to pursue studying on Level 2 but it is not a vocational certificate.

2.2.d Comparability of Methods and Forms of Study

The compared programmes are full-time programmes, requiring 180 ECTS credits to complete (the only exception is RWTH, requiring 210 ECTS, accumulated over a 3.5-year period).

The proposed Faculty's programme is comparable with the compared programmes in its methods and forms. The educational process consists of traditional lectures, seminars, practical work, seminar and laboratory exercises and project work. The teaching methods proportions of the proposed programme are somewhere between the respective EPFL's and RWTH's proportions, where there is a little less project work, and TU Delft with the biggest volume of this work.

The programmes reveal different shares of optionality. With 24.5%, this share is fairly high in the proposed programme. Out of this number, the share of elective specialised courses is 17.8% and the share of elective general courses is 6.7%.

2.2.e Opportunities for Including the Programme in International Partnership (Mobility) and Common European Higher Education Area

The analysed programmes predict co-operation and exchanges as part of Socrates/Erasmus programmes and bilateral agreements between universities. Similar international co-operation is also predicted by the submitted programme as it is based on ECTS credit system and is comparable to similar European programmes. Within the Socrates/Erasmus programme, students and teachers exchange with several European universities has already been introduced.

The fact that the proposed programme is taught in Slovene, should not make student exchange more difficult because most courses envisage foreign languages literature while practical work should not be hindered by the language. Besides, the proposed programme envisages the possibility for some courses to be presented in English and consultations with heads of the courses be done in English. Other presented undergraduate programmes are also taught in national languages and allow the possibility for some courses to be carried out in other languages.

2.2.f Differences Between the Proposed and Foreign Programmes in Terms of Specific Needs and Requirements of National Economy and Public Services

A difference arises in the area of mechanical engineering topics in specialised course groups, where there are less different topics, compared to large universities (EPFL, TUM, TU Delft and RWTH), and they are nationally conditioned, or in other words, depend on the diversity of economic operators' areas of action.

Along with a comparable extent of fundamental compulsory courses, the emphasis of the proposed Level 1 University Study Programme MECHANICAL ENGINEERING – Research and Development Programme is on a great extent of fundamental specialised courses as a result of a specific situation in Slovenia, which requires wide knowledge of different engineering fields. However, optionality is very extensive and covers basic principles of the Bologna reform.

2.3. Curriculum with Credit Assessment of Study Requirements

The curriculum consists of four course sets, named and acronymed as follows:

- compulsory general courses (CGC)
- compulsory specialised courses (CSC)
- elective specialised courses (ESC)
- elective general courses (EGC)

Compulsory general courses (**CGC**) include fundamental mathematics, physics, mathematical and numerical modelling knowledge. CGC courses represent 23.8% of the study programme.

Compulsory specialised courses (**CSC**) provide students with fundamental mechanical engineering knowledge. CSC courses represent 51.6% of the study programme.

Elective specialised courses (**ESC**) allow students to acquire detailed knowledge from narrowly specialised areas of the study programme and to focus on areas of their personal interests. The optionality system allows students to either narrowly specialise or remain in the domain of a well-versed mechanical engineer. ESC courses represent 17.7% of the study programme.

Elective general courses (**EGC**) include topics from other study programmes, picked up by students according to their preferences, at any faculty or university. EGC courses represent 6.6% of the study programme. With a view to directing the professional profile of an optimum quality graduate of the Level 1 University Study Programme, the Faculty suggests, but does not condition, topics, included in the 1-S, 2-S and 3-S groups. The topics, usually appearing in the form of special knowledge, either technical (civil engineering, biological engineering, informatics...) or non-technical (pedagogy, languages, management, modern design,...), widen the horizons of engineering skills and complement the graduate's competencies. Through elective choice of specialised training, the graduate can directly verify the acquired competencies in an industrial or research environment.

2.3.a Type and Share of Learning Units in Terms of Their Inclusion in the Programme Structure

Level 1 University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** is a 3-year programme, with study requirements amounting to 180 ECTS credits: 60 credits in each year or 30 credits in each semester. Out of the total number of credits, 136 credits (75.5%) are from the compulsory part of the programme (CGC: 43 ECTS or 23.8%; CSC: 93 ECTS or 51.6%) and 44 credits (24.4%) from the elective part of the programme (ESC: 32 ECTS or 17.7%; EGC: 12 ECTS or 6.6%). The programme does not include the diploma work. Students acquire part of specific experiences in laboratory units as part of their regular learning time.

The study programme does not include compulsory practical training but the student can opt for professional training, amounting to 5 ECTS, which corresponds to a 3-week guided practical work in an industrial or research environment, resulting in a project work.

In line with the Bologna reform, the curriculum includes all elements that provide the student with adequate fundamental knowledge and broadness. With marked optionality, it allows profiling these skills according to the will and interests of an individual student. Level 1 programme includes neither branches nor modules, however, the student has every opportunity for narrow professional specialisation if he or she so wishes. Within the 12 ECTS credits for elective general courses, the student chooses freely among study programmes from any faculty or university. The curriculum break down to course sets (CGC, CSC, ESC and

EGC) is shown in Table 2.3.1. Advice to students on choosing elective general courses is provided by their tutors.

Carrying out the submitted programme, we will closely follow the principle of students understanding mechanical engineering as a science. During the self-evaluation process, we will supervise the programme continuously and complete it, if necessary.

Table 2.3.1: Course Sets of the Programme

Compulsory general (CGC)	**ECTS**	**%**	**Compulsory specialised (CSC)**	**ECTS**	**%**	**Elective specialised (ESC)**	**ECTS**	**%**	**Elective general (EGC)**	**ECTS**	**%**
Mathematics 1	9	5.0	Statics and Kinematics	6	3.3	**Elective *course 1***	7	3.8	**Elective *course 01***	4	2.2
Mathematics 2	8	4.4	Descriptive Geometry and Technical Documentation	7	3.8	Rigid Body Dynamics			Free choice and/or 1-S group		
Physics	8	4.4	Energy and Environment	4	2.2	Fluid Dynamics			**Option 1-S:** *Chemistry, Electrical Engineering,*		
Mathematics 3	6	3.3	Strength of Materials	6	3.3	**Elective *courses 2 and 3***	10	5.5	*Pedagogy, Didactics, Psychology,*		
Numerical methods	5	2.7	Engineering Materials 1	3	1.6	Product Design and Development			*Human Physiology, Protection of the Environment*		
Numerical Modelling Methods	7	3.8	Space Modelling and Representation	5	2.7	Power Engineering			*Mechanical Engineering in Wood Processing, Agricultural Technology …*		
			Thermodynamics	8	4.4	Manufacturing Technologies 2			**Elective *course 02***	3	1.6
			Engineering Materials 2	5	2.7	Polymer Science			Free choice and/or 2-S group		
			Machine Elements 1	6	3.3	**Elective *Course 4***	5	2.7	**Option 2-S:** *Fundamentals of Quality*		
			Fluid Mechanics	7	3.8	Fundamentals of Mechatronics			*Enterprise Economics, Foreign Language*		
			Heat Transfer	6	3.3	Technical Acoustics			*Development and Marketing of New Products*		
			Machine Elements 2	6	3.3	**Elective *courses 5 and 6***	10	5.5	*Engineering communication*		
			Manufacturing Technologies 1	5	2.7	Internal Environment			*Traffic and Traffic Installations, …*		
			Project Management	3	1.6	Hydraulics and Pneumatics			**Elective *course 03***	5	2.7
			Measurement Techniques	6	3.3	Production Engineering			Free choice and/or 3-S group		
			Design Methodology	5	2.7	Laser Systems			**Option 3-S:** *Practical Training*		
			Tribology	5	2.7				*Teaching and Learning Psychology*		
									Medical Physics, Management ...		

Number of courses in the set	**6**	**17**	**6(12)**[1]	**3**[2]
ECTS number in the set	**43**	**93**	**32**	**12**
Proportion of the course set in the programme [%]	**23.8**•	**51.6**•	**17.7**•	**6.6**•

[1] The course set **Elective specialised courses** includes a numerically defined set of 12 courses and the student picks up 6 of them, amounting to 32 ECTS
For a more detailed understanding of the selection process, see Year 3 curriculum in Table 4.5.5.

[2] Within the course set **Elective general courses** the student picks up 3 courses, amounting to 12 ECTS, from any programme and any faculty or university.

2.3.b Curriculum

YEAR 1	Course set	Contact lessons						
		L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
1st semester								
Mathematics 1	CGC	45		45	90	135	225	9
Statics and Kinematics	CSC	45		30	75	75	150	6
Descriptive Geometry and Tech. Documentation	CSC	45		45	90	85	175	7
Energy and Environment	CSC	45		15	60	40	100	4
Elective course 01 [1]	EGC						100	4
1st semester total		**180** [1+]		**135** [1+]	**315** [1+]	**335** [1+]	**750**	**30**
2nd semester								
Mathematics 2	CGC	45		45	90	110	200	8
Physics	CGC	60		45	105	95	200	8
Strength of Materials	CSC	45		30	75	75	150	6
Engineering Materials 1	CSC	30		15	45	30	75	3
Space Modelling and Representation	CSC	30		30	60	65	125	5
2nd semester total		**210**		**165**	**375**	**375**	**750**	**30**
1st and 2nd semester total		**390** [1+]		**300** [1+]	**690** [1+]	**710** [1+]	**1500**	**60**

[1] Elective course 01, 4 ECTS in total, is chosen by the student according to his or her preferences from the course set **Elective general courses**, from any programme, any faculty or university.

[1+] Total hours, excluding hours from the **Elective general courses** course set.

YEAR 2	Course set	Contact lessons						
		L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
3rd semester								
Mathematics 3	CGC	45		30	75	75	150	6
Thermodynamics	CSC	60		30	90	110	200	8
Engineering Materials 2	CSC	45		30	75	50	125	5
Machine Elements 1	CSC	45		30	75	75	150	6
Numerical methods	CGC	30		30	60	65	125	5
3rd semester total		**225**		**150**	**375**	**375**	**750**	**30**
4th semester								
Fluid Mechanics	CSC	60		30	90	85	175	7
Heat Transfer	CSC	45		30	75	75	150	6
Machine Elements 2	CSC	45		30	75	75	150	6
Manufacturing Technologies 1	CSC	45		15	60	65	125	5
Project management	CSC	30		15	45	30	75	3
Elective course 02 [2]	EGC						75	3
4th semester total		**225** [2+]		**120** [2+]	**345** [2+]	**330** [2+]	**750**	**30**
3rd and 4th semester total		**450** [2+]		**270** [2+]	**720** [2+]	**705** [2+]	**1500**	**60**

[2] Elective course 02, 3 ECTS in total, is chosen by the student according to his or her preferences from the course set **Elective general courses**, from any programme, any faculty or university.

[2+] Total hours, excluding hours from the **Elective general courses** course set.

L - lectures
S - seminar
W - laboratory work
CL - contact lessons
SW - hours of student's personal work
WR - total work required

* student workload amounts to 60 ECTS/year, which corresponds to 1500 hours/year (ΣWR); hours include contact lessons (ΣCL) and student's personal work (ΣSW).

YEAR 3	Course set	Contact lessons L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
5th semester								
Numerical Modelling Methods	CGC	45		30	75	100	175	7
Measurement Techniques	CSC	45		30	75	75	150	6
Elective course 1 [4]	ESC	45		30	75	100	175	7
Elective course 2 [4]	ESC	30		30	60	65	125	5
Elective course 3 [4]	ESC	30		30	60	65	125	5
5th semester total		**195**		**150**	**345**	**405**	**750**	**30**
6th semester								
Design Methodology	CSC	30		30	60	65	125	5
Tribology	CSC	30		30	60	65	125	5
Elective course 4 [4]	ESC	30		30	60	65	125	5
Elective course 5 [4]	ESC	30		30	60	65	125	5
Elective course 6 [4]	ESC	30		30	60	65	125	5
Elective course 03 [3]	EGC						125	5
6th semester total		**150** [3+]		**150** [3+]	**300** [3+]	**325** [3+]	**750**	**30**
5th and 6th semester total		**345** [3+]		**300** [3+]	**645** [3+]	**730** [3+]	**1500**	**60**

[3] Elective course 03, 5 ECTS in total, is chosen by the student according to his or her preferences from the course set **Elective general courses**, from any programme, any faculty or university.

[3+] Total hours, excluding hours from the **Elective general courses** course set.

[4] The student chooses courses 1-6 from the course set **Elective specialised courses**, 32 ECTS in total, according to the following formula:

Elective course 1 from range 3-A
Elective courses 2 and 3 from range 3-B
Elective course 4 from range 3-C
Elective courses 5 and 6 from range 3-D

L - lectures
S - seminar
W - laboratory work
CL - contact lessons
SW - hours of student's personal work
WR - total work required

* student workload amounts to 60 ECTS/year, which corresponds to 1500 hours/year (ΣWR); hours include contact lessons (ΣCL) and student's personal work (ΣSW).

Elective specialised courses		Range	Contact lessons L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
24	Rigid Body Dynamics	3-A	45		30	75	100	175	7
25	Fluid Dynamics	3-A	45		30	75	100	175	7
26	Product Design and Development	3-B	30		30	60	65	125	5
27	Energy Machines and Apparatus	3-B	30		30	60	65	125	5
28	Manufacturing Technologies 2	3-B	30		30	60	65	125	5
29	Polymer Science	3-B	30		30	60	65	125	5
30	Fundamentals of Mechatronics	3-C	30		30	60	65	125	5
31	Technical Acoustics	3-C	30		30	60	65	125	5
32	Internal Environment	3-D	30		30	60	65	125	5
33	Hydraulics and Pneumatics	3-D	30		30	60	65	125	5
34	Production Engineering	3-D	30		30	60	65	125	5
35	Laser Systems	3-D	30		30	60	65	125	5

Elective general courses, offered by UL FME		Range	Contact lessons L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
36	Electrical Engineering	1-S	30		15	45	55	100	4
37	Chemistry	1-S	30		15	45	55	100	4
38	Fundamentals of Quality	2-S	30		0	30	45	75	3
39	Enterprise Economics	2-S	30		0	30	45	75	3
40	Practical Training	3-S	0		0	0	125	125	5

LEVEL 1 UNIVERSITY STUDY PROGRAMME
MECHANICAL ENGINEERING
RESEARCH AND DEVELOPMENT PROGRAMME
UNIVERSITY OF LJUBLJANA, FACULTY OF MECHANICAL ENGINEERING
Study Programme Presentation

1. Study Programme Details

Title :

Level 1 University Study Programme

MECHANICAL ENGINEERING – Research and Development Programme

Duration:

3 years

Number of ECTS:

180

Graduate's professional degree:

Diplomirani/-a inženir/-ka strojništva (UN)

(Bachelor of Science in Mechanical Engineering)

abbreviated to **dipl.inž.str. (UN)**

2. The Fundamental Programme Objectives and General Competences

- To provide graduates with quality knowledge, based on solid fundamental skills and understanding a wide range of mechanical engineering topics, thus providing the graduates with adequate competences for employment in case they decide to terminate the studies. Should they decide to pursue further studies, the acquired knowledge is an adequate basis for studying on the postgraduate research level.
- To develop critical judgement and synthesis abilities and to exercise professional responsibility.
- With the acquired knowledge from a wide range of engineering topics, comparable with similar study programmes in Europe, the graduate will be capable of linking up different interdisciplinary fields.

3. Admission Requirements and Selection Criteria in Case of Restricted Enrolment

Level 1 University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** can be entered by anyone who has:

A passed the matura exam,

B passed the vocational education final exam in any of the secondary schools and the exam in one of the matura subjects: Mechanics, Physics, Mathematics, Computing, Electrical Engineering or Foreign Language; the selected subject must not be one of those that the candidate has taken as part of the vocational education final exam,

C completed any of the 4-year secondary school programmes before June 1, 1995

Number of places available: 300.

In case of restricted enrolment:
Candidates from items A and C will be selected on the basis of

- grade point average of matura or final exam and 60% of points,
- grade point average in third and fourth year 40% of points;

Candidates from item B will be selected on the basis of

- grade point average of vocational education final exam, 40% of points
- grade point average in third and fourth year and 40% of points
- result of a matura subject 20% of points

4. Provisions, Relating to the Use and Embodiment of Criteria for Recognition of the Knowledge and Skills, Acquired Before Programme Enrolment

It is possible to recognise student's knowledge and skills, corresponding to the **MECHANICAL ENGINEERING – Research and Development Programme** syllabus. Recognition of the knowledge and skills, acquired before enrolment, is confirmed or rejected by Faculty's University Study Commission, after the student has filed an application, supported by written certificates and other documents, confirming the acquired knowledge and its contents, and in accordance with the rules on procedures and criteria for recognising informally acquired knowledge and skills, approved by the University of Ljubljana's Senate on May 29, 2007. In case the University Study Commission establishes that the acquired knowledge can be recognised, it can be valued with the same number of ECTS credits, otherwise accumulated during the regular course.

5. Conditions for Promotion

5.1 Study Requirements and Conditions for Promotion from One Year to Another

Students can enter the next year when they have fulfilled all the requirements, prescribed by the syllabus of the current year, and have accumulated 60 ECTS credits.

In exceptional circumstances, a student can enter the next year without fulfilling all requirements, prescribed by the syllabus of the particular year of study but should have clear reasons, set out in Article 153 of the University of Ljubljana Statute (motherhood, a long disease, exceptional family and social circumstances, a recognised person with special needs, active participation in top professional, cultural and sports events, active participation in the university bodies) or reasons as a result of concurrent studying, migration from one university to another, language difficulties (foreign students), extra workload due to international exchange, or increased amount of work as part of extra development and research work. In the application, the student should state cogent reasons for unfulfilled requirements and submit a time plan for taking the missing examinations for the previous term. Whether or not the reasons are plausible is decided by a special commission that includes the vice dean for educational affairs of the study programme **MECHANICAL ENGINEERING – Research and Development Programme**, the mentor of the student's current year and the mentor of the year that the student wishes to enter.

The Faculty of Mechanical Engineering has an established tutoring and mentoring system. It is in our plans to offer the same assistance also within the new Undergraduate University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme**, which has been harmonised with item 9 of Article 7 of the Accreditation Rules. Students will have their mentors from as early as Year 1 onwards. Small groups of students will also have their own tutors, coming from the teaching staff. They will help students choose among the specialised branches of study, elective courses and similar.

The student who has shown exceptional study results shall be given the option to speed up his or her promotion. The decision shall be adopted by the Faculty Senate upon the candidate's application and opinion of the University Study Commission. The decision shall provide for the details of the accelerated promotion.

5.2 Conditions for Repetition of a Year

Students who have not fulfilled all requirements, prescribed by the syllabus, to enter the next year, can repeat the year if they have accumulated at least 30 ECTS credits. During the study period, a student can repeat a year only once.

In exceptional circumstances, a student can enter the next year without fulfilling all requirements, prescribed by the syllabus of the particular year of study but should have clear reasons, set out in Article 153 of the University of Ljubljana Statute (motherhood, a long disease, exceptional family and social circumstances, a recognised person with special needs, active participation in top professional, cultural and sports events, active participation in the university bodies) or reasons as a result of concurrent studying, migration from one university to another, language difficulties (foreign students), extra workload due to international exchange, or increased amount of work as part of extra development and research work. In the application, the student should state cogent reasons for unfulfilled requirements and submit a time plan for taking the missing examinations for the previous term. Whether or not the reasons are plausible is decided by a special commission that includes the vice dean for educational affairs of the study programme **MECHANICAL ENGINEERING – Research and Development Programme**, the mentor of the student's current year and the mentor of the year that the student wishes to enter.

6. Conditions for Completion of Study

A student completes the study when he or she fulfils all requirements, prescribed by the syllabus, amounting to 180 ECTS credits.

7. Migrations Over Study Programmes

a) General
Migration shall mean termination of student's original study programme and continuing studying under the new study programme **MECHANICAL ENGINEERING – Research and Development Programme**, where all or part of the requirements, fulfilled within the original programme, are recognised as fulfilled requirements of the programme **MECHANICAL ENGINEERING – Research and Development Programme** (Migration over study programmes criteria – Official journal of RS no. 45/94).

An examination, passed under the original study programme is considered passed in the new study programme if the syllabuses of the two courses overlap by at least 75%. In terms of credit evaluation of a year (60 credits), a recognised examination is valued at the same number of credits as the original study programme but not more than the value of the new Level 1 study programme **MECHANICAL ENGINEERING – Research and Development Programme**.

Changing a study programme or branch due to unfulfilled requirements of the previous study programme or branch is not considered migration in the sense of the paragraph above.

The following migrations are anticipated within the University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme**.

- from similar Level 1, technical sciences university study programmes
- from university study programmes from the field of mechanical engineering and similar technical sciences, adopted after 1995,
- from higher education study programmes from the field of mechanical engineering, adopted before 1995.

In compliance with the rules on assessment and marking the knowledge at the Faculty, the Faculty's University Study Commission can impose a student additional requirements (differential examinations) and the deadline when the requirements are to be fulfilled.

In this case, the Faculty's University Study Commission can recognise some of the examinations that the student has passed under the original study programme and are not scheduled under the new study programme **MECHANICAL ENGINEERING – Research and Development Programme,** on account of optionality outside the Faculty. If a student is coming to the University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** from reformed higher education programmes at and outside the University of Ljubljana, the University Study Commission can recognise also some of the student's examinations from the previous programme on account of optionality outside the Faculty.

A student can enter Year 2 or 3 of the reformed University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** if:
- he or she meets the conditions for entering the study programme
- there are places available and
- he or she has fulfilled study requirements of the preceding year under the original programme

b) Entering Year 2
A student can enter Year 2 of the new mechanical engineering university study programme if the syllabus of Year 1 of the new University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** does not vary by more than 30 credits from the syllabus of the first year of the original study programme. However, the University Study Commission can impose a student additional requirements (differential examinations) of up to 20 credits, which are to be fulfilled before entering Year 3.

b) Entering Year 3
A student can enter Year 3 of the new University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** if the syllabus of Years 1 and 2 of the new University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** does not vary by more than 45 credits from the syllabus of the first and second year of the original study programme. However, the University Study Commission can impose a student additional requirements (differential examinations) of up to 30 credits, which are to be fulfilled before beginning a new study.

8. Assessment

Students' attainment during the courses is graded at the end of the learning period when their attainment and performance are assessed. Examination methods are defined in the courses' syllabuses. General examination rules are covered by the Examination and assessment rules for the students of the UL FME, confirmed by the Faculty Senate, the details of which are set out in the Study rules.

The form of the examination mark is set out in the Examination and assessment rules for the students of the Faculty in accordance with the course structure, defined by the study programme.

In compliance with the University of Ljubljana statute, the following grading scale is used:
- 10 - (91-100%; excellent; outstanding performance with minor errors),
- 9 - (81-90%; very good; above the average standard but with some errors),
- 8 - (71-80%; very good; generally good work),
- 7 - (61-70%; satisfactory; fair but with significant shortcomings),
- 6 - (51-60%; sufficient; passable performance, meeting the minimum criteria),
- 5 to 1 - (50% and less; insufficient, the performance does not meet the minimum criteria).

A candidate passes the assessment of knowledge if he or she gets one of the grades between sufficient (6) and excellent (10).

9. Curriculum with Credit Assessment of Study Requirements

The curriculum consists of four course sets, named and acronymed as follows:

- compulsory general courses (CGC)
- compulsory specialised courses (CSC)
- elective specialised courses (ESC)
- elective general courses (EGC)

Compulsory general courses (**CGC**) include fundamental mathematics, physics, mathematical and numerical modelling knowledge. CGC courses represent 23.8% of the study programme.

Compulsory specialised courses (**CSC**) provide students with fundamental mechanical engineering knowledge. CSC courses represent 51.6% of the study programme.

Elective specialised courses (**ESC**) allow students to acquire detailed knowledge from narrowly specialised areas of the study programme and to focus on areas of their personal interests. The optionality system allows students to either narrowly specialise or remain in the domain of a well-versed mechanical engineer. ESC courses represent 17.7% of the study programme.

Elective general courses (**EGC**) include topics from other study programmes, picked up by students according to their preferences, at any faculty or university. EGC courses represent 6.6% of the study programme. With a view to directing the professional profile of an optimum quality graduate of the Level 1 University Study Programme, the Faculty suggests, but does not condition, topics, included in the 1-S, 2-S and 3-S groups. The topics, usually appearing in the form of special knowledge, either technical (civil engineering, biological engineering, informatics...) or non-technical (pedagogy, languages, management, modern design,...), widen the horizons of engineering skills and complement the graduate's competencies. Through elective choice of specialised training, the graduate can directly verify the acquired competencies in an industrial or research environment.

9.1 Type and Share of Learning Units in Terms of Their Inclusion in the Programme Structure

Level 1 University Study Programme **MECHANICAL ENGINEERING – Research and Development Programme** is a 3-year programme, with study requirements amounting to 180 ECTS credits: 60 credits in each year or 30 credits in each semester. Out of the total number of credits, 136 credits (75.5%) are from the compulsory part of the programme (CGC: 43 ECTS or 23.8%; CSC: 93 ECTS or 51.6%) and 44 credits (24.4%) from the elective part of the programme (ESC: 32 ECTS or 17.7%; EGC: 12 ECTS or 6.6%). The programme does not include the diploma work. Students acquire part of specific experiences in laboratory units as part of their regular learning time.

The study programme does not include compulsory practical training but the student can opt for professional training, amounting to 5 ECTS, which corresponds to a 3-week guided practical work in an industrial or research environment, resulting in a project work.

In line with the Bologna reform, the curriculum includes all elements that provide the student with adequate fundamental knowledge and broadness. With marked optionality, it allows profiling these skills according to the will and interests of an individual student. Level 1 programme includes neither branches nor modules, however, the student has every opportunity for narrow professional specialisation if he or she so wishes. Within the 12 ECTS credits for elective general courses, the student chooses freely among study programmes from any faculty or university. Advice to students on choosing elective general courses is provided by their tutors.

9.2 Curriculum

YEAR 1	Course set	Contact lessons						
		L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
1st semester								
Mathematics 1	CGC	45		45	90	135	225	9
Statics and Kinematics	CSC	45		30	75	75	150	6
Descriptive Geometry and Tech. Documentation	CSC	45		45	90	85	175	7
Energy and Environment	CSC	45		15	60	40	100	4
Elective course 01 [1]	EGC						100	4
1st semester total		**180** [1+]		**135** [1+]	**315** [1+]	**335** [1+]	**750**	**30**
2nd semester								
Mathematics 2	CGC	45		45	90	110	200	8
Physics	CGC	60		45	105	95	200	8
Strength of Materials	CSC	45		30	75	75	150	6
Engineering Materials 1	CSC	30		15	45	30	75	3
Space Modelling and Representation	CSC	30		30	60	65	125	5
2nd semester total		**210**		**165**	**375**	**375**	**750**	**30**
1st and 2nd semester total		**390** [1+]		**300** [1+]	**690** [1+]	**710** [1+]	**1500**	**60**

[1] Elective course 01, 4 ECTS in total, is chosen by the student according to his or her preferences from the course set **Elective general courses**, from any programme, any faculty or university.

[1+] Total hours, excluding hours from the **Elective general courses** course set.

YEAR 2	Course set	Contact lessons						
		L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
3rd semester								
Mathematics 3	CGC	45		30	75	75	150	6
Thermodynamics	CSC	60		30	90	110	200	8
Engineering Materials 2	CSC	45		30	75	50	125	5
Machine Elements 1	CSC	45		30	75	75	150	6
Numerical methods	CGC	30		30	60	65	125	5
3rd semester total		**225**		**150**	**375**	**375**	**750**	**30**
4th semester								
Fluid Mechanics	CSC	60		30	90	85	175	7
Heat Transfer	CSC	45		30	75	75	150	6
Machine Elements 2	CSC	45		30	75	75	150	6
Manufacturing Technologies 1	CSC	45		15	60	65	125	5
Project management	CSC	30		15	45	30	75	3
Elective course 02 [2]	EGC						75	3
4th semester total		**225** [2+]		**120** [2+]	**345** [2+]	**330** [2+]	**750**	**30**
3rd and 4th semester total		**450** [2+]		**270** [2+]	**720** [2+]	**705** [2+]	**1500**	**60**

[2] Elective course 02, 3 ECTS in total, is chosen by the student according to his or her preferences from the course set **Elective general courses**, from any programme, any faculty or university.

[2+] Total hours, excluding hours from the **Elective general courses** course set.

L - lectures
S - seminar
W - laboratory work
CL - contact lessons
SW - hours of student's personal work
WR - total work required

* student workload amounts to 60 ECTS/year, which corresponds to 1500 hours/year (ΣWR); hours include contact lessons (ΣCL) and student's personal work (ΣSW).

YEAR 3	Course set	Contact lessons L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
5th semester								
Numerical Modelling Methods	CGC	45		30	75	100	175	7
Measurement Techniques	CSC	45		30	75	75	150	6
Elective course 1 [4]	ESC	45		30	75	100	175	7
Elective course 2 [4]	ESC	30		30	60	65	125	5
Elective course 3 [4]	ESC	30		30	60	65	125	5
5th semester total		**195**		**150**	**345**	**405**	**750**	**30**
6th semester								
Design Methodology	CSC	30		30	60	65	125	5
Tribology	CSC	30		30	60	65	125	5
Elective course 4 [4]	ESC	30		30	60	65	125	5
Elective course 5 [4]	ESC	30		30	60	65	125	5
Elective course 6 [4]	ESC	30		30	60	65	125	5
Elective course 03 [3]	EGC						125	5
6th semester total		**150** [3+]		**150** [3+]	**300** [3+]	**325** [3+]	**750**	**30**
5th and 6th semester total		**345** [3+]		**300** [3+]	**645** [3+]	**730** [3+]	**1500**	**60**

[3] Elective course 03, 5 ECTS in total, is chosen by the student according to his or her preferences from the course set **Elective general courses**, from any programme, any faculty or university.

[3+] Total hours, excluding hours from the **Elective general courses** course set.

[4] The student chooses courses 1-6 from the course set **Elective specialised courses**, 32 ECTS in total, according to the following formula:

Elective course 1 from range 3-A
Elective courses 2 and 3 from range 3-B
Elective course 4 from range 3-C
Elective courses 5 and 6 from range 3-D

L - lectures
S - seminar
W - laboratory work
CL - contact lessons
SW - hours of student's personal work
WR - total work required

* student workload amounts to 60 ECTS/year, which corresponds to 1500 hours/year (ΣWR); hours include contact lessons (ΣCL) and student's personal work (ΣSW).

Elective specialised courses		Contact lessons Range	L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
24	Rigid Body Dynamics	3-A	45		30	75	100	175	7
25	Fluid Dynamics	3-A	45		30	75	100	175	7
26	Product Design and Development	3-B	30		30	60	65	125	5
27	Energy Machines and Apparatus	3-B	30		30	60	65	125	5
28	Manufacturing Technologies 2	3-B	30		30	60	65	125	5
29	Polymer Science	3-B	30		30	60	65	125	5
30	Fundamentals of Mechatronics	3-C	30		30	60	65	125	5
31	Technical Acoustics	3-C	30		30	60	65	125	5
32	Internal Environment	3-D	30		30	60	65	125	5
33	Hydraulics and Pneumatics	3-D	30		30	60	65	125	5
34	Production Engineering	3-D	30		30	60	65	125	5
35	Laser Systems	3-D	30		30	60	65	125	5

Elective general courses, offered by UL FME		Contact lessons Range	L	S	W	ΣCL	ΣSW	ΣWR*	ECTS*
36	Electrical Engineering	1-S	30		15	45	55	100	4
37	Chemistry	1-S	30		15	45	55	100	4
38	Fundamentals of Quality	2-S	30		0	30	45	75	3
39	Enterprise Economics	2-S	30		0	30	45	75	3
40	Practical Training	3-S	0		0	0	125	125	5

10. Information on the Available Elective Courses and Mobility

The study programme offers optionality in all three years. While there is only one elective course in Years 1 and 2, amounting to 4 and 3 ECTS respectively, the optionality based exclusively on professional diversity is introduced into the programme in Year 3. This is actually the key conceptual difference between the new programme and the old one. This optionality, which was sharply laid out in the old programme according to the selected professional field, e.g. power engineering, design or production engineering, led to a relatively narrow specialisation. The new concept, introducing four elective groups of professional courses, each having two or four subjects, enables the student to profile himself or herself to his or her own choosing either for general mechanical engineering or for a distinct specialisation. Accordingly, only four courses are compulsory in Year 3. The number of credits, intended for elective courses in Year 3, amounts to 32 ECTS from professional options and to another 5 ECTS from external options. Taking into account the elective courses in Years 1 and 2, which are externally elective as well, the number of credits intended for external optionality is 12 ECTS, or 6.7% of the programme. The share of professional optionality is 32 ECTS, corresponding to 17.8% of programme content. There are 12 elective professional courses.

The study programme does not include compulsory practical training, but the student can opt for a professional training amounting to 5 ECTS credits, corresponding to a three-week supervised practical work in an industrial or research environment with a realised project assignment. The student is in this way given the opportunity to attain better qualifications for future employment.

In the spirit of Bologna process, the mobility of students is guaranteed through the acknowledgement of credits the student acquires in the arranged cooperation at another university or upon migration from another institution or programme. The share of acknowledged or required credits is appropriately regulated.

11. Presentation of Individual Courses

01_**Mathematics 1** (9 ECTS): Basic concepts of set theory and numbers, real and complex numbers. Basic concepts of spatial vectors with the definition of basic operations - dot product, cross product, scalar triple product, vector triple product, and the definition of equations for spatial lines and planes. Basic concepts of sequences - limit point and limit, operations on sequences, definition of number e. Basic concepts of functions of a single real variable - elementary functions, limit, continuity, undefined expressions. Derivative: definition of derivative, differentiation rules, derivatives of elementary functions, differential, l'Hôpital's rule, Taylor series, plane curves. Function analysis – curvature, local extrema, graphs.

02_**Statics and Kinematics** (6 ECTS): Statics and kinematics are an indispensable part of technical education. The knowledge acquired represents a basic theoretical tool for all branches of engineering. The student attains basic knowledge of mechanics. The Statics chapter acquaints the student with the basic concepts of mechanics and with the methodology for abstraction of real problems, leading to the creation of a physical model and its mathematical formulation. This is completed with the basic knowledge on systems of rigid bodies, the concept of internal and external forces and equilibrium of rigid bodies in two- and three-dimensions. The student in greater detail gets familiar with the methodology for performing equilibrium analysis of composite bodies involving standard structural elements and with determination of forces and moments. He or she masters the concept of three-dimensional space and the methodology of mathematical modelling of space using vector calculus. The Kinematics chapter provides basic knowledge on describing the two- and three-dimensional motion of rigid bodies. The knowledge acquired is a basis for all branches of engineering. During the course, the student will

also master the thought process necessary for the abstraction of real problems, formulation of physical models and corresponding mathematical models. He or she also acquires the first experience in project-based work and writing reports.

03_**Descriptive Geometry and Technical Documentation** (7 ECTS): The course consists of two parts: the basics of descriptive geometry (~1/3) and the basics of technical drawing (~2/3) in accordance with ISO standards – as such establishing the foundation for technical communication in the field of mechanical engineering.
In the descriptive geometry part, the students get acquainted with the basic rules of projecting spatial objects to planes and learn the basic methods for solving characteristic problems that arise in the process: determination of true size and form by rotation and collineation / affinity, determination of intersections between planes and simple curved surfaces, surface meshes for solids, determination of piercing points between lines or curves and planes, solving simple intersections of solids. Parallelly, they are acquainted with the basics of descriptive geometry necessary for using modern 3D modelling tools (CAD).
In the technical drawing part, the students get to know the basic rules of ISO standards and adopted agreements in the profession, necessary for the interpretation and creation of various types of technical drawings. A special emphasis is placed on the rules for presentation of objects on technical drawings, adopted simplifications, rules on dimensioning and the use of symbols, dimensional tolerances and fits (ISO), geometric tolerancing (GDT) and the basics of tolerance analysis, designating of roughness and condition of surfaces and edges, particularities in drawing of welded assemblies, soldered/brazed parts, adhesive-bonded parts and castings. The students also learn the adopted agreements and simplifications in the drawing of common machine elements and in the drawing of schematics, together with general rules and principles important for the successful use of computer aided design (CAD) tools and management of technical drawings.

04_**Energy and Environment** (4 ECTS): The topics of this course are intended for all students of mechanical engineering. It promotes the basic idea that energy and materials should not be taken for granted. They must conscientiously be dealt with economically, as the natural resources of energies and materials are finite and will become more and more expensive, and the impact on the environment due to exploitation of energy and materials for products will get more and more intense. The costs of energy and materials will be taking over an increasingly larger share in the final price of products, also owing to the costs incurred by the reduction of harmful emissions and the elimination of damage to the environment.
The students master the knowledge on preparation of energy, on global and local energy supply, energy supply systems and the impact of energy and materials on the environment. They learn to determine the quantity and the value of energy that is input into products. They obtain basic information on the procedures for reduction of energy consumption, lowering the energy intensity of processes and products, and on the causes of environmental impacts in manufacturing and decommissioning of products. The students learn about process systems and the environment, long-term system planning and best practices. In carrying on with their studies, the students of mechanical engineering will have to be capable of using the described knowledge and autonomously assess the energy intensity and harmful impacts to the environment, presented by the processes they will be dealing with later on in the studies and in professional life. In the future, the design of new products will be conditioned with such evaluations, even more in a period of an aggravated situation in the energy market and international agreements and commitments, related to environmental protection.

05_**Mathematics 2** (8 ECTS): The definition of indefinite and definite integral, integration methods - integrals of elementary functions, integration by substitution, integration by parts, improper integrals. Applications of calculus – area of figure, arc length, volume and area of solid figures, center of mass, optimization problems.

Basic concepts from the theory of differential equations for functions of a single real variable – equations with separable variables, first order homogenous equation, Bernoulli, Lagrange, Clairaut equation, second order linear differential equation.
Linear algebra: systems of linear equations, Gaussian elimination, determinants, Cramer's rule, matrices, rank of matrix, eigenvalues and eigenvectors.

06_**Physics** (8 ECTS): The knowledge of basic natural phenomena is essential for a successful study of mechanical engineering, as well as for the future work of mechanical engineers and masters of science in research & development and in the industry generally. In the Physics course, the students learn to use mathematical methods to deal with physical topics, providing a foundation for dealing with more complex engineering problems later on during their studies.
The goal of the course is to provide the students with a sound theoretical and practical physical foundation, preparing them for further study of modern mechanical engineering. An important emphasis is given to continuous work and to introduction of teamwork in seminars and laboratory exercises. The course covers topics from the whole field of physics.

07_**Strength of Materials** (6 ECTS): The course on the Strength of Materials has the basic purpose of calculating the distribution of internal forces in uniaxial structural elements and constructions. The course's topics present a continuation of the course on Statics, where the student learns the methods to determine the forces and moments in an arbitrary point, but only in summary form, so the course of Statics was not interested with the form of cross-section of uniaxial structural elements. On the other hand, the strength of materials seeks to answer the question on how the internal quantities of state are distributed across the cross-section, meaning that form and shape of cross-section are crucial for the strength. The means of the strength of materials, which takes into account the deformability of bodies, enable the determination of external reactions to statically indeterminate structural elements. Based on knowing the distribution of internal quantities of state, it is possible to select the dimensions of structural elements according to the external loads. The main task of science of the strength of materials is therefore selecting the dimensions of uniaxial structural elements and constructions. This knowledge is a foundation for all other courses, which have to take the shape and dimensions of structural elements into account, in order to prevent fracture or undesired deformations.

08_ **Engineering Materials 1** (3 ECTS): The course provides the students with basic knowledge to understand the material properties from the viewpoints of crystal structure and microstructure. The starting point is the composition of solids, proceeding to material science through cooling curves and basic phase diagrams. Material analyses depart from microstructural examinations of samples, where the students are acquainted with microscopes and with preparation techniques for optical microscopy. The course continues with the mechanical properties of materials, various methods for determination of strength (tensile, compressive...), various procedures for determination of hardness as well as static and dynamic strength of materials. The students get acquainted with material properties from tabular data, collected in manuals.
In the first part of the course, they also learn about casting procedures and properties of castings, as well as about different forming procedures used to obtain semi-manufactured products, such as rolling, drawing and extrusion. In the process, they learn about cast and forgeable alloys and about their material properties and use.

09_**Space Modelling and Representation** (5 ECTS): Modelling of space is the foundation for virtual modelling of products. One has to understand the difference between the mathematical description of geometry and the composition of primitives into complex objects that are the ordinary modern products. The student is first acquainted with the presentation technology, the possibilities for entering data and for presentation of data in a real-world environment. The exercises therefore have to demonstrate appropriate environments, showing the reality of use to the student. Later on, the student learns how to describe space with coordinate systems in a

global and local world. The basics of Bernstein polynome, B-curves and different spatial interpolations are presented. Furthermore, B-curves on free surfaces and methods for shaping free surfaces are presented: adding, cutting, local modality, curving etc. Models of NURBS curves and direct use are derived. Finally, the problems in patching different free surfaces and limitations to contact boundaries are indicated.

10_**Mathematics 3** (6 ECTS): Theory of functions of several variables - partial derivatives, differentiation of composite functions, higher order derivatives, extrema, constrained extrema, implicit functions.
Vector analysis - integrals of functions of several variables, Fubini's theorem, substitution of a new variable, vector fields, curve integral of vector fields, surface integral of vector fields, Gauss' theorem, Stokes' theorem, applications of vector analysis.
Probability and statistics - events, random variables, distributions, expected value, descriptive statistics, sampling, bivariate regression.

11_**Thermodynamics** (8 ECTS): The student is acquainted with material properties, where a special emphasis is placed on temperature and the basic principles of thermodynamics, formalised with the zeroth, first and second law of thermodynamics. A special emphasis is placed on the irreversibility of processes, aiming to qualify the student for a critical assessment of energy and exergy losses in processes from the viewpoint of sustainable development.
Complex systems, breakdown, thermodynamic {P,Q} system. Local scale: element, state; Time scale: process. Structural model, principle of feedback loop; narrower system, wider system, narrower surroundings, wider surroundings. Properties of clean materials. States of matter: solids, liquids, gas (steam). Solids: temperature expansion, thermal stress. Liquids: temperature expansion, anomalies of water. Gases: PVT system, thermal equation of state; real gases, phase transitions.
First law of thermodynamics. Accumulated energies, transient energies. Work, technical work, heat. Caloric equation of state, heat capacity. Ideal gas laws. Second law of thermodynamics. Irreversibility. Entropy. Thermodynamic relations; Helmholtz function, Gibbs function, Maxwell's thermodynamic relations. Clapeyron relation, Joule-Thomson coefficient. Exergy and anergy. Thermodynamic balances. Coupled processes. Structural analysis, zeroth law, first law, second law: Power cycle and feedback loop. Steam engine and Rankine cycle. Improvements to the steam process. Gas processes. Internal combustion engines. Cooling and heating processes; Properties of coolants. Steam cooling processes. Heat pump. Transformation processes. Transport processes.

12_**Engineering Materials 2** (5 ECTS): The course provides the students with basic knowledge on ferrous and non-ferrous alloys, as well as on modification of material properties through various heat treatment and thermochemical procedures. This is followed by the powder metallurgy technology, acquainting the students with powder production, pressing and sintering. Special emphasis is placed on the description of diffusion processes and other modified procedures for manufacturing of special sintered parts. Among non-metal materials, polymer materials are presented with typical polymerization reactions, supported with various tests for the determination of polymer properties. Basic procedures for forming semi-manufactured and final products from polymer materials are introduced.
The technical ceramics part includes the overview of raw materials, preparation of raw materials, forming, pressing and sintering of products. Various procedures for forming, drying and sintering sintered products are presented. A special emphasis is placed on engineering ceramics from the viewpoints of properties and use. This is followed by composite materials on the basis of metals, polymers and ceramics, with an emphasis on the manufacturing, use and testing of composites.
The last chapter is Corrosion and corrosion protection of metals. Different types of corrosion, rates of chemical reactions and methods for measuring corrosion are presented. Finally, various methods of protecting metals and metal structures from corrosion are described, from mechanical to chemical and galvanic.

13_**Machine Elements 1** (6 ECTS): Development and production technical system, technical system linked to operation, maintenance, regeneration and recycling. Design formation and evaluation, basics of design. Evaluation criteria: functionality, dimensional adequacy, safety, reliability, RMS values. Damage, carrying capacity determination and strength, deterministic and probabilistic approach of dimensional adequacy determination. Inseparable joints: welding, soldering, bonding and riveting. Separable joints: tension bolt, fit bolt and driving screw, pins, bolts, shaft-hub connections. Axles and shafts. Pressure vessels, pipes and shutoff elements: cylindrical, flanges, bottoms and covers, washers, bolted connections and pipes and shutoff elements. Springs: steel, rubber and pneumatic.

14_**Numerical Methods** (5 ECTS): A mechanical engineer has to be familiar with modern computer-supported methods of solving technical problems. These methods can be classified into experimental and computational methods. In the latter, a mathematical model is written and generally solved by using a computer, mostly with numerical methods. Accordingly, three interrelated topics are treated in scope of this course: Matlab programming language, methods for numerical solving of mathematical models and Matlab programming language tools for symbolic computation.
Matlab programming language: constants, variables, functions, expressions, definition of vectors, matrices and sub-matrices, functions for building, editing and calculations with matrices, functions for connecting textual and numerical expressions, reading and writing data, graphical presentation of data, logical values, logical operators and logical expressions, control statements, user functions.
Numerical methods: Sources and propagation of errors through numerical calculations. Methods of solving systems of linear equations. Methods of interpolation and approximation. Methods of solving non-linear equations and systems of non-linear equations. Numerical differentiation and integration. Numerical solving of differential equations.
Matlab's tools for analytic mathematics: simplification of expressions, differentiation, limit, integration, series, Taylor series, equations and systems of equations, eigenvalue problem, ordinary differential equations and special functions.

15_**Fluid Mechanics** (7 ECTS): The main purpose of Fluid Mechanics course is to teach physical and mechanical properties of fluids, and, based on these findings, determine the influence of fluids on rigid and deformable bodies, both theoretically and experimentally. The determination of physical and mechanical properties of fluids mostly involves experimental work. The term 'fluid' includes gases and liquids, constantly undergoing changing of form under certain conditions, and possibly also of density and volume. Another factor greatly influencing the mechanical properties is temperature. In studying the influence of a static fluid on solid bodies that are totally or partially submerged in a fluid, we may use certain idealisations, as there is no influence of viscosity on the fluid-solid body interaction in these cases. In a fluid flow field, which may be artificially limited with walls or represent the flowing around a solid body, the interactions between the fluid flow and the solid body may be studied on the basis of certain idealisations, so in this way simplified results of calculations can also be useful for the industrial practice. The influence of chosen assumptions on the calculations is examined in the laboratory. Fluid statics is interested with the studies of stable floating of partially submerged bodies, as the metacentric height also influences the tilting of ships along their longitudinal axes. Based on the calculated force of the fluid flow, acting on aerodynamic and hydrodynamic profiles obtained through Kutta - Joukowsky conformal transform, it is possible to derive practically useful shapes of airfoils and blades, so that the buoyancy and consequently efficiency of fluid flow are as large as possible. This knowledge is the foundation for all other courses that must take the influence of fluids on rigid or deformable bodies into account.

16_**Heat Transfer** (6 ECTS): The introduction overviews the development of the field of heat transfer. The student is acquainted with the basic principles of conduction, convection and radiation. In scope of the conduction equation, he or she learns the approach towards solving the problems of one-dimensional stationary conduction, with or without internal generation of heat, as well as the importance and use of extended surfaces in heat transfer. In the studies of

multi-dimensional stationary and non-stationary conduction, the student is acquainted with analytical and numerical approaches to solving the problems of heat transfer, with an emphasis on the use of finite differences method. The student is then introduced through various practical examples into the use of generalised capacity analysis for solving the problems of non-stationary heat transfer. In scope of convection, the basic principles and a description of free and forced convection is presented, with and without phase transitions. A heat exchanger is studied to present the student with the advantages of log mean temperature difference method and with the relation between a heat exchanger's efficiency and the number of exchanger units, using them in a practical example to determine the characteristics of a heat pipe and its limitations in operation. Through basic principles of radiation and the introduction of the factor of mutual exposition, the student will be trained to determine the radiation heat transfer rate between several differently aligned surfaces in a room. Studying passive and active techniques for the improvement of heat transfer, the student will be oriented to think creatively about the efficient use of energy. The course's final chapter is dedicated to heat transfer phenomena on micro and nanoscale.

17_**Machine Elements 2** (6 ECTS): Bearings: basics of friction, lubrication and cooling, plain and roller bearings. Transmission and transformation of rotational movement, transformation parameters (gear ratio, utilization ratio). Couplings: principles, rigid couplings, position aligning, flexible couplings, switching conditions, sprague couplings, torque and speed of rotation limitations, safety and torque couplings. Transmissions: centre-to-centre distance, gear ratio and utilisation ratio. Friction and form principle of transmission. Friction gears, belt drives with flat and V belts, synchronous belts, chains. Gear drives: parameters, the law of toothing, interference and involute teeth, spur and helical gears, bevel gears and cylindrical gears, carrying capacity of gear drives and standards.

18_**Manufacturing Technologies 1** (5 ECTS): Modern development of marketable products demands the knowledge of various manufacturing possibilities already in the starting phase. In selecting materials and their thermo-mechanical states, in defining the attributes of form, required accuracy and surface quality, it is necessary to select the most rational and cost-optimal manufacturing technology, depending on the volume of production and the anticipated market life of a product. The course reviews classic and modern machining (chip-cutting) operations based on a defined cutting geometry of the tool, such as: turning, milling, drilling, threading and sawing. An undefined cutting geometry is used by the following operations: grinding, honing, superfinish, polishing. We explain the difference between classic chip-cutting and HSC - High-Speed Cutting operations, which guarantees competitiveness to manufacturers operating in the European market.
The chapter on forming deals with the most common material forming procedures, such as pressure forming, drawing, bending, joining by forming, forming with a direct supply of energy, cutting. Special chapters are dedicated to rapid low-series manufacturing by forming, combinations of forming and chip-cutting, as well as to particularities in the machining of semi-manufactured products that have been prepared in different ways. The course's final chapter is dedicated to the analysis of environmental impacts from the selected technologies, and to the balance of energy that is spent during the manufacturing of a certain product.

19_**Project Management** (3 ECTS): The foundations of project management are teamwork and knowing the methods of creativity. The course presents the difference between solving problems individually and in a team, the method of forming teams while taking into the account nine different team roles, and the communication between the head of the team and the members. Project work and team work will be inefficient if the team members don't know the methods of creativity. The course deals with those methods of creativity that are the most appropriate for solving problems in technical environments.
Project planning begins by setting the project goals (knowing the methods of teamwork and creativity) and forming the work breakdown structure of the project's. It concludes by creating a network diagram for the project. Project planning is followed by time, resource and cost analyses, which have to confirm the project's feasibility. Continuous tracking of project execution guarantees that the project will be concluded according to the planned timetable and within planned costs.

20_**Numerical Modelling Methods** (7 ECTS): Generally speaking, modelling is a tool that enables a controlled analysis of problems by mapping a physical/technical problem to an appropriate equivalent form. In case of mathematical mappings, it is often difficult or even impossible to solve such models explicitly. The only tool available to the analyst is numerical modelling, a priori taking the approach of approximative solving and moving the treatment from the continuous to a discrete space. The student learns the principles and masters the methods of physically objective numerical modelling. Based on simple technical cases, the student learns to understand mathematical models, recognize the significance of physical quantities appearing in the model, as well as their role in defining the boundary value problem. The approximation approach to solving boundary value problem equations has a general setting with differential and integral formulations used as the starting points. The Finite difference method and the Finite element method are their direct numerical derivatives.

21_**Measurement Techniques** (6 ECTS): Substantial technical and other changes, occurring in the last decade as a result of the development of a new generation of manufacturing means and procedures, have also induced an intensive development of modern measurement technology. Increasingly complex and complicated systems in the field of material production and the extensive research & development work in the real environment pose ever tougher demands for special knowledge and competences in modern measurement technology. The core requirements of proposed new teaching content from the field of practical and scientific metrology, or measurement technology in general, are therefore oriented to planning and development of high-quality computer-supported measurement systems, which fulfil the increasing demands regarding the measurement accuracy combined with minimum measurement uncertainty, at the same time enabling repeatability, reliability and the speed of the measurement process itself, and the increasing demands regarding the capturing, transferring and processing of measured values. The answer of modern measurement technology to these and other demands is the development of new sensors and devices, new measurement methods and procedures, new system and informational concepts (for standardised measurement systems), providing increased reliability and compatibility of hardware and software, at the same time making the developmental achievements and findings available to different other areas of science and technology.

22_**Design Methodology** (5 ECTS): Product development is placed in the centre of activities in a modern industrial and human environment. Modern developed environments understand that only a share of products can be developed randomly. The purpose of this course is therefore to present the student with the need for a methodology of development for all products. The student gets acquainted mostly with the functional requirements and with the derivation of working principles. He or she then acquires the necessary knowledge to evaluate the appropriately designed solutions. The students learn about the basic characteristics of the design process. He or she recognises various technical systems from an integral point of view. So far, he or she has only understood technical systems partially, while the globality in the use of technical systems can be recognised when looking at them integrally. The methods for a systematic and radical product development are derived. Criteria are set for various approaches to robust design, design for assembly, manufacturing, transport, maintenance, use etc. Specific parameters for the definition of mentioned characteristic design procedures are recognised. The student will prove if he or she has the necessary knowledge for a specific task with a seminar assignment. It is therefore essential for the student to pick an appropriate topic and defend it publicly.

23_**Tribology** (5 ECTS): The course presents the basic concepts from the field of interacting surfaces in relative motion, lubrication and lubricants, friction and wear. The course describes the importance of load-bearing tribological contacts for power transmission in systems and the key properties of surfaces that influence friction and wear. We explain the basic types of lubricants and the quality of lubrication, which may be evaluated through the system's position on the Stribeck curve. In this regard, we explain the role and the basic types of additives in lubricants, as well as the basic characteristics of individual lubrication types. Main sources of

friction and their influencing factors are studied. This is followed by the most common wear mechanisms and their characteristics. The last part of the course deals with the methods for surface analyses, tribological studies and basic principles of testing. The consequences of friction, wear and various aspects of lubricants and lubrication are summarized, their role in damage to machine elements is explained, together with the possibilities for their detection and tracking.

24_**Rigid Body Dynamics** (7 ECTS): The relation between a dynamic model and a real engineering system, equation of motion, methodology for solving problems in dynamics. Dynamics of a particle in connection with applications in mechanical engineering: force, mass, acceleration; linear, curved motion; work and energy (kinetic, potential), power, efficiency, impulse and linear momentum, angular momentum. Dynamics of a system of particles: motion of centre of mass, linear momentum, angular momentum in an arbitrary rotation, work, energies.
Dynamics of a rigid body: mass moments of inertia, axial, principal, mass products of inertia, parallel translation of axes, coordinate system rotation. Planar motion: translation, rotation, general. Forces and moments, work and energies. General spatial motion. Rotation about a stationary axis, static and dynamic mass balancing of rigid rotors. Designing a flywheel.
Impact: velocities in direct- and oblique central impact, energies in impact - efficiencies of hammering and forging.
The basics of mechanical vibrations: free and forced vibrations of systems with a single degree of freedom, undamped and damped vibrations, harmonic, centrifugal excitation, critical speed of single-mass elastic rotors, transmissability of vibroisolation, basics of vibration measurement - seismic theory.

25_**Fluid Dynamics** (7 ECTS): Fluid: basic properties, axiom of continuum;. General balance of a change in local property. Integral analysis methods – averaging. Laminar flow: Continuity equation; continuity wave. Equation of motion; dynamic wave, Bernoulli's principle. Energy equation. Turbulent flow: Reynolds' rules of averaging. Reynolds' turbulent stress. Energy spectrum. Euler's averaging across volume. Euler's averaging across a streamline. Streamtube. The change of total pressure and irreversibility.
Phenomenological principles vs. terminating conditions. Second law of thermodynamics. Constitutive equations of state. Mechanical constitutive equations of state. Energetic constitutive equations. Integration of Reynolds' equations of motion (RANS). Boussineq's theory. Prandtl's theory of mixing length. Dimensional analysis. The law of wall. Models: DNS, RSM, SST, LES; k-epsilon. Basic types of physical variables. Basic properties of random variables. Reynolds' physical image of turbulent flow. Description of a turbulent field, correlation, intensity, scale, spectrum. CFD, boundary layer, microfluidics, compressible flows.

26_**Product Design and Development** (5 ECTS): The course on Product Design and Development provides the student with the fundamental information on why and how new products are created. We seek to present a more complex understanding on how the requirements evolve, either fully basic or upgraded requirements. Finding opportunities for new products is the basic motivation for development. The relation between the development of new technologies and new products is emphasised. The development of new products is connected to the environment, represented by social, economical, technological and legislative factors. Market analysis is presented to the student as a means for recognising the conditions for product development. The development of new products acts as a generator to research new technologies and know them better. The understanding of an integral production system is a prerequisite for understanding the lifecycle of a product, from the idea to its disposal from the environment.
This is followed by the importance of teams and individual team roles in the product development process. The cooperation between different functions in a company belongs to internal company factors in product development. The student is presented with macro and microeconomic conditions to provide a relevant attitude towards the development of new products. Development of new products versus researching product characteristics for specific

operating conditions. The difference between the development of a new product and the copying of known solutions is highlighted. The influence of this difference on the position of a business system in a narrower and wider environment. The student learns about all important elements of a production system and is presented with the logical structure of developmental chains. The student is also presented with the role of development centres in large corporate systems, so he or she can understand the flow of information, projects and orders. The logic of SME companies in the integral management of demand for products is presented.

27_**Power Engineering** (5 ECTS): The Power Engineering course is dedicated to a systematic overview of technical applications when conversion of primary energy sources into secondary, final - useful form is concerned. The students learn how to use the fundamental theoretical principles (from various areas of engineering) to determine and understand the phenomena in machines or devices and their operation. The students get acquainted with the basic characteristics of: driving- and driven machines (the purpose of use); hydraulic- and thermal machines (type, compressibility of work medium); displacement- and turbomachines (method of operation); energy devices (heat exchangers, boilers, ejectors, direct electro to chemical energy conversion). The students understand the operation principles and use of the mentioned machines and devices in the technical practice, their integration and role in wider power systems and the basic theoretical approaches for determining the basic design quantities.

28_**Manufacturing Technologies 2** (5 ECTS): The content of this course covers the basics of non-conventional manufacturing technologies, joining technology and thermal cutting. The tasks of engineers in the industry and the directions of development of manufacturing systems are presented. Manufacturing is studied from the viewpoint of interrelations between design, technology and material. Individual non-conventional technologies are presented in detail. Their specific characteristics from the viewpoints of physical principle of material removal, integrity of generated surfaces, accuracy and economic efficiency of the process are presented. Based on practical examples, the students select appropriate technologies corresponding to the specific requirements of the product.
The second part of the course gives the basic differences between individual joining technologies from the physical-metallurgical point of view, as well as the differences seen by a user in the industry. An informative overview of welding, soldering/brazing and adhesive bonding technologies is given. The basics of metalizing and the possibilities for the repair of worn machine elements are given. The course continues with the basics on welding energy sources, the welding arc, plasma, laser and electron beam from the viewpoint of practice and industrial use. The basic quality requirements are presented for the whole field of material joining.

29_**Polymer Science** (5 ECTS): The importance of polymers as construction materials is increasing. Their use is rapidly growing in the industry owing to the advantages provided by these materials in comparison to the traditional materials, such as metals. Some main advantages are: simple forming, resistance to corrosion, advantageous strength/weight ratio, multifunctional purpose of use... They are expected to bear and withstand loads through their whole life. This calls for forecasting of long-term reliability of structural elements, which in turn requires the knowledge about material properties. Designing with polymers is quite challenging, as the mechanical properties of polymers are highly time-dependent (in contrast to metals).
In scope of the Polymer Science course, the student attains basic knowledge about the behaviour of molten and solid polymer materials. He or she masters the methodology for characterisation of melt and solid polymers. The basics of technological procedures for the processing of polymers and composites are mastered, as well as the basic concepts of product design for the use of such materials.

30_**Fundamentals of Mechatronics** (5 ECTS): Mechatronics is an interdisciplinary technical field, combining the knowledge of mechanical engineering, electrical engineering and information technology. The goal of the course is to acquaint the students of mechanical engineering with this field, its basic concepts and structures, as well as the elements and

characteristics of mechatronic products and systems. The basic functional elements are presented: object of control (device or process), actuators, sensors, controllers. Basic structures of mechatronic systems and the relations between the elements and the surroundings (input and output quantities, controlled parameters, reference) are explained. Control elements are described in detail, with an emphasis on the digital technology. The role of software is determined. The basic properties of functional elements and systems are presented, as characterised by static and dynamic characteristics in time and frequency domains. The steps in design of mechatronic systems are given. The engineering tools used to support the design are presented. The subject is illustrated with numerous examples. The lectures are accompanied by demonstrations, executed on specially developed teaching aids and laboratory equipment. They enable the students to cooperate actively and comprehend and absorb the new knowledge more easily.

31_**Technical Acoustics** (5 ECTS): Noise is a problem of our civilisation. It damages the hearing and causes multiple psychophysiological disorders in humans and animals. It also influences the working efficiency. Noise is therefore a problem of environmental protection and of workplace humanisation. Machines and devices are the main sources of noise at the workplace and in the natural and living environment. The silence of a product is a very good marketing argument. In order to be capable of building a silent machine or reducing the noise of an operating machine, we have to know how the noise is generated, i.e. the mechanisms of noise generation. The mechanisms of noise generation are different and depend on the type of machine, its dimensions, power and operating conditions.
In scope of this course, the students get acquainted with the principles of noise and with the corresponding terminology, especially with the logics of decibel scale and sound levels. Next they learn about the mechanisms of noise generation in various elementary sources of noise and in complex machines and devices, which operate in industrial halls or outdoors, at different operating regimes. In scope of exercises, the student confirms experimentally the theoretical interpretations obtained during the lectures, thereby obtaining a visual image of noise emission for different machines and noise sources/mechanisms of noise generation.

32_**Internal Environment** (5 ECTS): Internal environment is a basic professional course, dedicated to the laws of working and living environments in buildings. The student learns the influencing parameters and criteria of internal environment (thermal environment, air quality...), which dynamically influence the comfort and possibly present a risk to human health. The causes of harmful internal environments and the measures and models for their improvement are presented. This is followed by a presentation of principles for synthesis and management of studied environment, including efficient ventilation, removal of harmful impurities and air age analysis.

33_**Hydraulics and Pneumatics** (5 ECTS): Hydraulics and pneumatics is a field of mechanical engineering that is present in many mechanical engineering applications, from automation, machine tools and forming equipment, mechatronic systems and agricultural machinery, construction equipment and other machine applications. During the last years, the worldwide share of industry in the field of hydraulics and pneumatics is rapidly increasing, indicating that the demand for experts in this field is growing and that the hydraulic and pneumatic systems are more and more useful. The rapid development of technology, mainly through globalisation of production and consumption, has led to growing users' demands for more and more capable and efficient machinery. The development of microelectronics and mechatronics during the last years has strongly influenced the development of hydraulic and pneumatic technology as a whole.
Principally the basics of conventional hydraulics and pneumatics and proportional technology will be presented in scope of course Hydraulics and Pneumatics (H&P). In frame of the course, the students will attain basic knowledge including the theoretical grounds for calculations and design in the practical use of fluid power systems. They will understand the basics of H&P systems, constructional realizations and operation of most important and widely used H&P conventional and proportional components, and acquire the basic knowledge for the design of

H&P control and technical systems using these components in practice. The acquired knowledge will also be a suitable foundation for the maintenance of machines and plants, equipped with hydraulics and pneumatics. The acquired knowledge will be used by the students for the upgrade later on in Level 2 of studies.

34_**Production Engineering** (5 ECTS): Production engineering is a field of mechanical engineering, which covers the ever increasing needs of a modern market economy for an efficient organisation of companies, economical manufacturing and service operations, as well as the increasing needs for the automation of manufacturing, especially assembly. The course Production engineering provides the students with the basic knowledge on assembly in a manufacturing process, assembly systems, automated and robotic assembly, as well as knowledge on approaches towards classical and modern company organisation, analysis of economical operation of companies, methods for determining the times and basics of investment engineering.
After their lectures are completed, the students will be capable of making decisions in the process of product development according to the available possibilities of assembly, as well as in designing assembly processes and systems. They will be able to form the most appropriate organisational structure, analyse economic efficiency, determine time standards and prepare the investment accounts. The knowledge, acquired in this course, will be a foundation for upgrading in Level 2 of studies.

35_**Laser Systems** (5 ECTS): The ever more intense introduction of lasers into modern industrial production is leading to intense transformation of production in the direction of new product development and high value-added manufacturing processes. Lasers have an important role in the field of modern micro and nanomanufacturing technologies, as well as in the field of rapid and flexible manufacturing and in rapid prototyping.
The course aims to provide the students with sound theoretical and practical foundations of engineering laser applications, thereby preparing them for further studies in the fields of modern mechanical engineering, where the laser systems are becoming indispensable. An important emphasis in this course is given to the acquisition of knowledge and skills, important for the practical use of laser systems in industrial or research environments. The course includes topics from the fields of engineering optics, laser sources, laser safety, laser measuring systems and laser processing systems.

36_**Electrical Engineering** (4 ECTS): The Electrical Engineering course provides the students of mechanical engineering with the knowledge on electrical engineering in such an extent and form, which enables them to use the tools, systems and components of electrical engineering in the execution of their professional assignments. The course presents the operating principles of electric and electronic circuits, the principles of implementation of analogue signal processing, high-voltage circuits and the principles of operation for digital systems. The structure, manufacturing and use of passive and active components in electric and electronic circuits are explained.

37_**Chemistry** (4 ECTS): The Chemistry course refreshes the students' knowledge acquired in the lower education levels. An important part of the course is the presentation of topics and theoretical principles that are related to mechanical engineering and are therefore often confronted by mechanical engineers in the practice. The connection between the structure of matter and its influence on the chemical properties of matter is clearly presented. Numerous examples of matters and materials are described to demonstrate the applicability and the connection of chemical matter to everyday life and, especially, mechanical engineering (as evident from the individual points of Curriculum model).

38_ **Quality Fundamentals** (3 ECTS): In the modern market economy, the demands for quality level are ever increasing as a result of growing customers' and buyers' requirements, as well as due to competition between competing companies. One of the ways to increase the company's revenue and reputation is to deploy a modern quality assurance system that should

ensure an appropriate foundation for providing better products and services. The system itself does not lead to better products directly, but it ensures better process stability, guaranteeing expected product quality level and, indirectly, better customer satisfaction. Successful companies, having a clear vision for their business, build their success on planning, management and quality assurance in accordance with international standards. According to Ishikawa, quality assurance begins and ends with education, which has to be properly organised on all levels.
The student acquires basic knowledge in the field of quality assurance, including various aspects of quality and quality management systems, as well as appropriate tools, techniques and methods to achieve the required goals. He or she also acquires the skills to find and use new information from various sources, as well as to transfer this knowledge into the entrepreneurial environment in the process of solving professional problems in the field of quality assurance.

39_**Business Economics** (3 ECTS): For a future engineer, it is very important to know the basic concepts of business economics. The students will learn about basic characteristics of companies, their business processes and the role of business functions. Special attention is devoted to business assets and liabilities. Also very important for engineers is the topic on costs and their types, as this is the foundation for the calculation and evaluation of cost-effectiveness of technical solutions.

40_**Practical Training** (5 ECTS): The student works autonomously, taking an agreed position in an industrial or research institution (operating in the wider field of mechanical engineering) under the supervision of an assigned mentor. He or she continuously executes a project assignment and keeps a work log as a component of project work. The project assignment with attachments documenting the student's work is then presented and defended in front of the mentor at the faculty.