University
of Ljubljana

Faculty
of Mechanical Engineering

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Slovenia

LEVEL 1 HIGHER PROFESSIONAL STUDY PROGRAMME

MECHANICAL ENGINEERING

PROJECT ORIENTED APPLIED PROGRAMME

Programme Presentation

Ljubljana, September 2008

LEVEL 1 HIGHER PROFESSIONAL STUDY PROGRAMME
MECHANICAL ENGINEERING
PROJECT ORIENTED APPLIED PROGRAMME
UNIVERSITY OF LJUBLJANA, FACULTY OF MECHANICAL ENGINEERING
Study Programme Presentation

1. Study Programme Details

Title:

Level 1 Higher Professional Study Programme
MECHANICAL ENGINEERING – Project Oriented Applied Programme

Duration:

3 years

Number of ECTS credits:

180

Graduate's professional degree:

Diplomirani/-a inženir/-ka strojništva (VS)
(Bachelor of Applied Science in Mechanical Engineering)
abbreviated to **dipl.inž.str. (VS)**

An informative presentation of the study programme in **MECHANICAL ENGINEERING – Project Oriented Applied Programme** is available on the internet address:
http://www.fs.uni-lj.si/educational_process/higher_professional_education/

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. 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 engineering 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 Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied Programme** can be entered by anyone who has:

– passed the final exam in any of the 4-year secondary schools, the vocational education matura exam or the matura exam.

Number of places available:

A – Full-time study:

420	Ljubljana
60	Novo mesto
60	Portorož

B – Part-time study:

60	Ljubljana
40	Nova Gorica
40	Celje

In the case of limited enrolment, candidates will be selected based on

- grade point average of the final exam, the vocational education matura exam or the matura exam and 60% of points,
- grade point average in the third and fourth year 40% 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, acquired before programme enrolment and corresponding to the **MECHANICAL ENGINEERING – Project Oriented Applied Programme** syllabus. Recognition of the knowledge and skills, acquired before enrolment, is confirmed or rejected by Faculty's Higher Professional 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 Higher Professional 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, and the study commitment fully recognized.

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 fully or partly the requirements, prescribed by the syllabus of the current year, and have accumulated at least 54 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 – Project Oriented Applied Programme**, the mentor of the student's current year and the mentor of the year that the student wishes to enrol.

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 Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied 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 Higher Professional 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 – Project Oriented Applied Programme**, the mentor of the student's current year and the mentor of the year that the student wishes to enrol.

5.3 Conditions for Extension of Student Status

In accordance with Article 70 of the Higher Education Act the student status expires if a student does not graduate within 12 months of the end of the last semester or does not progress to the next year during the studies. In case of legitimate reasons the status can be extended by a maximum one year. Mother students who give birth to a baby have the right for the extension of the student status by one year for each live-born baby.

In accordance with Article 240 of the UL Statutes, the student status is suspended during the motherhood, fatherhood or prolonged illness, exceeding one year.

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.

The study programme does not envisage the possibility of completion of individual programme parts. The programme is treated and executed as a whole.

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 – Project Oriented Applied Programme**, where all or part of the requirements, fulfilled within the original programme, are recognised as fulfilled requirements of the programme **MECHANICAL ENGINEERING – Project Oriented Applied 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 – Project Oriented Applied 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 Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied Programme**.

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

The Faculty's Higher Professional Study Commission can impose a student, in compliance with the rules on assessment and marking the knowledge at the Faculty, additional requirements (differential examinations) and the deadline when the requirements are to be fulfilled. In this case, the Faculty's Higher Professional 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 – Project Oriented Applied Programme,** on account of optionality outside the Faculty. If the student is coming to the Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied Programme** from reformed higher education programmes outside the University of Ljubljana, the Higher Professional Study Commission can recognise also some of the student's examinations from the previous programme on account of optionality inside the Faculty.

A student can enrol Year 2 or 3 of the reformed Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied Programme** if:

- he or she meets the conditions for enrolling the study programme
- there are places available and
- he or she has fulfilled study requirements of the preceding year under the original programme

b) Enrolling Year 2

A student can enrol Year 2 of the new mechanical engineering higher professional study programme if the syllabus of Year 1 of the new Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied Programme** does not vary by more than 30 credits from the syllabus of the first year of the original study programme.

Additional requirements (differential examinations) of up to 20 credits can be imposed, however, by the Higher Professional Study Commission, which are to be fulfilled by the student before enrolling Year 3.

b) Enrolling Year 3

A student can enrol Year 3 of the new Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied Programme** if the syllabus of Years 1 and 2 of the new Higher Professional Study Programme **MECHANICAL ENGINEERING – Project**

Oriented Applied Programme does not vary by more than 45 credits from the syllabus of the first and second year of the original study programme.

Additional requirements (differential examinations) of up to 30 credits can be imposed, however, by the Higher Professional Study Commission, which are to be fulfilled by the student before finishing the 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 defined in the courses' syllabuses are detailed in the implementation plans for each academic year. 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)

The study includes also compulsory one-month practical training (PRT) and the diploma work (DIP); They are classified as compulsory specialised courses (CSC) and their share in the entire study programme is 11,1$^{\bullet}$%.

Compulsory general courses (**CGC**) include fundamental mathematics, physics, mathematical and numerical modelling knowledge. CGC courses represent je 15,0% of the study programme.

Compulsory specialised courses (**CSC**) provide students with fundamental mechanical engineering knowledge. CSC courses represent in total 68,3$^{\bullet}$% of the study programme and 57,2$^{\bullet}$% when practical training and diploma work are excluded.

Elective specialised courses (**ESC**) allow students to acquire detailed knowledge from specialised professional areas of the study programme. For that reason the study programme is divided, after the initial integrated part devoted to fundamentals in mechanical engineering, in several modules and sub-modules covering specific topics. This two-stage

optionality system allows students to specialise as much as possible according to their personal interests. ESC courses represent je 11,6•% 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 5,0% of the study programme. With a view to directing the professional profile of an optimum quality graduate of the Level 1 Higher Professional Study Programme, the Faculty suggests, but does not condition, topics which are offered in eleven elective courses. Their topic can be of interest also for students from other engineering study programmes.

Practical training (**PRT**) is provided in the study programme by compulsory one-month practical work, performed in an industrial or research environment and amounting to 8 ECTS, while representing 4,4•% of the study programme. The practical training is individually monitored and professionally guided by corresponding mentors at the faculty and in industrial company, and it ends by a realized project work.

Diploma work (**DIP**) amounting to 12 ECTS and representing 6,6•% of the study programme is the final obligation in the study programme. In the diploma work an applied project-oriented theme preferebly taken directly from an industrial environment is elaborated. By successful defense of his or her diploma work the student completes all by the curriculum prescribed obligations of the study programme.

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

Level 1 Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied 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, 105 credits (58,3•%) are from the compulsory part of the programme (CGC: 27 ECTS or 15.0%; CSC: 78 ECTS or 43,3•%). In each specialization study module there are 25 credits (13,8•%) from the compulsory part (CSC: 25 ECTS or 13,8•%) and 21 credits (11,6•%) from the elective part of the programme (ESC: 21 ECTS or 11,6•%). The remaining 29 credits are obtained respectively through free choice of two elective general courses (EGC: 9 ECTS or 5,0%), one-month practical training (PRT: 8 ECTS or 4,4•%) and realization of the diploma work (DIP: 12 ECTS or 6,6•%). Apart from the experience obtained on the practical training in industrial or research environment with the elaborated project and diploma work, a large part of the specific experience is acquired also in laboratory units in the regular teaching posts.

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. The programme includes accordingly a compulsory integrated part which is divided in Year 2 into five modules each covering specialised professional areas in mechanical engineering and aviation. Level 1 Higher Professional Study Programme **MECHANICAL ENGINEERING – Project Oriented Applied Programme** consists of the following modules:

POWER, PROCESS AND ENVIRONMENTAL ENGINEERING,
ENGINEERING DESIGN, MACHINE OPERATION AND MAINTENANCE,
PRODUCTION ENGINEERING,
MECHATRONICS,
AVIATION.

In Year 3 the programme is further divided into sub-modules. The number of sub-modules the individual module is divided to depends on specifics of the professional area. The existing programme modules are divided into sub-modules as follows:

POWER, PROCESS AND ENVIRONMENTAL ENGINEERING:
- *Power Engineering,*
- *Household and Sanitary Technology,*
- *Process engineering.*

ENGINEERING DESIGN, MACHINE OPERATION AND MAINTENANCE:
- *Material Handling and Self-propelled Machines,*
- *Vehicle Engineering,*
- *Maintenance Management.*

PRODUCTION ENGINEERING:
- *Production Technologies,*
- *Production Management,*
- *Welding Technologies.*

MECHATRONICS:
- *Mechatronics.*

AVIATION:
- *Airplane Pilot/Helicopter Pilot,*
- *Aircraft Design and Maintenance.*

With exception of the *Airplane Pilot/Helicopter Pilot* sub-module, which is regulated by JAR FCL (Joint Aviation Requirements Flight Crew Licencing) of the European Joint Aviation Authority JAA, the curriculum for each module and sub-module is structured in the same way. Quality of the curriculum is demonstrated with a high degree of electiveness provided both by the required number of elective courses to be selected by the student in a certain stage of the study and by the number of courses given in the elective courses sets. Advice to students on choosing elective general courses is provided by their tutors.

9.2 Curriculum

Table 9.2a: Year 1 Curriculum

YEAR 1	Course set	Contact lessons							
		L	S	W	OW	ΣCL	ΣSW	ΣWR*	ECTS*
1st semester									
Engineering Mathematics 1	CGC	30		45		75	75	150	6
Engineering Physics	CGC	45		30		75	100	175	7
Technical Documentation	CSC	30		45		75	75	150	6
Electrical Engineering and Electronics	CSC	30		30		60	65	125	5
Energetics and Environment	CSC	30	15			45	30	75	3
Informatics and Computing	CGC	15		30		45	30	75	3
1st semester total		**180**	**15**	**180**		**375**	**375**	**750**	**30**
2nd semester									
Engineering Mathematics 2	CGC	45		30		75	75	150	6
Engineering Mechanics 1	CSC	75		45		120	130	250	10
Product Conceptualisation & Systems Design	CSC	30		30		60	65	125	5
Mesurement	CSC	30		30		60	65	125	5
Production Engineering	CSC	45	15			60	40	100	4
2nd semester total		**225**	**15**	**135**		**375**	**375**	**750**	**30**
1st and 2nd semesters total		**405**	**30**	**315**		**750**	**750**	**1500**	**60**

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

* Student's workload amounts to 60 ECTS/year, which corresponds to 1500 hours/year (ΣWR); hours include contact lessons (ΣCL) and student's personal work (ΣSW).
Student's personal work includes also sports activities amounting to 60 hours/year and organized by the Faculty in Year 1 and Year 2.

Table 9.2b: Year 2 Curriculum

YEAR 2 [1,2]	Course set	Contact lessons					ΣSW	ΣWR*	ECTS*
		L	S	W	OW	ΣCL			
3rd semester									
Engineering Materials	CSC	45		30		75	50	125	5
Engineering Thermodynamics 1	CSC	45		30		75	75	150	6
Engineering Mechanics 2	CSC	60		45		105	95	200	8
Machine Elements 1	CSC	45		30		75	75	150	6
Compulsory module course S1 [3,4]	CSC	30		30		60	65	125	5
3rd semester total [4]		**225**		**165**		**390**	**360**	**750**	**30**
4th semester									
Heat and Mass Transfer	CSC	30		30		60	65	125	5
Machine Elements 2	CSC	45		30		75	50	125	5
Programming and Numerical Methods	CGC	30		30		60	65	125	5
Fundamentals of Control	CSC	30		30		60	65	125	5
Compulsory module course S2 [3,4]	CSC	30		30		60	65	125	5
Compulsory module course S3 [3,4]	CSC	30		30		60	65	125	5
4th semester total [4]		**180**		**195**		**375**	**375**	**750**	**30**
3rd and 4th semesters total [4]		**405**		**360**		**765**	**735**	**1500**	**60**

[1] In Year 2 the study programme is divided into following five modules:
Power, Process and Environmental Engineering - PPE
Engineering Design, Machine Operation and Maintenance - DOM
Production Engineering - PRO
Mechatronics - MEC
Aviation - AVI
which are subsequently divided into sub-modules. The corresponding sub-module division is as follows:
PPE: Power Engineering
Household and Sanitary Technology
Process Engineering
DOM: Material Handling and Self-propelled Machines
Vehicle Engineering
Maintenance Management
PRO: Production Technologies
Production Management
Welding Technologies
AVI: Airplane Pilot/Helicopter Pilot
Aircraft Design and Maintenance

[2] In order to get certified in *Theoretical training for Airplane pilot/Helicopter pilot in accordance with JAR FCL ½* regulation a student of the AVIATION module must choose in Year 2 the *Airplane Pilot/Helicopter Pilot* sub-module. Before the start of the 4th semester he/she must obtain PPL(A) license and have a valid 1st and 2nd class health certificate. Specialized aviation courses within the prescribed range (JAR FCL ½) should be carried out in 18 months from the beginning of the 4th semester, and at least 80% presence at the courses and rate of 7/7 is required.

[3] Compulsory module courses S1-S3 amounting to 15 ECTS are chosen in a manner specified by Table 9.2b-1 depending on the module.

[4] In the AVIATION module the courses hour structure and associated totals differ slightly from the above given, due to fulfilment of the JAR regulation requirements. However, the courses ECTS structure is not changed.

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

* Student's workload amounts to 60 ECTS/year, which corresponds to 1500 hours/year (ΣWR);
hours include contact lessons (ΣCL) and student's personal work (ΣSW).
Student's personal work includes also sports activities amounting to 60 hours/year and organized by the Faculty in Year 1 and Year 2.

Table 9.2b-1: Compulsory module course sets in Year 2

YEAR 2 – Compulsory module courses S1-S3		**Contact lessons**						
		L	**S**	**W**	**OW**	**ΣCL**	**ΣSW**	**ΣWR***	**ECTS***
Module: POWER, PROCESS AND ENVIRONMENTAL ENGINEERING									
S1	Energy Production	30		30		60	65	125	5
S2	Engineering Thermodynamics 2	30		30		60	65	125	5
S3	Energy Supply	30		30		60	65	125	5
Module: ENGINEERING DESIGN, MACHINE OPERATION AND MAINTENANCE									
S1	Engineering Design Methodology	30		30		60	65	125	5
S2	Products Effectiveness	30		30		60	65	125	5
S3[3]	Engineering Mechanics 3	30		30		60	65	125	5
	Fundamentals of FE Analysis	30		30		60	65	125	5
Module: PRODUCTION ENGINEERING									
S1	Technology of Materials	30		30		60	65	125	5
S2	Technology of Cutting Processes	30		30		60	65	125	5
S3	Technology of Forming Processes	30		30		60	65	125	5
Module: MECHATRONICS									
S1	Engineering Design Methodology	30		30		60	65	125	5
S2	Programmable Logic Controllers	30		30		60	65	125	5
S3	Introduction to Software Engineering	30		30		60	65	125	5
Module: AVIATION									
S1	Flight Instruments	45		15		60	65	125	5
S2	Aircraft Aeromechanics	40		20		60	65	125	5
S3[4]	Aviation Meteorology	50		30		80	45	125	5
	Non-destructive Testing	30		30		60	65	125	5
3rd and 4th semesters total (AHP)[5]		**450**		**335**		**785**	**715**	**1500**	**60**
3rd and 4th semesters total (ADM)[6]		**430**		**335**		**765**	**735**	**1500**	**60**

[3] As compulsory module course S3 in the ENGINEERING DESIGN, MACHINE OPERATION AND MAINTENANCE module one of the two given courses: **Engineering Mechanics 3** or **Fundamentals of FE Analysis** is chosen.

[4] As compulsory module course S3 in the AVIATION module one of two given courses is chosen. Students of the *Airplane Pilot*/*Helicopter Pilot* sub-module choose **Aviation Meteorology**, whereas students of the *Aircraft Design and Maintenance* sub-module choose **Non-destructive Testing**.

[5] Hours total in Year 2 in the AVIATION module; sub-module *Airplane Pilot*/*Helicopter Pilot* (AHP).

[6] Hours total in Year 2 in the AVIATION module; sub-module *Aircraft Design and Maintenance* (ADM).

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

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

Table 9.2c-S: Year 3 Curriculum for modules: Power, Process and Environmental Engineering; Engineering Design, Machine Operation and Maintenance; Production Engineering and Mechatronics

YEAR 3 – **PPE, DOM, PRO and MEC**	**Course set**	**Contact lessons**					**ΣSW**	**ΣWR***	**ECTS***
		L	**S**	**W**	**OW**	**ΣCL**			
5th semester									
Compulsory module course S4[7]	CSC	30		30		60	65	125	5
Compulsory module course S5[7]	CSC	30		30		60	65	125	5
Elective module course M1[8]	ESC	30		30		60	40	100	4
Elective module course M2[8]	ESC	30		30		60	40	100	4
Elective programme course P1[9]	ESC	30		30		60	40	100	4
Elective programme course P2[10]	ESC	30		30		60	40	100	4
Elective general course 01[11]	EGC							100	4
5th semester total		**180**[11+]		**180**[11+]		**360**[11+]	**290**[11+]	**750**	**30**
6th semester									
Elective module course M3[8]	ESC	30		30		60	65	125	5
Elective general course 02[11]	EGC							125	5
Practical Training	CSC	5		0	19 5	200	0	200	8
Diploma Work	CSC	40		0	16 0	200	100	300	12
6th semester total		**75**[11+]		**30**[11+]	**355**	**460**[11+]	**165**[11+]	**750**	**30**
5th and 6th semesters total		**255**[11+]		**210**[11+]	**355**	**820**[11+]	**455**[11+]	**1500**	**60**

[7] Compulsory module courses S4-S5 amounting to 10 ECTS are chosen in a manner specified by Table 9.2c-1 depending on the module.

[8] Elective sub-module courses M1-M3 amounting to 13 ECTS are chosen in a manner specified by Table 9.2c-2 depending on the sub-module.

[9] As elective programme course P1 amounting to 4 ECTS one of the two in Table 9.2c-3 given courses: **Mechanics of Non-metallic Materials** or **Maintenance Technology** is chosen.

[10] As elective programme course P2 amounting to 4 ECTS any course defined by the curriculum of this study programme can be chosen. The respective course sets are given by Tables 9.2b-1, c-1, c-2, c-3, c-4 and c-5.

[11] Elective general courses 01 in 02 amounting to 9 ECTS are chosen arbitrarily from any study programme at any faculty or university. Within this framework the faculty offers additionally a set of 11 courses (Table 9.2c-5).

[11+] Hours total without considering the structure of elective general courses 01 in 02.

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

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

Table 9.2c-L: Year 3 Curriculum for module: Aviation

YEAR 3 – AVI (AHP/ADM)	**Course set**	**Contact lessons**							
		L	**S**	**W**	**OW**	**ΣCL**	**ΣSW**	**ΣWR***	**ECTS***
5th semester									
Compulsory module course S4[7]	CSC	45		15		60	65	125	5
Compulsory module course S5[7]	CSC	30		15		45	30	75	3
Compulsory module course S6[7]	CSC	30		15		45	30	75	3
Elective module course M1[8]	ESC	60/45		45/30		105/75	45/75	150	6
Elective module course M2[8]	ESC	30		30		60	40/65	100/125	4/5
Elective programme course P1[9]	ESC	30		30		60	40	100	4
Elective general course 01[11]	EGC							125/100	5/4
5th semester total (AHP)[5]		**225**[11+]		**150**[11+]		**375**[11+]	**250**[11+]	**750**	**30**
5th semester total (ADM)[6]		**210**[11+]		**135**[11+]		**345**[11+]	**305**[11+]	**750**	**30**
6th semester									
Elective module course M3[8+]	ESC	115/30		15/30		130/60	20/65	150/125	6/5
Elective general course 02[11]	EGC							100/125	4/5
Practical Training[10]	CSC	5		0	195	200	0	200	8
Diploma Work	CSC	40		0	160	200	100	300	12
6th semester total (AHP)[5]		**160**[11+]		**15**[11+]	**355**	**530**[11+]	**120**[11+]	**750**	**30**
6th semester total (ADM)[6]		**75**[11+]		**30**[11+]	**355**	**460**[11+]	**165**[11+]	**750**	**30**
5th and 6th semesters total (AHP)[5]		**385**[11+]		**165**[11+]	**355**	**905**[11+]	**370**[11+]	**1500**	**60**
5th and 6th semesters total (ADM)[6]		**285**[11+]		**165**[11+]	**355**	**805**[11+]	**470**[11+]	**1500**	**60**

[5] Hours total in Year 3 in the AVIATION module; sub-module *Airplane Pilot*/*Helicopter Pilot* (PLH).
[6] Hours total in Year 3 in the AVIATION module; sub-module *Aircraft Design and Maintenance* (SVL).
[7] Compulsory module courses S4-S5 amounting to 11 ECTS are chosen in a manner specified by Table 9.2c-1 depending on the module.
[8] Elective sub-module courses M1-M3 amounting to 16 ECTS are chosen in a manner specified by Table 9.2c-2 depending on the sub-module.
[8+] Elective sub-module course M3 in the *Airplane Pilot*/*Helicopter Pilot* sub-module consists of two courses amounting to 6 ECTS, M3[a] in M3[b], respectively.
[9] As elective programme course P1 amounting to 4 ECTS one of the two in Table 9.2c-3 given courses: **Mechanics of Aircraft Flight** or **Mechanics of Helicopter Flight** is chosen.
[10] Flight training of at least 45 hours, realized by the student of the *Airplane Pilot/Helicopter Pilot* sub-module out of the study programme as a part of the PPL(A) license programme, is recognized as practical training amounting to 8 ECTS.
[11] Elective general courses 01 in 02 amounting to 9 ECTS are chosen arbitrarily from any study programme at any faculty or university. Within this framework the faculty offers additionally a set of 11 courses (Table 9.2c-5).
[11+] Hours total without considering the structure of elective general courses 01 in 02.

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

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

Table 9.2c-1: Compulsory module course sets in Year 3

YEAR 3 – Compulsory module courses S4-S6		**Contact lessons**						
		L	**S**	**W**	**OW**	**ΣCL**	**ΣSW**	**ΣWR***	**ECTS***
Module: POWER, PROCESS AND ENVIRONMENTAL ENGINEERING									
S4	Energy Use	30		30		60	65	**125**	**5**
S5	Fluid Movers	30		30		60	65	**125**	**5**
Module: ENGINEERING DESIGN, MACHINE OPERATION AND MAINTENANCE									
S4	Hydraulics and Pneumatics	30		30		60	65	**125**	**5**
S5	Investment Engineering & Project Management	30		30		60	65	**125**	**5**
Module: PRODUCTION ENGINEERING									
S4	Process Planning	30		30		60	65	125	5
S5	Investment Engineering & Project Management	30		30		60	65	125	5
Module: MECHATRONICS									
S4	Introduction to Mechatronic Systems	30		30		60	65	125	5
S5	Investment Engineering & Project Management	30		30		60	65	125	5
Module: AVIATION									
S4	Aircraft Engines 1	45		15		60	65	125	5
S5	Aircraft Systems	30		15		45	30	75	3
S6	Aircraft Structures	30		15		45	30	75	3

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

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

Table 9.2c-2: Elective sub-module course sets in Year 3

YEAR 3 – Elective sub-module courses M1-M3	Contact lessons L	S	W	OW	ΣCL	ΣSW	ΣWR*	ECTS*
Module: POWER, PROCESS AND ENVIRONMENTAL ENGINEERING								
Sub-module: POWER ENGINEERING								
M1 Internal Combustion Engines	30		30		60	40	100	4
M2 Effectiveness & Reliability of Energy Systems	30		30		60	40	100	4
M3 Advanced Technologies in Energetics	30		30		60	65	125	5
Sub-module: HOUSEHOLD AND SANITARY TECHNOLOGY								
M1 Building Services Engineering	30		30		60	40	100	4
M2 Heating, Cooling and Air Conditioning	30		30		60	40	100	4
M3 Renewable Energy Sources	30		30		60	65	125	5
Sub-module: PROCESS ENGINEERING								
M1 Process Engineering	30		30		60	40	100	4
M2 Tests Design & Validation of Process Systems	30		30		60	40	100	4
M3 Environmental Process Technology	30		30		60	65	125	5
Module: ENGINEERING DESIGN, MACHINE OPERATION AND MAINTENANCE								
Sub-module: MATERIAL HANDLING AND SELF-PROPELLED MACHINES								
M1 Steel Structures	30		30		60	40	100	4
M2 Design of Self-propelled Machines	30		30		60	40	100	4
M3 Power Drives	30		30		60	65	125	5
Sub-module: VEHICLE ENGINEERING								
M1 Theory of Machines and Mechanisms	30		30		60	40	100	4
M2 Vehicle Engineering	30		30		60	40	100	4
M3 Traffic Logistics	30		30		60	65	125	5
Sub-module: MAINTENANCE MANAGEMENT								
M1 Technical Diagnostics	30		30		60	40	100	4
M2 Design of Self-propelled Machines	30		30		60	40	100	4
M3 Power Drives	30		30		60	65	125	5
Module: PRODUCTION ENGINEERING								
Sub-module: PRODUCTION TECHNOLOGIES								
M1 Assembling Technology	30		30		60	40	100	4
M2 Alternative Technologies	30		30		60	40	100	4
M3 Quality Assurance	30		30		60	65	125	5
Sub-module: PRODUCTION MANAGEMENT								
M1 Handling Systems	30		30		60	40	100	4
M2 Technology Planning and Product Design	30		30		60	40	100	4
M3 Production Management	30		30		60	65	125	5

Sub-module: WELDING TECHNOLOGIES

M1	Joining Technology	30	30	60	40	100	4
M2	Welding Process Equipment	30	30	60	40	100	4
M3	Materials and Product Testing	30	30	60	65	125	5

Module: MECHATRONICS

Sub-module: MECHATRONICS

M1	Controlled Electric Devices	30	30	60	40	100	4
M2	Industrial Automation	30	30	60	40	100	4
M3	Hydraulic and Pneumatic Systems	30	30	60	65	125	5

Module: AVIATION

Sub-module: AIRPLANE PILOT / HELICOPTER PILOT

M1	Air Navigation 1	60	45	105	45	150	6
M2	Aviation Phraseology	30	30	60	40	100	4
M3[a]	Aviation Law and Regulations	45	15	60	15	75	3
M3[b]	Aviation Medicine and Psychology	70	0	70	5	75	3

Sub-module: AIRCRAFT DESIGN AND MAINTENANCE

M1	Light Aircraft Structures	45	30	75	75	150	6
M2	Aircraft Maintenance	30	30	60	60	125	5
M3	Aircraft Design	30	30	60	65	125	5

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

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

Table 9.2c-3: Elective programme course sets in Year 3 (linked choice)

YEAR 3 – Elective programme course P1	Contact lessons					ΣSW	ΣWR*	ECTS*
	L	S	W	OW	ΣCL			
Mechanics of Non-metallic Materials[1]	30		30		60	40	100	4
Maintenance Technology[1]	30		30		60	40	100	4
Mechanics of Aircraft Flight [2]	30		30		60	40	100	4
Mechanics of Helicopter Flight [2]	30		30		60	40	100	4

[1] Elective programme courses in modules: PPE, DOM, PRO and MEC.
[2] Elective programme courses in module: AVIATION.

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

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

Table 9.2c-4: Elective programme courses in Year 3 (free choice)

YEAR 3 – Elective programme course P2	Contact lessons							
	L	S	W	OW	ΣCL	ΣSW	ΣWR*	ECTS*
Construction Materials	30		30		60	40	100	4
Plastic Product Design and Manufacturing	30		30		60	40	100	4
Heat Pumps	30		30		60	40	100	4
Precision Engineering	30		30		60	40	100	4
Heat Treatment Design	30		30		60	40	100	4
Joining and Heat Cutting of Materials	30		30		60	40	100	4
Computer Integrated Manufacturing	30		30		60	40	100	4
Engineering Acoustics	30		30		60	40	100	4
Materials in Power and Process Engineering	30		30		60	40	100	4
Lubrication Engineering	30		30		60	40	100	4
Production Metrology	30		30		60	40	100	4
Hydropower Systems	30		30		60	40	100	4
Welded Structures	30		30		60	40	100	4
Fundamentals of Laser Technology	30		30		60	40	100	4
Vehicle Transmissions	30		30		60	40	100	4
Wear Resistance Surface Engineering	30		30		60	40	100	4
Material Handling Systems	30		30		60	40	100	4
Materials Weldability	30		30		60	40	100	4
Mechanical Process Engineering	30		30		60	40	100	4
Machine Tool Design	30		30		60	40	100	4

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

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

Table 9.2c-5: Elective general courses in Year 3 (offered by the Faculty)

YEAR 3 – Elective general courses	Contact lessons							
	L	S	W	OW	ΣCL	ΣSW	ΣWR*	ECTS*
Aircraft Operating Procedures	30		0		30	45	75	3
Helicopter Operating Procedures	30		0		30	45	75	3
Material Handling and Warehousing	30		30		60	40	100	4
Aircraft Engines 2	30		30		60	40	100	4
Sanitary and Fire Protection Engineering	30		30		60	40	100	4
Polymer Technology	30		30		60	40	100	4
Technical Safety	30		30		60	40	100	4
Computer Data Processing Fundamentals	30		30		60	60	100	4
Air Navigation 2	50		45		95	30	125	5
Aircraft Performance	60		60		120	5	125	5
Helicopter Performance	60		60		120	5	125	5

L - lectures	CL - contact lessons	CGC - Compulsory general course
S - seminar	SW - hours of student's personal work	CSC - Compulsory specialised course
W - laboratory work	WR - total work required	ESC - Elective specialised course
OW - other work	CS - course set	EGC - Elective general course

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

10. Information on the Available Elective Courses and Mobility

The study programme offers optionality only from Year 2 on, that is after the student has chosen one of the modules offered by the study programme. In this regard the optionality is very high; following his/her ambitions and professional preferences the student can choose among five modules which are branched further into several sub-modules each.
Although the optionality is substantionally reduced on the module level of the study, it is still an important line of the curriculum. Thus, the student continues his/her professional education in accordance with the specialized compulsory and elective topics defined by the module and sub-module curricula. The study programme consists of twelve sub-modules, two of them from the aviation field. Of total 180 credit points the student activities amounting to 105 credit points (58,3•% of the programme; CGC: 27 ECTS, or 15,0%; CSC: 78 ECTS, or 43,3•%) are mandatory in the integrated part of the programme. On the module level 25 credit points (13,8•%) are obtained from compulsory courses (CSC: 25 ECTS, or 13,8•%) and 21 credit points from ellective courses (ESC: 21 ECTS, or 11,6•%) considering sub-module curricula. The remaining 29 credit points are obtained through external optionality (EGC: 9 ECTS, or 5.0%), one-month practical training (PRT: 8 ECTS, or 4,4•%) and diploma work (DIP: 12 ECTS, or 6,6•%).

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. Programme Courses Presentation

001_**Engineering Mathematics 1** (6 ECTS): The course provides a transparent and in engineering oriented introduction to main areas of mathematics, as necessary for technical studies. After an introduction to set theory and numbers the spatial vectors are presented as one of the essential resources in engineering, which is followed by basic concepts of sequences, limits and functions. Within the theory of functions derivatives are defined and their intuitive meaning presented, which is followed by their application to extremum problems and function approximation using the Taylor series expansion.

002_**Engineering Physics** (7 ECTS): Introduction. Kinematics. Mechanical energy. Gravitation. Solid bodies and fluids. Temperature. Thermodynamic processes. Vibrations and waves. Sound. Electric field and electric current. Magnetic field and magnetic induction. Wave optics and optical instruments. Quantum, atomic and nuclear physics.

003_**Technical Documentation** (6 ECTS): The course consists of two parts - the basic descriptive geometry (~ 1 / 4) and the basics of technical drawing (~ 3 / 4) 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: the determination of the true shape and size by means of rotation and colinear/affinity similarity, determination of cross sections of planes and simple curved surfaces, surface meshing of solid bodies, determination of intersections lines or curves through the plots and solving simple intersections of bodies. They are acquainted with the basics of descriptive geometry necessary for using modern 3D modelling tools (CAD), as well. 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.

004_**Electrical Engineering and Electronics** (5 ECTS): The 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.

005_**Energetics and Environment** (3 ECTS): The course consists of three basic parts: the environment, energy and process engineering. The environment is discussed with regard to the impact that the human behaviour in a modern society has on the processes and quality of environmental spheres. Principles of a sustainable development and the importance of maintaining the quality of environment are presented first, which is followed by a description of the natural processes in environmental spheres and the reasons why those processes have begun to change in the industrialization era. The most important anthropogenic sources of pollution from noxious gases to dust, heavy metals, radiation and noise are presented. In the second part of the course the power energy technologies, supplying the civilization with the energy, are elaborated. Students get acquainted with the techniques of power supply and energy conversion, in particular with reference to environmentally friendly energies, exploitation of renewable energies and finite energy. The methods and procedures of efficient energy usage are presented. Finally, the reasons why and where environmentally harmful substances occur in those processes together with consequences of their environmental release are investigated. Students get acquainted with the concept of emission and immission, environmental monitoring and requirements for the environment protection. In this regard technologies to reduce air emissions and water pollution, strategies and technologies of waste materials management are presented.

006_**Informatics and Computing** (3 ECTS): Basics of information technology - a unit of information, information capacity and information coding. Digital representation of different kinds of information used in computer processing; the difference between digital and analog data. Computer architecture and functioning of a computer. Computer hardware - storage devices and media, input/output devices, computer networks. Computer software: operating systems and system tools, programs for word, spreadsheet and image processing, computer programs for design, numerical modelling, numerical analysis and results display.

007_**Engineering Mathematics 2** (6 ECTS): The course introduces the definition of indefinite and definite integral and methods for its calculation, which is followed by some applications from infinitesimal calculus – area and volume calculation. In the continuation basic concepts from the theory of functions of several variables and the definition of partial derivatives is given. Solution to unconstrained and constrained minima and maxima problems. In the final part of the course the fundamentals of differential equations with their physical background are given. Types of differential equations that can be solved with elementary methods, such as equations with separable variables and linear differential equation with constant coefficients, are considered.

008_**Engineering Mechanics 1** (10 ECTS): Introduction to the statics; axioms and laws of mechanics. Equilibrium analysis of force systems; the definition of a beam structure and its supports. Statics of beam and truss structures. Statics of ropes. Friction. Static cross-section area characteristics. Introduction to the strength of materials; stresses and strains, stress-strain relationship. Basic and complex loading cases. Stress analysis of basic loading cases. Stress analysis of complex loading cases. Buckling of rods. Statically indeterminate structures. Fundamentals of membrane structural elements.

009_**Product Conceptualisation and Systems Design** (5 ECTS): Natural processes and systems in conjunction with technical processes and systems. Environment and products that provide certain functionality. Product features in conjunction with the technical process. Structured construction of machinery and equipment. Integrating functions of the products in a structural assembly. The difference between R&D design process and pure design approach. Definition of the main, auxiliary, complementary and linking functions for a product or technical system. Demonstration of products developed in R&D design process from a view point of fulfilling the required functionality. Case studies of designing technical systems and building up links on the level of individual product features. The definition of information representing a product or system. The structure of technical documentation in conjunction with the structure of a product or technical system. The system analysis and design. Examples of design using the system analysis.

010_**Measurement** (5 ECTS): The introductory part of the course is designed to display general practical importance of measurements in engineering practice, which is followed by the inventory of fundamental metrology concepts in engineering metrology. Emphasis will be placed on the measurement of physical quantities and their relationship. The metrology infrastructure in Slovenia will be roughly commented. In the continuation the theoretical basis of statistical processing, evaluation and presentation of measured values will be given. The central part of the contents is a description of the essential elements and components that build up a measuring chain. Physical, signal, measurement and metrological characteristics will be given, along with the peculiarities and limitations of modern measuring devices and accompanying monitoring methods for measurement of the mechanical and thermodynamic process state quantities in mechanical engineering.

011_**Production Engineering** (4 ECTS): Students learn about the possibilities and limitations of manufacturing processes and systems, starting from conventional technologies, like machining, forming and welding, making acquaintance with non-conventional technologies as well, and finishing with manipulation and assembly systems. Trends of modern production engineering including concurrent engineering and engineering economics are highlighted, as well as the role of a technology engineer in the production process. The following technologies: turning, milling, forging, extrusion, deep drawing, turning, chip formation, planing, drilling, threading, sawing, grinding, honing, superfinish, polishing, plasma, flame and laser cutting, EDM and abrasive water jet cutting are presented in this context. The principles of sustainable development and issues regarding environment protection are emphasized.

012_**Engineering Materials** (5 ECTS): Introduction to materials structure and behaviour: Understanding of crystal structure and microstructure, crystal size and microstructure properties, atoms, inter-atomic bonds and crystallization of the basic crystal lattice, defects in crystals and crystal grain boundaries. Mechanical properties of materials: Tensile and bending test, tension force-elongation diagram, tensile and bending strength, yield stress, strain. Hardness: Overview of measurements of hardness, toughness, static and dynamic strength, fatigue and creep of materials. Phase diagrams and alloys: Definitions and basic concepts, typical binary diagrams, lever rule, phases and microstructure of Fe-Fe_3C system. Microstructure and properties of steel and iron-based castings; applications. Fundamentals of heat treatment of steel: Dependence of phase transformation on the heating and cooling

rate. A brief overview of annealing, hardening and tempering. Non-ferrous metals and alloys based on Al, Mg, Cu (brass, bronze), Ti, Ni, Zn, alloys for bearings, brazing. The casting technology with a summary of foundry techniques. Fundamentals of metal- and alloy-forming to a semi-product: Rolling, drawing, profiling and extrusion. Powder metallurgy: Powder production and preparation, pressing, sintering, further processing. Fundamentals of chemical and electrochemical corrosion with an overview of the types of corrosion and procedures for corrosion protection. Ceramics: Crystal structure, mechanical and thermal properties. Polymers: Thermoplastics, duroplasts and elastomers. Composites: Definition of a composite, characteristics of phases in composite materials, types and properties of composites. Concrete and wood: Composition and its impact on mechanical properties.

013_**Engineering Thermodynamics 1** (6 ECTS): Thermodynamics deals with a topic that is extensively used in engineering, biology, chemistry and physics. Historically, it had evolved from heat engines as a typical mechanical engineering discipline, but later it developed into a natural science discipline. Engineering thermodynamics is used today not only in the construction and development of engines, heating and cooling systems, but also in the integrated electronic components and in a number of other areas all the way to economics. This course gives basic concepts and definitions, such as the thermodynamic system, control volume, state variables and standards in thermodynamics. Students get acquainted with the effect of temperature on the properties of matter, in particular in gaseous state. The ideal gas equation of state and the first law of thermodynamics are explained, which is followed by the second law of thermodynamics. In the context of the latter recoverable and unrecoverable processes, entropy and its properties, loss of work due to irreversibilities, energy as the sum of exergy and anergy are discussed. At the end the most representative applications of the right and left cyclic processes are given.

014_**Engineering Mechanics 2** (8 ECTS): Introduction: Explanation of basic concepts, the correlation between a real engineering system in the dynamics and a corresponding dynamics model, momentum equation, the methodology of solving problems in dynamics. Dynamics of a mass particle with reference to applications in mechanical engineering: Force, mass, acceleration, linear and curvilinear motion, work and energy (kinetic, potential), power, efficiency, impulse and momentum, angular momentum. Dynamics of a system of mass particles: Motion of the center of the mass system and the corresponding energies. Dynamics of rigid bodies: Definition of mass moments of inertia and their variation when subject to parallel shift or rotation of the coordinate system; principal values. Planar motion: translation, rotation, general motion. Rotation around a fixed axis, mass-static and dynamic balancing of rigid rotors with a determination of the flywheel. Collisions: Speed analysis in co-linear collision. Fundamentals of mechanical vibrations: Free and forced vibration of a one degree of freedom system, undamped and damped oscillations, harmonic and centrifugal excitation, resonance of rotating one-mass flexible rotors, vibroinsulation characteristic. Fluid Mechanics: Euler's equation, Pascal's law. Free surface level of a fluid in a translationally and rotationally moving container. Fluid forces on the container walls. Buoyancy and stability of floating bodies. Fluid dynamics: Types of motion, continuity equation, Euler's and Bernoulli's equation and their application, sound speed, flow of viscous fluids in pipelines.

015_**Machine Elements 1** (6 ECTS): Development and production technical system, technical system linked to operation, maintenance, regeneration and recycling. Basic principles of design, design generation and its evaluation. 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. Springs: Steel, rubber and pneumatic springs. Bearings: Fundamentals of friction, lubrication and cooling, sliding and roller bearings. Seals. Clutches: Principles, rigid couplings, position aligning, flexible connections, switching conditions, one-way clutches and brakes, torque and

rotational speed safety limitations torque limit and rotational speed, safety and start-up clutches.

016_**Heat and Mass Transfer** (5 ECTS): The subject gives basic and useful knowledge on energy and mass transport phenomena resulting from the thermal gradient and mass concentration gradient in the mixture. Through individual heat transfer mechanisms (conduction, transfer and radiation) the student acquires insight into the fundamental laws, and discovers the way of their possible application. Linkage of all three mechanisms is studied by analysing heat transfer case-studies envolving heat transfer through structural elements in mechanical and civil engineering. To intensify heat transfer, especially in a gas flow, the use of extended surfaces is presented as the best-known measure to compensate for the lower heat transfer coefficient. The acquired theoretical knowledge is then applied in heat exchangers design and analysis by making use of methodologies for calculation and sizing up. Exposition of the mass transfer topics is given with reference to already gained knowledge on heat transfer; the analogy between mass and heat transfer at low mass transfer rates. A relatively great complexity of the experimental acquisition of empirical data concerning the mass transfer is exposed. Fortunately, in deriving fundamental relationships in mass transfer we can take advantage of the existing analogy between heat and mass transfer.

017_**Machine Elements 2** (5 ECTS): Transmission and transformation of rotary motion, transformation parameters (ratio and efficiency). Gears: Wheelbase, gear ratio and efficiency. Friction based and shape based principle of transmission. Friction drives, 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. Pressure vessels, piping and shutoff elements: Cylindrical flanges, bottoms and lids, seals, bolted connections, piping and shutoff elements.

018_**Programming and Numerical Methods** (5 ECTS): Introduction to Programming with Matlab. Algorithms and flowcharts. Constants, variables, functions and expressions. Vectors and matrices, matrix calculus and related tools. Character type variables. Reading input data and writing results. Simpler and more sophisticated graphical presentation of data. Logical expressions and control statements. User defined functions. Introduction to Numerical Methods: Source and propagation of errors through numerical calculations. Methods of solving systems of linear equations, basic methods and computational tools. Methods of interpolation and approximation. Methods of solving non-linear equation and systems of non-linear equations. Numerical differentiation and integration. Numerical solving of ordinary differential equations. Symbolic variables and expressions, computation with symbolic expressions, polynomials, analytical solving of equations and systems of equations, differentiation and integration, Taylor series and general series, solving eigenvalue problem, Laplace transformation and inverse Laplace transformation.

019_**Fundamentals of Control** (5 ECTS): About cybernetics, administrative system and control system; examples from the history since the days of the Industrial Revolution to the present day. General starting-points, methods and objectives of the course. Block diagram of a control system. Ways and means of displaying the dynamic properties of components in control systems; application to individual areas of engineering (mechanics, thermal engineering, electrical engineering, hydraulics, ..., case of a compound widget of second-order). About analogy in general; practical application of analogy between mechanical and electrical systems. From a conceptualisation to the realization of analog computer circuits. Elements of control systems theory (linearization, control loop equation and characteristic equation of the control system); application to a hydraulic servomotor in a position-control system and temperature-control feedback control system. Behaviour of the control system; analysis of the control system behaviour using transfer functions and impulse transfer functions, description of the P, I, D controllers behaviour, dynamic accuracy of the control

system response, effect of the parameters (size and nature) built in the control system on the accuracy. The frequency methods (frequency response characteristic and frequency diagrams). Stability of the motion of a control system and how to configure the parameters of control devices. Discrete systems. Building elements of control devices (sensors, controllers, commands). Construction and starting up of control systems.

020_**Energy Production** (5 ECTS): The course deals with the conversion of primary energy into heat, mechanical work and electric power. Since the largest share of primary energy, besides the potential energy of water and wind energy, is in the form of chemical internal energy of fossil fuels, there is a whole chapter dedicated to fuels, chemical composition of fuels, combustion, control of combustion, smoke composition and ecological consequences of the smoke release or the use of fossil fuels. The following section discusses the processes in thermal power plants, where basic components are steam boiler, steam turbine, steam elements and condensor. For all these elements construction and operating principles as well as functional characteristics of the thermodynamic circular processes are discussed. Then follow the conversion of potentials of water flows into mechanical work and electricity in hydroelectric plants. The essential nature of these systems, the description and characteristics of different types of water turbines, hydrological conditions and characteristics of different types of storage is emphasized. This is followed by a desription of the basics of internal combustion engines, which are potentially, having the effect of thermal propulsion machinery highest energy conversion efficiency of primary energy into mechanical work, more suitable alternative for heat and electricity production or mechanical work.

021_**Engineering Thermodynamics 2** (5 ECTS): The course which is the continuation of Engineering Thermodynamics 1 covers the basic features of single-phase, two phase and binary real substance (examples: natural gas, water and water vapor, moist air and binary mixtures) and their use in energy and process engineering. Students become acquainted with the basic principles of combustion and the third law of thermodynamics. Also the basic principles of fluid flow important in thermodynamic studies are discussed. On those principles is based the quality evaluation of thermodynamic processes in power, process and environmental engineering, including the energy transmission and distribution systems and their monitoring.

022_**Energy Supply** (5 ECTS): Energy supply is crucial for normal life and functioning of the economy. Students will gain knowledge for the technical realization of systems for energy supply and management of such systems with a view of achieving the highest possible reliability and energetic efficiency. Characteristics, common features and specifics of district heating, district cooling and gas distribution. Methodologies for determination of flow conditions in pipes and pipeline networks. Review of system elements, such as pipeline networks, fittings, heating and cooling stations and compressor stations. Description of methods and measures used to maximize reliability and to minimize energy losses (heat losses in district heating, heat load in district cooling) of individual supply systems. In the end, some methods of control and management of these systems are elaborated from view point of ensuring the highest possible level of reliability and thermo-economic efficiency.

023_**Engineering Design Methodology** (5 ECTS): The purpose of the course and program. Product as a technical system with demonstration examples and analysis. The boundary of the technical system. General information on the product function, design model, functionality and technical design. The definition of functional requirements (common, complementary, etc..), the morphological matrix and assessment methods. The division of functions into levels and derivation of the links between individual levels. Working principles, definitions and characteristics of the design process. Assembling of the product features; respective assembling criteria and assessment methods. Connection of different working principles into a system. Product design in view of the technology feasibility. Case-studies with design derived upon technology, processing, manufacturing, assembling and transport requirements. Ergonomics and its impact on the product. Demanufacturing technologies and design for recycling.

024_**Product Effectiveness** (5 ECTS): Concepts, definitions and product attributes. Effectiveness and cost. Basic models of reliability. Impact of product structure on reliability. Reliability assessment; goals, reliability allocation, assessment methods). Failure modes with analysis of potential failures and their consequences. Safety analysis and the tree structure of damage. Maintainability and maintainability assessment; goals, maintainability allocation, assessment methods. Fundamentals of supportability and availability.

025_**Engineering Mechanics 3** (5 ECTS): Methods of stress, strain and displacement structural analysis. Sizing up and cross-sectional optimisation of the elements of a structure subject to demanded load carrying capacity and functionality requirements. Elasto-plastic analysis and sizing-up of cold-rolled semi-products considering plastic hardening. Limit stress analysis. Design and stress analysis of lightweight structures. Harmonic oscillations and the corresponding description in terms of periodic Fourier functions. Impact of material and geometry on the vibration behaviour. Discussion on the most appropriate choice of materials to be built in the structure. Basic methods for sizing-up structures made of composite materials.

026_**Fundamentals of FE Analysis** (5 ECTS): The course will present the basic elements of the finite element method (FEM), a powerful computational means for solving technical problems, especially with regard to the analysis of mechanical or thermal response. A short theoretical background of FEM will be given with the emphasis put on a description of the various types of finite elements and methods used to discretize the analyzed domain. Students will expertize in running a FEA computer program for problem case-studies, which involves several steps: building of a geometric model, domain discretization with FE, specification of the boundary conditions, the primary degrees of freedom, solving the resulting system of equations and presentation of the analysis results with a corresponding discussion. Assessment of the obtained results quality will be acquired by a comparative investigation considering different mesh density and FE type, as well as by a comparison to known exact analytical solutions.

027_**Technology of Materials** (5 ECTS): Single- and multi-component systems. Determination of microstructural transformations. Solidification of the melt: thermodynamic and kinetic treatment of solidification of metals, cooling of the melt, nucleation in the melt, crystallization, grain boundaries, dendritic structure, properties of castings. Ingot pouring, continuous casting, investment casting, die casting, the rules of good casting, change of equilibrium diagram upon the increase of cooling rate, segregation, defects and damage due to the melt shrinkage during the solidification and further cooling of the melt, shrinkage cavities, gas bubbles and porosity, residual stresses, distortion. Ternary and multi-component alloys: formation and use of ternary diagrams. Overview of the alloys with intermetallic compounds. The impact of the steel cooling rate on the resulting microstructure: slow cooling, rapid cooling – hardening, quenching agents and phases of hardening. Time-temperature transformation and continuous cooling transformation diagrams: construction of TTT diagrams, the mechanism and morphology of pearlite and bainite formation, martensitic transformation. Hardenability and through-hardenability: tests according to Jominy and Grossman, the impact of carbon and alloying elements content, the impact of mass, coolant and the size of austenitic grains. The effect of alloying elements on the kinetics of continuous and isothermal transformation of austenite, the selection of modes of heat treatment of tool steels, mechanical properties of steels with secondary hardening, tempering characteristics, defects in the hardening of tool steels. Stresses and cracks during hardening as a result of thermal and transformation stresses. Local and surface hardening. Chemo-thermal processes of surface hardening: case hardening, nitriding, carbonitriding. Hot and cold forming processes, the state and properties of material after the thermo-mechanical treatment in terms of microstructure, deformation necessary to complete the recrystallization, the differences between cast materials and hot or cold plastic-formed materials. Comparison of forming processes used in the manufacturing of different products from ferrous, non-ferrous and non-metallic materials or composites.

028_**Technology of Cutting Processes** (5 ECTS): Explanation and demonstration of cutting in scope of a non-demanding introduction to the theory of cutting, later focused on the cutting technology. Presentation of modern cutting processes (turning, drilling, milling, threading, reaming, grinding, polishing, superfinish, honing) in direct connection with simultaneous planning of cutting technology (prescription of cutting data, appropriate geometry and tool grades). The students will learn about modern cutting tools and materials, and use a databank of technological data to select the optimal cutting parameters for rational machining.

029_**Technology of Forming Processes** (5 ECTS): Deformation – unit strain, true strain, rate of deformation, anisotropy. Flow of material, determination of true stress-strain curves, analytical form. Ideal deformation work in one or more stages, with and without intermediate heat treatment. Change in hardness, heat and friction during the transformation. Force, work and efficiency. The effects on formability and its assessment. Deep drawing with and without holders, deformations, force, influence on the workability limit. Bending, precision, force, initial length. Cutting, force, gap between the cutting edges, precision. Forward and backward extrusion, tool load, precision. Drawing, rolling, stamping. Characteristics, loads and design of single-stage dies. Polymer processing. Injection moulding – drying of granulate, injection moulding cycle, the characteristics of machines and moulds. Powder injection moulding. Drawing of composite profiles, winding, tailored blanks, manual and machine lamination.

030_**Programmable Logic Controllers** (5 ECTS): Programmable logic controllers are an essential building block of modern industrial automation. The course with the same name provides the theoretical basis, practical knowledge and skills, facilitating the efficient use of programmable logic controllers (PLCs) in solving specific control tasks in the field of mechatronics and industrial automation.
The subjects covered deal with the theoretical foundations of logic control systems, structure and function of PLCs, their role and importance in modern industrial automation systems, their components, standard programming languages and computer tools for their programming, and the practical aspects of their use in the industrial environment. Selected examples of practical usage of PLCs in the practice are also presented.

031_**Introduction to Software Engineering** (5 ECTS): Introduction to ANSI-C programming language as the common denominator for the programming of small, medium and large-scale systems. Programming and software development for micro-computer control of process systems: determination of state transitions diagrams, definition of data structures, program structures and optimal use of available microcontroller memory. Software quality assurance for real-time operation. Programming and software development for distributed industrial process control, and distributed computer systems for the management of industrial processes. Fundamentals of object-oriented programming. The division of applications to distributed functional self-contained objects, the interfaces connecting them, and the information flows between them. Modular program design. Forming of software structures and the determination of transition diagrams. Simultaneous design of software architectures using the top-down and bottom-up approach. Advantages and trends in the development of high-level programming languages. Software technologies to provide connectivity for geographically-distributed information and communication systems. Software quality assurance. Development of software architecture before the coding. Advantages and complexity of teamwork. Periodic team reviews of software project. Linking into information systems: seven layer reference OSI communications model: description, importance of the model, examples of implementation. Overview of software technologies for the global connectivity of software units in distributed information and communication systems. Review and comparison of communication and electrical properties of industrial buses and network systems: TCP/IP over Ethernet, Profibus, Modbus, CAN, ZigBee.

032_**Flight Instruments** (5 ECTS): Students learn about the basic operation of flight instruments such as altimeter, airspeed indicator, Machmeter, variometer, gyroscope, Pitot-static system. They will learn the methods for calculating the necessary characteristics of individual instruments.

033_**Aircraft Aeromechanics** (5 ECTS): The primary purpose of this course is for the students to learn the theory of the formation of lift on an aerofoil, the theory of viscous and inviscid flow, the theory of subsonic and supersonic aerodynamics, and that they are able to calculate the lift and the drag for a given body submerged in a fluid. Students learn the methods for determining the lift and the drag for different types of fluid flow. They will be able to use different numerical methods to calculate the value of flow variables in a fluid and obtain the knowledge to assess the impact of assumptions and simplifications in the selected numerical methods.

034_**Aviation Meteorology** (5 ECTS): The general terms of atmosphere and standard atmosphere. Meteorological variables and weather conditions (energy sources, air temperature, air pressure, air currents, adiabatic processes in an unsaturated atmosphere, air humidity, adiabatic processes in a saturated atmosphere, clouds, precipitation, visibility).

035_**Non-destructive Testing** (5 ECTS): Staff certification and laboratory accreditation, standards of non-destructive testing. Planning and execution of non-destructive tests, documentation of results, interpretation of results, critical assessment of error magnitude, archiving of documents/records. Surface integrity: effects of different manufacturing processes on the surface conditions and surface layer, residual stresses, structural changes, changes in hardness, defects in materials, automation of material inspection during and after the machining and production process, case studies of non-destructive inspection of materials in single-part and serial production. Optical methods and borescopic inspection, the use of optical devices, types of borescopes, evaluation of surfaces and defects, documenting. Penetrant testing: physical foundations, testing methods, evaluation of surfaces and methods of documenting the condition of surface. Investigations of surface defects by magnetic methods: physical foundations, methods of magnetisation, types of magnetic particles and particle carriers, magnetic films, part demagnetisation methods, control systems, measuring the leaking field, presentation of results. Investigation of material properties and defects in materials using eddy currents: physical foundations, testing procedures, part inspection systems, presentation of results. Investigations using X-rays and gamma rays: physical foundations, types and forms of X-ray tubes, types of anode heads, overview of intensity measurement methods, image quality and internal unsharpness, determination of optimal distance between the tube and the tested part, defect assessment, protection against radiation. Material investigations using ultrasonic and acoustic emission: physical foundations, the generation of ultrasound, testing procedures, testing equipment. Ultrasonic probes, special testing procedures.

036_**Mechanics of Non-metallic Materials** (4 ECTS): Polymers are becoming increasingly important as structural materials. Their use in the industry is growing rapidly due to the advantages offered by these materials compared to the more traditional materials such as metals. Some of the main advantages are: simple forming, corrosion resistance, favourable relationship between strength and weight, multi-functional use... They are expected to withstand the loads over the entire lifetime. This requires predicting the long-term reliability of structural elements, which in turn demands the knowledge about the properties of materials. Building from polymers is quite difficult because the mechanical properties of polymers are strongly time-dependent, as opposed to the metals. The students will be acquainted with the skills necessary for the successful use of non-metallic materials in engineering practice. They will learn about the methodologies of characterization of time-dependant non-metals, as well as adopt the basic concepts of product design using these materials.

037_**Maintenance Technology** (4 ECTS): The role and importance of maintenance in small, medium and large enterprises. Monitoring and evaluation of maintenance costs over the entire machine or device lifecycle. The purpose and objectives of maintenance. Advantages and disadvantages of maintenance technologies; maintenance after the break down, time-based or preventive maintenance, predictive or condition-based maintenance, proactive maintenance. Basic techniques of preventive and condition-based maintenance; vibration analysis, signal recording and processing, using vibration analysis to diagnose damages, measures to reduce damages due to vibration, techniques to analyse oil and particles in oil, other techniques of predictive maintenance. The importance of on-line and off-line techniques to the maintenance process, reliability of the measured data and cost analysis of the above techniques. Organizational charts of maintenance.

038_**Energy Use** (5 ECTS): The course presents topics related to the efficient use of energy in buildings and in industry. The methods for evaluating the efficient use of energy, the methods of the energy management, the use of energy accounting and energy audit in buildings and industrial processes are presented. The criteria for energy use and energy performance certificate are given. Measures and methods are given for improving the efficient use of energy, together with an economic evaluation. A model for the basic evaluation of energy investment projects is presented. A model of energy flows in buildings and industry is given, with a model for predicting the energy use. The requirements/measures for improving the efficient use of energy in the building envelope, devices and systems for heating, ventilation, cooling, air conditioning, hot water, technological processes, etc. are presented. A special emphasis is placed on energy use in buildings and industry. The concept of industrial production is always related to the use of energy and energy products and the systems making this possible are presented. In addition to electricity, the following energy products are manufactured: fuels, hot water and steam, and hot and compressed air. These energy products are used directly or indirectly in the technological processes. Also discussed is process water, its preparation, use and regulations on its release into the environment. An important chapter are energy audits, presenting the principles of efficient use of energy, the procedures for improving the energy efficiency and the basic principles of process heat recovery. This is followed by complete energy systems and their energy efficiency, with the possibility of self-sufficient energy supply for buildings. Energy-consuming specific industrial ventilation is the final topic of the course.

039_**Fluid Movers** (5 ECTS): Fluid-moving turbomachinery (fluid pumps, and gas compressors and fans) form the basis of equipment and every system that is moving or is itself moving any medium. They are present where there is lubrication, cooling, heating or ventilation, or a technological process involving any moving medium. In order to be able to manufacture or service a fluid-moving turbomachine, we have to know its operating principles and structure, as well as its performance. When necessary, we also have to be able to measure the performance. In this course the students will gain the necessary theoretical background, learn the principles of operation, get to know the necessary measurement equipment, the regulations, the process of maintenance, as well as learn how to select a new fluid-moving turbomachine. The exercises qualify the students to verify in practice the theoretical interpretations given in the lectures, and enables them to make a picture of the importance of fluid-moving turbomachinery for the operation of systems or processes.

040_**Internal Combustion Engines** (4 ECTS): Internal combustion engines are still the most energy-efficient propulsion systems, converting the energy of fuel into useful mechanical work with the highest total energy efficiency. In addition to their efficiency, they are able to produce a lot of work/power from a unit of displacement, with environmentally acceptable emissions of harmful substances in the exhaust gases. They are therefore still an indispensable propulsion unit in all forms of transport. The effectiveness of operation is linked to an effective preparation of the mixture in the cylinder, proper intake and combustion, which should be as good as possible to maximize the use of fuel and minimize the formation of

undesired combustion products. These requirements are met through proper structural design and engine equipment. High mechanical and thermal loads of engine parts are eliminated by adequate cooling, design of components and method of heat removal. The engine power can be increased by turbocharging. Modern alternative vehicle propulsion technologies include hybrid drives, which usually consist of internal combustion engines and electric motors. Furthermore, vehicle drive units can also be realised by fuel cells.

041_**Effectiveness and Reliability of Energy Systems** (4 ECTS): First part of the course deals with the efficiency of energy systems in order to stimulate the students for responsible and rational use of energy. In this context it is considered: inventory of industrial energy process, selection of energy balance layer, determination of efficiency of technological processes, energy-saving methods and their effectiveness; recovery, insulation, tightness, a tiered approach in the exploitation of waste heat from industrial processes, causes of equipment degradation, lower efficiency, revitalization of equipment, interconnection of energy and cash flows, statistical indicators and targeted monitoring of the use, practical applications. The second part deals with the operation of energy systems in terms of security. The topics discussed are: the importance of reliability in engineering, deterministic treatment of failures, physical causes of failures, degradation models, monitoring, statistical treatment of reliability, mathematical models and definitions, distributions of reliability, the importance of system maintenance, treatment and impact on the availability, spare parts, mathematical model of maintainability and reliability, system architecture and reliability, evaluation and prediction of device reliability with respect to the structural design of a device, the application of theory to case studies: the reliability of turbomachinery, reliability of energy systems, thermal power plants, nuclear plants, gas turbines.

042_**Advanced Technologies in Energetics** (5 ECTS): The course Advanced technologies in power engineering provides a systematic treatment of the concepts of energy conversion technologies, their limitations in terms of energy efficiency, use of raw materials, environmental strains and socio-economic sustainability. During the course the students learn about: technological measures to reduce the negative environmental consequences of the use of modern technologies in the energy sector, such as sequestration and storage of carbon dioxide, the strategy of using alternative primary energy sources and technologies for their successful integration into the energy supply, technologies for a sustainable use of energy from the biomass, modern trends of nuclear technology development (fission and fusion), the basic processes of extraction, storage and transport of hydrogen, using hydrogen fuel cell systems and the integration of decentralized production units into user networks.

043_**Building Services Engineering** (4 ECTS): The course allows the study of mechanisms of the indoor environment, energy use and consequential emission of harmful substances into the atmosphere. Students learn about the influence of external environmental parameters that affect the conditions in the building. Meteorological base: weather dynamics, external air temperature, models for the determination of external air temperature, wind, solar radiation. Degree days and use of energy. Criteria for the indoor environment and effects on the comfort and the health risks to the users of the rooms. Thermoregulation in humans and causes of SBS syndrome. Thermal environment and air quality, and models. Physical mechanisms of impurity transport. The effectiveness of ventilation and air age, models of removal of harmful impurities. Modern indoor environment - work productivity-economics. Heat loss and cooling load of buildings. Modeling building energy flows. Transformation of fuels. Substances as a medium for heat/cold transfer. The distribution of air flows in a room. Basic characteristics of heating, ventilation and air conditioning technology. Innovative HVAC technology for low-energy and passive buildings and the importance of architectural design for the shape factor of the building. One-dimensional and steady flow in pipes and pressure drop calculation. Sizing pipes, balancing and testing of pipelines. Properties and classification of gases. Characteristics of gas pipelines, gas distribution networks and the elements of building gas installations. The importance of intelligent building systems and control.

044_**Heating, Cooling and Air Conditioning** (4 ECTS): The course provides the foundations for the planning of machine installations in buildings and industry. The purpose is to provide effective heating, cooling and air conditioning devices and systems. Energy use and environmental impact. The elements of heating systems such as heat generators with an emphasis on condensation and biomass-fired boilers, radiators, piping, safety devices, fittings, components of cooling systems such as compressors, cooling towers, components of air-conditioning systems such as filters, heaters, refrigerators, dryers, air humidifiers, fans, circulating pumps, silencers, ducts; end (intake and drainage) elements are presented, followed by heating systems, such as local and central heating, low-temperature and high-temperature systems, convection and radiation systems, and single pipe and feed-and-return systems. Air Systems. District heating. Cooling systems, cooling processes, coolants used. Ventilation systems - natural, hybrid and mechanical ventilation, special and innovative ventilation designs, local ventilation. Air conditioning systems and their classification, air systems, single-channel and double-channel, air-water systems, induction devices, double-pipe, three-pipe and four-pipe systems. Systems using fan coils. Chilled beams. The regulation, control and protection of devices and systems. The course ends with a synthesis of content, including methods and criteria for system design according to the intended purpose of the building or the technological process, respectively.

045_**Renewable Energy Sources** (5 ECTS): Energy supply is an important aspect of approaching the goal of sustainable development, mitigation of climate change and reduction of disparities in the social development. Renewable energy sources (RES) can significantly contribute to achieving this goal. The necessary condition is engineering know-how we want to provide to the candidates during this course. The candidates are first acquainted with the types, characteristics and potential of various renewable energy sources. Later they learn about the physical, chemical and biological processes that occur in the conversion of RES, followed by the presentation of technologies. We will present the theoretical and technical efficiency of devices and systems, as well as the design methods. Considering that today more than a third of all final energy consumption is spent in buildings, the potential supply of buildings with heat, cold and electricity from renewable energy sources will be discussed in greater detail. In addition to the knowledge needed to design devices and systems, the students will acquire the necessary knowledge for the environmental impact assessment and economics of renewable energy conversion systems. The candidates will therefore be able to successfully participate in interdisciplinary working groups with colleagues of different professional profiles.

046_**Process Engineering** (4 ECTS): Introduction: the scope of work and mutual entanglement of thermal-, mechanical-, bio-, chemical- and environmental-process engineering. Basic thermodynamics of separation processes: mixtures and solutions, binary systems, vapor-liquid equilibrium, Raoult's law of ideal solutions, Henry's law, database of thermodynamic properties of pure substances and mixtures. Evaporation: boiling, boiling curve, non-continuous and continuous evaporation, types of evaporators and their application. Distillation and rectification: McCabe-Thiele diagram, reflux, tray and packed columns, binary enthalpy diagram, separation of azeotropic mixtures. Absorption, adsorption, crystallization, extraction: physical foundations, process, influencing parameters and criteria for the selection of procedure and equipment, using the McCabe-Thiele diagram and the binary enthalpy diagram. Drying: humid air, h-x diagram and exergy diagram for humid air, multi-stage drying, dryer types, selection of the drying process, depending on the type of goods in the pharmaceutical, food and process industries, freeze-drying. Bioprocess engineering: microbiological and biochemical processes, bioreactors and kinetics of bioprocesses. Chemical reaction engineering: reactors and reaction systems, catalysis. Management and process control: batch and continuous processes, process models, operation and safety of process systems. Process engineering: economic, environmental and social aspects of process technologies and sustainable development, standards and recommendations (best practice methods, GRI, IPCC, ISO 14000 ...), the engineering code. Presentation of results of

project work executed in form of creative teamwork on solving practical industrial engineering problems in the field of process engineering.

047_**Tests Design and Validation of Process Systems** (4 ECTS): The teaching content includes the presentation of established statistical methods and approaches to design of tests, which are typical for the validation and acceptance of process equipment and systems in a real environment. Special emphasis will be placed on the methodology of acceptance tests, processing of measurement readings, choosing the appropriate measuring equipment, using the application software and computer, as well as using and commenting the valid European and international standards and recommendations dealing with the acceptance tests.

048_**Environmental Process Technology** (5 ECTS): Interactions between the cycles of elements in nature: carbon, oxygen, hydrogen, nitrogen, sulfur and phosphorus cycle, mineralization and biosynthesis, ammonification, nitrification and denitrification, substances that deplete the ozone layer, global warming factor. Membrane environmental technologies: membranes, micro, ultra and nanofiltration, recycling and recovery operation, reverse osmosis, ion exchange, electrodialysis, pervaporation, the determination of operating parameters for the recovery and recycling microfiltration. Bioreactor. Technology of technological and municipal waste waters treatment. Analytical methods and physical-chemical properties of waste water. Wastewater treatment plants and technology for cleaning of exhaust gases: devices for separation of gaseous impurities, devices for separation of particles from exhaust gases. Fundamentals of treatment plant control and management: organizational structure, maintenance, control. Process variables and dynamic process operation. Presentation of a computer-controlled system for the management of a treatment plant in the real environment. Monitoring: sources of industrial emissions and their monitoring at the source, assessment of conformity, and environmental reporting on industrial emissions, boundary values of emissions and the seriousness of consequences of environmental impact, direct measurements and replacament parameters, mass balances, calculations, emission factors; forming the databases - measurement of physical parameters, sampling, storage, transport and storage of samples, sample preparation and analysis, data processing and reporting of results, monitoring requirements - the source of pollution, location and time of sampling and measurement, feasibility of limitations upon the available measurement methods, conditions of implementation, conformity assessment procedures; reporting, quality assurance and control.

049_**Hydraulics and Pneumatics** (5 ECTS): Hydraulics and pneumatics is an area of mechanical engineering that is present in many engineering applications ranging from automation, machine tools and forming machinery, agricultural machinery to construction equipment, particularly in mobile and other mechanical applications, and particularly in heavy industry. Where such systems are installed, their value is generally between 20% and 50% of the total value of machinery or plant. The course only covers the basics of conventional hydraulics, proportional hydraulics and the basics of other continuously operating controls. In this course, the students will gain basic knowledge in the field of conventional and proportional hydraulics including the theoretical foundations for the calculation, design and maintenance in the practical application of hydraulic drive and control systems. Students will understand the basics of these systems, the design variants and the operation of major and widely used conventional and proportional components, as well as gain the basic knowledge for practical design of hydraulic controls and systems using these components. The acquired knowledge will be an appropriate basis for the maintenance of machinery and plants equipped with hydraulics, as well as a good basis for further upgrading the knowledge in this field on a higher level, mainly in the field of hydrostatic drives.

050_**Investment Engineering and Project Management** (5 ECTS): Basic concepts of investment engineering. The types of investments. Criteria for investment account. Methods of investment account. Static investment account (the calculation of economy and

profitability). Dynamic investment account (capitalized value method, method of internal interest rate, annuities method). Differential investment and the marginal value of capital. The time of replacement of capital goods. The documentation necessary to execute the investment (investment proposal, pre-investment study, feasibility study, preliminary design, technical documentation). Teamwork and creativity methods. Project definition and types of projects. Objectives and strategies of the project execution. Work breakdown and organization of project participants. Matrix of responsibilities of project participants. The methods of planning event and activity-based network charts (analysis of structure, time, resources and project costs). Supervision and management of the project execution. Computer-aided project planning and management.

051_**Steel Structures** (4 ECTS): Mechanical properties of steel sheet metal and their dependence on the direction of measurement, thickness and temperature, layered tear-out. Criteria for the selection of steel that is resistant to brittle fracture. Preparation of the weld grooves, welded joints systemization. Classification of weld defects, levels of acceptability of weld defects, statically loaded welded joints. Static strength of butt, fillet and other typical welds, design and sizing of statically loaded welded joints. Fatigue (dynamic) strength of welded joints, design and sizing of dynamically loaded welded joints, welded beams and columns of open and closed cross-sections, reinforcing elements in thin-walled structures. Welded truss members, welded truss members made of round and rectangular tubes. Welded arch beams and frames. Fundamentals of sizing pressure vessels, pressure vessel risk categories, design loads, materials for pressure vessels, test groups. Determination of the minimum wall thickness for internal and external design pressure. Welded pressure pipelines and distributors. Welded tanks and some other complex structures. Deformations of welded elements and structures.

052_**Design of Self-propelled Machines** (4 ECTS): Definition of technical process. Relationship between the natural and engineering systems and between the natural and engineering processes. Technical system for the field of design (Hubka). Examples of basic process functions and their transfer to system. The inventory of requirements, supplemented requirements and wishes for individual cases. Linking functions to operating principles. Variation of operating principles: presentation of existing principles and finding new ones. Properties of the design environment. R & K process according to VDI 2221. Seven-stage development-design process (HUBKA). R & K iterative golden-loop process (DUHOVNIK). The following examples are presented during the course: lifting mechanism, harvesting timber from the forest, and a mechatronic system for transporting debris. The second part of the lectures is devoted to the presentation of various work machines and devices performing certain processes. The lectures cover the fields of agricultural, construction, wood-processing machines and handling equipment. In this part of the lecture, students learn about specific technological processes for which the technical systems are being developed.

053_**Power Drives** (5 ECTS): Fundamentals, classification and components of drive assemblies (electric, hydraulic, mechanical). The basic states of electric drive components, characteristics of electric motors, a comparison of AC and DC motors, synchronous - asynchronous electric motors, control, operational states of electric drive system. Fundamentals and characteristics of hydraulic drive assemblies, designs of hydraulic drive assemblies and their components, sizing and selection of components, control, control hydraulics, transient phenomena in the operation of hydraulic drives, design of hydraulic drives. Mechanical drive assemblies with a constant gear ratio - transfer of power, classification of mechanical drives, components of drive assemblies and their properties, the basic equations for determining the load capacity of elements, the impact of material and surface treatment on the reliability of drive assembly components. The classification of planetary gears, external and internal gear ratio, velocity charts, power transmission modes. Types of drive assemblies with a variable gear ratio, automatic transmissions, power flow, regulation/control. Type of defects of drive assembly components, deviations and tolerances

of drive assembly components, play, the impact on the load capacity and efficiency of drive assembly components. Operation of drive assemblies - noise, types of lubrication and cooling, heating, losses and efficiency, types of drive assembly component damages and their causes. Trends of development in drive technology (materials, surfaces, structure).

054_ **Theory of Machines and Mechanisms** (4 ECTS): The course provides knowledge to facilitate a basic understanding of mechanism operation and design. An emphasis is given to the mechanisms in the industrial practice and everyday life. Students learn the parts of the mechanisms, different designs and operating principles for the common types of mechanisms, as well as applications. They learn the basic concepts of mechanism design theory: the kinematic pairs of lower and higher order, the structure of the mechanism, dead points, efficiency of the transmission of forces and torque, working and return strokes. We present an analysis of kinematics and kinetics for planar mechanisms and selected methods for the synthesis of selected four bar and crank mechanisms according to different requirements. Curve mechanisms, basic types of followers and cam curves and their characteristics are presented, together with the rules of curve mechanism formation. Students learn to use dedicated software tools to model the mechanisms and the possibilities of improving the function of mechanisms.

055_**Vehicle Engineering** (4 ECTS): The course deals with the vehicle as a mechatronic system, operating in an interconnection with the driver and the environment. We are dealing mainly with the vehicle operation, backed by the maintenance process. Emphasis is put on the specifics of different vehicles and on the specifics of the operating environment. Students learn about the vehicle assemblies, their functionality, their key importance for the function of the vehicle and for the safe and reliable operation. The specifics of characteristic vehicle elements are emphasized: engine, transmission, wheel assembly, chassis, steering, braking system, passenger cabin and loading space. Characteristics of vehicles in transport and impact on traffic.

056_**Traffic Logistics** (5 ECTS): The aim of this course is to acquaint the students with the basics of logistics of land, water and air transport, with a focus on inland road transport. The technical solutions of transport vehicles and their equipment, technical solutions of road infrastructure and information systems for transport and warehousing are presented, followed by the categorization of vehicles into groups with the main emphasises of each vehicle group. Road transport vehicles and their systems are discussed in detail. Teaching takes the form of lectures and exercises. In the lectures, the theoretical basis of logistics systems are presented first, and the knowledge gained is then applied to the use of logistics methods in land road transport. Exercises are divided into field and project work. During field work, the students learn about practical problems on the subject matter and their existing solutions. The project work involves finding solutions to concrete problems using the acquired knowledge and literature.

057_**Technical Diagnostics** (4 ECTS): Objectives and importance of the techniques used to diagnose defects in the stress zones of stationary load-bearing elements and in the tribologic contact of load-bearing elements under relative motion. The methods used for continuous real-time and periodic monitoring of equipment through their life. The purpose and objectives of the diagnostics. The inclusion of diagnostics into preventive or time-based maintenance, predictive or condition-based maintenance, and proactive maintenance. Foundations for the analysis of defects. Fundamentals of techniques for continuous monitoring of defects, analysis of operating parameters, vibration analysis, power consumption analysis, noise analysis. Basic techniques for periodic monitoring of defects: techniques for analysis of oil and particles in oil, other techniques. Procedures and the use of techniques: measuring, signal recording and processing, fault diagnostics using the diagnostic techniques, measures to reduce the damage, estimation of reliability of the measurements.

058_**Process Planning** (5 ECTS): The role of process planning in the company organisation structure. Process planning in individual, serial and mass production. Time standards (random recording of state time structures, time recording methods, method of predetermined times – WF system, calculating the times of main use of work equipment, setting of time standards for the worker and work equipment, SMED method and POKA YOKE method). Design function in process planning (graphical representations of product structure and bills of materials, determination of required materials). Technological function in process planning (types of operations and processes, methods of representing operations and processes, technological process, classification of technological processes according to structure and form, tools for creation of technological processes, lead time of operation and order, product book). Operative function in process planning (manufacturing launch and dispatching). Basic methods to define the layout of work equipment.

059_**Assembling Technology** (4 ECTS): Assembly technology is an area of mechanical engineering, which covers the recently increasing needs of modern market economy for an effective automation, and particularly rationalization and good organization of assembly function. As a part of the manufacturing system, the assembly function takes an average of 50% of the manufacturing time and up to 30% of manufacturing costs. Effective organization and rationalization of assembly is therefore becoming more and more important. During the Assembly Technology course the students will gain basic knowledge about product structure, assembly operations, assembly technology in a manufacturing system, assembly systems, automated and robotic product assembly, as well as about the planning, reliability and availability of assembly systems. Upon the completion of the course, the students will have the decision making ability in product design according to the possibilities of assembly, in understanding and designing assembly processes and systems, as well as the ability to select an appropriate assembly process and system for a certain manufacturing system. The skills obtained in this course will also provide a foundation for upgrading the knowledge in this field in the second stage of study.

060_**Alternative Technologies** (4 ECTS): In this course, the students learn the theoretical and practical possibilities and limitations of unconventional/alternative manufacturing processes. In this context, the trends of modern production, the role of the technologist in the manufacturing process, simultaneous engineering and engineering economics are highlighted. The following technologies are presented: sinker and wire electric discharge machining, laser, oxy-fuel and plasma cutting, electrochemical and ultrasonic machining, abrasive air jet processing and abrasive blasting. Emphasize is also made on environmental protection issues. Students will learn in detail about unconventional/alternative technologies, so they can take into the account their advantages when designing products and selecting and planning technological processes for a given product. They will be able to take into account criteria such as: material, foreseen quantities, requirements for precision and surface integrity, and environmental requirements. The adopted knowledge is directly transferable and applicable in industrial environments, as well as in successful further studies.

061_**Quality Assurance** (5 ECTS): In the modern market economy, the demands for quality are increasing, the customers are demanding and well-informed, and the competition between the companies in individual industries is exceptional. One way to ensure the growth of income and improved reputation is by deploying the modern way of providing quality products and services. Successful companies, having a clear vision for their businesses, build their success on the planning, management and provision of appropriate quality of processes, products and services, in accordance with international standards. In order to do that, they need adequately trained and qualified engineers. The students acquire basic knowledge about quality assurance, including the various aspects of quality, quality systems, as well as appropriate tools, techniques and methods to achieve the required goals. They learn about the existing standard models of quality management, their structure, trends of

development, deployment and possibilities of certification. They acquire the ability to find and use new information from various sources, as well as the ability to transfer this knowledge into the business environment when solving concrete professional problems in the field of quality assurance.

062_**Handling Systems** (4 ECTS): Material and Resource handling as a part of manufacturing logistics is crucial to the manufacturing process itself and to uninterrupted production. It directly impacts the manufacturing costs, lead times, capacity of manufacturing systems, as well as effectiveness and flexibility of production. In modern manufacturing, proper handling, warehousing and transport provides the opportunities to optimize the production. Computer integrated and automated manufacturing cannot be imagined without a good command of handling and logistic processes. The proper selection of handling equipment and systems supports flexible manufacturing and production, which is very important for small and medium-sized enterprises. In the course, the students will learn about logistic processes: warehousing, transport and handling, as well as logistic and handling systems. The course is divided into several autonomous topics. In the introduction, the basic concepts and definitions of processes and systems and their impact on production are given. The chapter on warehousing deals with the importance, types and formation of stocks in production, the type and automation of warehousing systems and with the ways of identifying and tracking the warehoused objects. The chapter on transport and transport systems deals with transport activities, all types of transport devices and methods for determining the capacity and resources, used for the storage of materials in warehousing and transport. An important part of the lectures covers the design of devices for positioning and clamping in different types of manufacturing, mechanization and automation of these devices, and the economic viability of clamping devices. For the automation of manufacturing, one needs to know the options and the components enabling it. Various automated handling systems will be discussed. The prerequisites for seamless manufacturing are material, clamping devices, information and tools. Tool management is a part of the logistic process in the production and encompasses activities, tool flow monitoring and tool supply. To shorten the manufacturing times, especially in the forming process, the students are acquainted with fast die change both from the organizational and the technical point of view.

063_**Technology Planning and Product Design** (4 ECTS): Technology is an integral part of product development. The organization of product development has an important role. In the modern parallel approach, more attention is put to process planning, so the implementation phase of manufacturing can be shorter. Product planning includes a comprehensive review for the preparation of project (the product), which is handed over to the company management. The management may (or may not) commit the financial resources to begin the "development" of the product. The path from idea to product is executed using the QFD system. Modern manufacturing requires product design for machining and assembly, at the same time taking into the account the ecology and recycling. The next important stage is the design/selection of technologies, where technology is an important activity related to economics. We therefore present a series of new and advanced technologies that enable the fabrication of a "product". These include forming, cutting, EDM, laser machining, water jet, high speed machining, die casting, plastic injection moulding etc. Finally, we will determine the technology (machinery, tools, and parameters) for the selected process and optimize the manufacturing process with respect to time and cost of manufacture.

064_**Production Management** (5 ECTS): Functions of production planning and control. Production planning and control systems. Planning the production program. Material requirements planning (material requirements planning goals, methods for rough and fine material requirements planning). Capacity planning (capacity planning objectives, available capacities, standard capacities, rough capacity planning, flow scheduling and determination of capacity requirements). Rough and fine order scheduling (goals of scheduling, static and dynamic scheduling of orders). Inventory management and control, and material

management (types of states of the material in the warehouse, determining the optimal manufacturing and supply quantities, material management). Alternative methods of production planning and control (MRP system, KANBAN system, load-oriented order release). Overview of computer-aided production planning and control systems (features of commercial PPC systems, and the selection and deployment of PPC system in the company).

065_ **Joining Technology** (4 ECTS): The importance of material joining and thermal cutting in practice is shown. The use of different welding, brazing/soldering, adhesive bonding, thermal cutting and metallization processes in industrial applications. Overview of procedures from a practical point of view. Review of materials that are most commonly welded, brazed/soldered or adhesive-bonded in practice. Overview of material properties that change during the welding upon warming and melting and that affect the joint properties. Fusion welding and cold welding. Comparison between welding, brazing/soldering and adhesive bonding. The differences and the use of thermal cutting by laser, arc and flame. The difference in the states of matter during heat cutting. After the exam, the students will distinguish between welding, brazing/soldering and adhesive bonding, and will be able to autonomously select the most appropriate process for concrete cases. From a practical point of view, we will present the properties of arc, plasma (blow effect), electron beam and laser, and their use in practice. Calculation of preheating temperature for most structural steels. Review of causes of residual stresses and strains in joints. Occupational safety for different welding, cutting and brazing/soldering processes in practice.

066_**Welding Process Equipment** (4 ECTS): Review of electrical phenomena (Biot-Savart force, Lenz's law, induction, magnetism, diode, thyristor, transistor) needed to understand the electric welding machines, such as transformer, rectifier, generator, inverter and synergic arc welding power source. Sloping and horizontal static characteristics of power source. Pulsed power sources. Welding devices with high energy density (laser, electron beam, plasma). Power sources and other equipment for resistance welding (spot, projection, seam, flash, high-frequency welding). Machines and equipment for welding with mechanical energy (ultrasound, friction, mash welding, welding with trimming). Equipment for flame techniques. Equipment for flame, plasma, arc and laser metallization. Brazing (torch, arc, laser). Accessories and auxiliary equipment such as welding tables, clamps, measuring equipment, equipment for the preparation of weld pieces and for processing of welds after welding, equipment for preheating of weld pieces and for heat treatment after welding, and more. The basic European safety regulations for welding equipment.

067_**Materials and Product Testing** (5 ECTS): The meaning and purpose of testing: historical background on inadequate treatments of materials and manufacturing technologies with an emphasis on welding and welds, determination of mechanical and physical properties of materials, tests performed at ambient temperature, at higher and lower temperatures, for static and dynamic loads; the significance of destructive and nondestructive tests. The aim of these investigations is to determine the state of material and its properties, meeting the requirements of the structure. Surface integrity: the influence of various operational processes, and processing conditions on the properties of surfaces and surface layers. Metallurgical aspects of destructive tests on different types of welds: tensile test, bending test, notched-bar impact test, tensile- shear test. Research of weld crack susceptibility according to Lihaj, Braun-Boveri, Kizel and Robertsou. Testing of relaxation in the tempering of steels. Visual inspection of surfaces: surface preparation, measuring devices for visual inspection of welds, optical devices for observation and evaluation of fracture surfaces, faults, undercuts and cracks on the surface of welds. Optical microscopy. Light spectral analysis. Borescopic inspection. Electron microscopy with microprobes. Penetrant testing. Magnetic methods. Eddy currents. Investigations by X-rays and gamma-rays: physical foundations, types and forms of X-ray tubes, types of anode heads, tube focus, overview of intensity measuring methods, image quality and internal unsharpness, determination of optimal distance between the tube and the tested part, fault assessment, protection against radiation. Ultrasound investigations:

physical fundamentals, generation of ultrasound, testing procedures, testing equipment, ultrasonic probes, special testing procedures.

068_**Introduction to Mechatronic Systems** (5 ECTS): Mechatronics is an interdisciplinary engineering field that combines the knowledge of mechanical engineering, electrical engineering and informatics. The aim of this course is to acquaint the students with the basic structures, components and specific properties of mehatronic systems. Basic structures of mechatronic systems and links between the elements and the environment are described (input and output variables, controlled parameters, signals, reference). Also presented are graphical tools for the presentation of system structure. The steps of design, building, start-up, operation and maintenance of mechatronic systems are presented. Emphasis is placed on technical security issues at start-up and during operation. The course is illustrated with many examples. Lectures are accompanied by demonstrations on teaching and laboratory equipment, developed for this purpose, enabling the students to actively participate and easily comprehend and accept new knowledge.

069_**Controlled Electric Drives** (4 ECTS): To begin with, the electric drives are presented as actuators in the general scheme of a control system. This is followed by a brief description of operating principle of electric motor drives: DC, asynchronous and synchronous. Given that these topics are already taught in the Electrical Engineering course, we will focus on the creation of a model for each drive. In addition to the conventional electrical drives mentioned above, we will briefly present the stepping motors and solenoids. This will be followed by a description of control using transistors, thyristors and rectifiers. The informative section of chapter on electric drive control will include the presentation of software solutions for control and the simulations.

070_**Industrial Automation** (4 ECTS): In modern industry, the introduction of robots and other automated devices in the context of flexible automation is a very common challenge. Flexible automation not only provides greater productivity, the focus is on the humanization of work and on increased quality. However, in order to achieve these goals it is necessary to educate and train engineers, so that in addition to traditional know-how about systems and processes they also grasp the fields of control, programming and integration, with the aim of achieving high productivity and quality with ever smaller batches, and high availability of automated devices and systems.
In this context, the student gains the knowledge about the use of basic building blocks that have been presented in previous courses, such as the fundamentals of mechatronic systems, fundamentals of control, programmable logic controllers, and integration technologies. This knowledge is upgraded in terms of individual specific topics related to the automation of logistics in an industrial environment, to flexible automation of work systems, and control and test equipment and systems.

071_**Hydraulic and Pneumatic Systems** (5 ECTS): Hydraulic and pneumatic systems are an area of mechanical engineering that is present in many applications of mehatronic systems, from robotics, automation, machine tools and forming machines, other mechatronic systems and agricultural machinery to construction equipment and other mechanical applications. In the recent years, the share of industries with integrated hydraulic and pneumatic mechatronic systems has been rapidly growing globally (up to 7% annual growth), reflecting the growing need for experts in this field and the increasing usefulness of hydraulic and pneumatic systems. The development of microelectronics and mechatronics in recent years has also greatly affected the development of hydraulic and pneumatic components and systems in the direction of micro and nano components and systems. The Hydraulic and Pneumatic Systems course will provide just the basics of conventional and proportional H&P components and systems, and the basic knowledge for designing (electro)hydraulic and (electro)pneumatic systems, H&P micro and nano components and drives, and pneumatic controls with PLCs. In this course, the students will gain basic knowledge in this field,

including the theoretical foundations for the calculations and design in the practical application of hydraulic and pneumatic systems. They will understand the basics of H&P systems, and the operation of important and widely used H&P conventional, electric and proportional components and systems. They will gain the basic skills to design H&P control systems from these components in practice. The acquired knowledge will also be an appropriate basis for the maintenance of mechatronic systems, equipped with hydraulic and pneumatic systems. The students will use the acquired knowledge as a basis for further upgrading the knowledge in this field on a higher level.

072_**Aircraft Engines 1** (5 ECTS): The course topics in the field of aircraft piston engines include an overview of basic configurations of engines according to the arrangement of cylinders for aircraft use. This is followed by an overview of major engine components and actuators, and a section on engine lubrication, cooling, and ignition systems. Aircraft fuels, preparation of the air-fuel mixture in the carburettor and fuel injection, basics of normal combustion of preprepared mixture and detonation combustion are discussed briefly. The impact of external atmosphere - changes in altitude on the engine's operation and performance is discussed. In this context, the mechanically driven superchargers and exhaust gas powered turbochargers are presented. Auxiliary systems assisting the normal operation of aircraft piston engine are also discussed.

073_**Aircraft Systems** (3 ECTS): Students learn in detail about aircraft systems. They learn which systems are indispensable on an aircraft and which are not, as well as about the redundancy of critical systems. Students will be acquainted with basic pneumatic, hydraulic and electric components, which are the basic building blocks of complex systems.

074_**Aircraft Structures** (3 ECTS): Students learn about the basic types of aircraft structures. Aerodynamic, ground and inertial loads are discussed. According to the given loads they learn the methods for sizing of wing spars, ribs, struts, wing skins and fuselage. The students learn the basics of composite structures and design of individual elements from composite materials. The results of calculations will be verified in the laboratory in a corresponding laboratory exercise.

075_**Air Navigation 1** (6 ECTS): Students learn about the basics of navigation and various types of projections, and the importance of loxodromes and orthodromes in aviation. They learn to use special aeronautical charts. They learn to use calculations in navigation and determine the position in space.

076_**Aviation Phraseology** (4 ECTS): Developing the following language skills: communication, reading and understanding of technical texts, knowledge of professional terminology, knowledge of functional textual form. Linguistic means of transmission: definition, classification, deployment of examples, expression of contrast, similarity, purpose, conditional, temporal relations etc. Repetition of grammar with an emphasis on structures occurring in communication and in the professional language.

077_**Aviation Law and Regulations** (3 ECTS): Learning about air law and regulations. The concept of law and its practical application in aviation. The most important domestic and international regulations governing air traffic. Legal regulation of air traffic in individual branches of law (civil, criminal, public, international private and international public law). International agreements and organizations: Chicago Convention, other international agreements, competences and responsibilities of aircraft pilot in charge (PIC) regarding flight safety and security measures, liability of the carrier and the pilots for passengers and goods on the ground in case of injury or damage while operating the aircraft, commercial activities and associated rules (rental). Annex 8 – Airworthiness of Aircraft. Annex 7 - Aircraft Nationality and Registration Marks. Annex 1 - Personnel Licensing. Rules of the air: Annex 2. Flight procedures – aircraft operations, Doc. 8168-OPS/611, Volume 1: foreword, definitions

and abbreviations, departure procedures, arrival and approach procedures, waiting procedure, altimeter setting procedure, secondary surveillance radar transponder operative procedures. Air traffic service: air traffic service (ATS) - Annex 11, Air regulations and air traffic services. Aeronautical Information Services: Annex 15. Aerodromes: Annex 14. Supporting activities: aircraft arrival and departure, entry and exit of persons and luggage. Search and rescue: Annex 12. Security measures: Annex 17. Aircraft incident investigation: Annex 13. JAR FCL: National law: national laws and differences to relevant ICAO Annexes, and Joint Aviation Requirements (JAR).

078_**Aviation Medicine and Psychology** (3 ECTS): Students learn about the basics of aviation medicine and psychology containing the basic anatomy, physiology and pathophysiology. Flight hygiene: influence of height, influence of acceleration, influence of temperature changes, effects of noise and vibration, impacts affecting visual ability and ability of hearing, sensory illusions. Hygiene of travelers: sleep, rest, food, alcohol, tobacco, medicine, aviation disease. Human factors: basic principles; human factors in aviation, the powers and limitations, accident statistics, concepts of flight safety. Basic psychology and health maintainance: basic anatomy, psychology, pathopsychology, atmosphere composition, respiratory and circulatory system, high altitude environment, ozone, radiation, humidity, human and his environment, sensor system, central and peripheral nervous system, vision, hearing, balance, sensory signals integration, health and hygiene, personal hygiene, intoxication, limited capability. Human information processing, attention and alertness, guidance of attention, divided attention, perception, illusion, subjectivity of perception, processing from the bottom up and top-down, memory, sensory memory, working memory, long-term memory, motoric memory (skills), response selection, learning methods and techniques, motivation and performance, human error and reliability, similarity, frequency, causality, theory and model of a human error, generating errors, internal causes, external causes, ergonomics, economics, social environment, decision making, concepts of decision making, structures, boundaries, risk, practical application, avoiding mistakes and handling the errors occurrence: cockpit management, security awareness, crew members coordination, the dynamics of small groups, leadership, responsibilities, communication, personality, individual differences in personalities, below or over average stress level, stress, tiredness, body rhythm and sleep, managing stress and tiredness, higher level of automation in the cockpit, advantages and disadvantages, working concepts.

079_**Mechanics of Aircraft Flight** (4 ECTS): Propellers: conversion of engine torque to thrust, engine failure or engine stoppage, design of the power absorption, moments and couples of forces from the propeller operation. Mechanics of flight: forces acting on the plane, asymmetric thrust, emergency descent, diagram of available and necessary traction force or power, flight duration, flying range, flight culmination, ability of take-off and landing. Stability: conditions for stable equilibrium in the horizontal flight, methods of achieving the forces equilibrium, static longitudinal stability, cross-directional static stability, dynamic longitudinal stability, dynamic cross-directional stability. Control: general, modifying the angle of the aircraft above the horizontal plane, vibration control, steering around the transverse axis control around a vertical axis, control around the longitudinal axis, interaction of different planes (oscillation/rotation), means to reduce the forces control, mass balance, balancing.

080_**Mechanics of Helicopter Flight** (4 ECTS): Students learn the basic theory of the ideal propeller, which is developed afterwards into the theory of the propeller blade. The features and understanding of the forces acting on aircraft in various maneuvers. Analytical and numerical methods for calculating the stability of the aircraft about all three axes as well as the necessary parameters to control the helicopter flight. The results of numerical calculations are checked experimentally in the laboratory.

081**_Light Aircraft Structures** (6 ECTS): The basic aim is to study methods for calculating the distribution of internal forces and stresses in the uniaxial and planar thin-walled structural elements and structures. The students are able, based on some internal state variables distribution, to calculate the dimensions, so that each structural element, as well as the whole structure, is geometrically stable and secure against possible collapse. Further, students learn about methods for determining stress, strain and displacement response that are specific to a slender structural elements. Furthermore, students also learn about the impact of operating temperature on the carrying capacity of structural elements. An important objective of this course is therefore the geometric optimization of light aircraft construction, in which one of the optimization criteria for the selection of the most suitable material of structural parts is used. Ultralight aircraft structures often use a wide variety of composite materials which are also sensitive to the appearance of cracks due to orthotropic mechanical properties.

082**_Aircraft Maintenance** (5 ECTS): Importance, role and purpose of maintenance activities and its place in aviation. Aircraft inspection systems (preventive, predicted). General. Small and large aircrafts. Pre-flight inspection. Emergency inspections. Execution of 100 hourly and annual review. Overview of the structure of passenger aircraft. Methods of technical diagnostics for maintenance. The working methods of the aircraft overhaul (identification and command). Aviation technical publications: documentation for the new aircraft type approval certificate, supplemental type-approval certificate, the documentation for the aircraft, engine and propeller already in use, Advisory Circular – AC, Service Difficulty Reporting program - SDR. Airworthiness directives, Service Bulletin and Alert Service bulletin, Instruction for continued ariworthiness. Other: the conduct and grading of technical publications, standard aircraft parts: general aviation standards, bolts, nuts, washers, fasteners (bolts, rivets), special fasteners, other (pins, safety wire, universal closures, wire parts). Repair of aircraft structures: general, classification structure (carrier, non-structural), injuries classification, general guidelines and examples.

083**_Aircraft Design** (5 ECTS): Students learn about the process of calculating the entire aircraft. According to customer wishes they are able to determine the basic geometry, determine the basic aerodynamic properties, select the required engine and determine the aircraft performance. Students also learn several methods for the preliminary calculation of the aircraft.

084**_Construction Materials** (4 ECTS): Characteristics of the formed semi-cast and sintered parts from the point of view of materials types and mechanical and physical properties; students learn about the production program, dimensions, deviation and usefulness of such elements. Characteristics of heat-treated parts: overview of an integrated and surface heat treatment, dimensional changes as consequence of heat treatment, residual stresses after heat treatment, heat treatment of gears, fabrication and heat treatment of different types of springs, the choice of materials for the axels in terms of providing adequate mechanical properties including the surface integrity. Use of Lamonts diagrams for the determination of mechanical properties of machine parts after heat treatment, Assims diagram for selecting the annealing temperature of steel. Fatigue of materials: the influence of shape and surface state on fatigue, defects and inhomogeneities of the material, the influence of gases and liquids on the degradation of materials and the impact on time strength and endurance limit. Materials creep: the influence of pressure and temperature drift. Ambient effects and material on the creep process, creep-resistant materials, tracking and predicting the creep process for the remaining lifetime of the structure. Damage of materials: the choice of materials based on mechanical properties and fracture toughness, thermal effects of different technologies or different operating conditions on the fracture-mechanical properties of materials, fracture of materials due to stress corrosion in chemically aggressive media, corrosion damage, the compatibility of materials in structures in order to prevent corrosion (anodic and cathodic protection as well as other security procedures). Review of non-destructive materials testing:

visual inspection, magnetic, magnetic-inductive methods, acoustic methods, radiation methods.

085_**Plastic Product Design and Manufacturing** (4 ECTS): Comparison of the characteristics of synthetic materials, ceramics and natural materials (stone, wood). Criteria for selecting materials as blocks for each structure. Plastics processing technology. Injection moulding: tooling, inlet channels, nozzles. The influence of injection moulding technology on distortion of the final product. Forming technologies for plastics sheets and thick plates. Injection cavity moulding (including glass). Casting of ceramic materials and plastics. A method of extrusion is presented along the problems of distortion in the application under different conditions. Structural elements and their characteristics. Material couplings: welding (heat welding, ultra sound, etc.). Removable mechanical coupling: coupling, assembly and deformation joints. Examples of calculations of the permanent bias. Features of tribological systems: metallic material; artificial materials. Composite materials and their properties. Electrical conductivity and insulating properties. Analysis of typical structural elements of non-metallic materials. Examples are derived from the mechanical elements. Material couplings, clip-clap links, bearings (sliding, rolling), complex assemblies.

086_**Heat Pumps** (4 ECTS): In this course we want to provide the students with the useful knowledge for later work in heating, cooling and air conditioning systems. They get acquaintance with the criteria for the selection and use of heat pumps in relation to the energy and economic analysis. They are educated on the sources of heat: water, air, soil and waste heat with respect to their availability, impact on energy efficiency and environmental impact. Special attention is devoted to the refrigerants, their specific requirements, energy and environmental assessment. The students are provided with he characteristic elements of the heat pump depending on their type and their correlation to cooling systems. Discussion on structural characteristics, usage and the limits of the compressor, evaporator, condenser and control and safety systems. For a comprehensive decision on the choice of heat pumps, a methodology of annular energy consumption is presented. A comprehensive decision whether or not to choose a heat pump requires a methodology to define the annual energy use, annual working and heat number, annual heating costs as well as the inclusion of heat pumps in the combined heating systems.

087_**Precision Engineering** (4 ECTS): The course provides knowledge to facilitate a basic understanding of the precision systems operation and design, their limitations and ways of transferring information / loads in various configurations. Students learn about basic building blocks in precision engineering and about their features validated in practice, different design solutions and implementations of the principles of precision systems. The methods for the analysis of individual elements (couplings, safeguards against removal, shaft couplings, springs, torque transfer elements, bearing, seals, coupling systems) are presented. Based on the set of problems students carry out an analysis and their possible adaptation of the problem. Students are also familiarized with the concept of dimensional tolerances (ISO), geometric tolerances (GDT) and tolerances analysis. They get acquainted with the use of software used for modeling and analysis of precision systems and possibilities of adapting their functions.

088_**Heat Treatment Design** (4 ECTS): Designing heat treatment technology for heating and over-heating: prescribing the conditions necessary for heating, heat transfer methods, basic data on the heating rate in the chamber and salt kilns, stacking items for annealing or hardening furnace, the effects of heat treatment of steels, steels in heat sensitivity, determination C equivalent required for mechanics before and after heating and quenching. Practical tips for heating, austenitizing and quenching in normalization. Calculation of the heating time, the use of namograms, determination of heating time at austenitizing temperature in dependence of the object shape (defined by the shape coefficient). Selection of technological parameters for tempering: Hallomon-Jaff hardness relationship obtained by

diffusion of carbon from martensite lattice, Kraft Lamont method. Protection from the heat treatment: anti-oxidation, decarburization, exothermic, endothermic and an inert atmosphere in the kiln, controlling the composition of the protective gas. Prescription of various thermal processing in vacuum: annealing, quenching, tempering, hardening carbo-nitriding, degassing, brazing, sintering. Resources, facilities and equipment required for heat treatment: the integrity of the process of heat treatment of parts, classification of furnaces and continuous lines, deep and multi-purpose ovens. Planning and scheduling the equipment for a room heat treatment. Cooling and quenching: determination of cooling time. The range of coolers, selection and production of equipment for cooling. The impact of the objects movement in refrigerants as a function of surface area and volume of the cylindrical part and the transfer of data to other types of objects. Control procedures and facilities required for heat treatment. Errors in heat treatment, taking into account the volume changes for the heat treatment in the design of individual parts, the size of the allowance for grinding, the impact of austenite and the secondary carbides in the volume changes and residual stresses.

089_**Joining and Heat Cutting of Materials** (4 ECTS): Demonstration of joining and heat cutting of materials in practice – the proof of importance. The use of different welding processes, brazing, adhesive bonding, thermal cutting and metallisation in industrial applications. Review of the procedures from a practical point of view. Review of the materials which are most commonly welded or glued in practice. Overview of the properties of materials during the process of welding by warming and melting changing and affecting the properties of joint. Melt welding and cold welding. Comparison of soldering and welding, gluing. The differences and the use of heat cutting by laser or flame. The difference in physical states of material during heat cutting. After the examination the students are able to distinguish welding, soldering and bonding, as well as making their own decisions on the appropriate process selection for specific examples. From a practical point of view properties of plasma (wind effect), electron beam and laser, and their use in practice are presented. Calculation of the preheating temperature of most steels. Review of the reasons for residual stresses and strains in joints. The protection and safety at work during different methods of welding, cutting and soldering in practice.

090_**Computer Integrated Manufacturing** (4 ECTS): The structure of the production system and the role of integrated information systems. The definition of information and material flows in production. Operations such as cyber system. Analysis of the computer elements of integrated manufacturing: computer-based development and construction products, methods and tools, computer aided design technology (methods and tools), the inclusion of a comprehensive quality assurance in the CIM, computer-aided manufacturing. The design of an information system used for production. Computer networks in production. Creating databases and optimization models in conjunction with the planning of production technologies. The role of online technologies in production. Numerical control of machining systems. The structure of the elementary work system. Programming machine tools, NC programs, structure, analysis of software systems. Rapid prototyping of products. Their integration into the development process. Project work: the students select one of given subjects and analyze it independently. (Possiblity of teamwork). The topics from the following areas: production of computerized programs for direct implementation of the treatments in an integrated CAD / CAM environment (ProEngineer or Mastercam). In this context, it is necessary to establish a machine, fixture, tools and technological parameters as well as to develop an NC code to work on. Program testing on the machine, the development of segments of databases for design and manufacturing, the use of online technologies in production.

091_**Engineering Acoustics** (4 ECTS): Noise is a problem of civilization, causing damage to the hearing as well as causing several psychophysiological disorders in humans and animals. Noise may also affect the concentration at work and the work efficiency. Noise is the problem of environmental protection, health protection and humanization of the

workplace. Machinery and equipment are the leading causes of noise both in natural and living environment. Noiseless product is a very good selling point. In order to be able to make a silent machine or reduce the operational noise of the machine students should be able to locate the noise source, define it, and determine its sound power. We must also be able to define the limits and the reduction quantity of the noise source. In this course, students get acquainted with the necessary theoretical basics, measuring equipment, acoustic environment and the necessary regulations to be followed for the proper measurement and definition of the noise source. It also takes note of the rules and regulations prescribing conditions for the proper measurement of noise in the workplace and in the natural and living environment, as well as to determine noise of traffic and / or urban noise. Students learn to choose the proper engineering and / or an alternative method for reducing noise at source, during the noise transmission or reception. The exercises are also adapted to experimentally check the theoretical interpretation given in the lectures and to create a picture of the sources and formation mechanisms of noise.

092_**Aircraft Engines 2** (4 ECTS): A review of basic physical principles that determine gas turbine engine thrust, followed by an overview of major engine components such as: inducer, compressor stages, combustion chamber, gas turbine, exhaust system with thrust nozzle, is given. Thrust reverser types and their function as well as afterburning process is also discussed. Mechanical transmission and driving systems and different auxiliary gas engine units as: starter motors, electric generator, the Auxiliary power unit (APU) are also presented. Gas turbine engine performance during take-off at different ambient conditions (injection of water and methanol), performance of the engine at higher altitudes is also discussed. Fuel delivery system and components, ignition systems and normal starting procedure as well as starting malfunctions are shown and discussed.

093_**Lubrication Engineering** (4 ECTS): The course gives an introduction to different types of surfaces, lubrication and lubricants, friction and damage. Emphasis is given on the importance of lubricated contacts for power transmission systems and on the key characteristics of surfaces that affect friction, wear and damage. The basic types of lubricants and lubrication quality is explained. In this context we also introduce the role and the basic types of additives in lubricants and basic characteristics of certain types of lubrication. We deal with a specific type of lubricants, their characteristics and classification and the selection criteria. We treat the main sources of friction and impact on them. The last part of the course deals with damage experienced by load-carrying elements, methods for surface analysis and basic principles of surface testing. The consequences of friction, wear and various aspects of lubricants and lubrication are summarized and their role in damage of machine elements and possibility of their detection and monitoring is given.

094_**Production Metrology** (4 ECTS): The course covers the production metrology and the applied science of metrology in the field of dimensional measurement. In the introductory lectures the students learn the terminology field, the system of basic units and the concept of traceability tools and standards. Understanding the role of metrology in production practice is clarified by considering practical cases. The core of the course consists of a discussion on measurement errors in dimensional measurements, analysis of results, measures to reduce uncertainty and also on the design types of meter lengths, angles and external diameters, gears and screw parameters. Modern trends in the length measurements are included in lectures by considering three-coordinate measuring instruments, machine vision and micro-measurement products. Computer analysis of measurement data is exercised through practical examples done both in the laboratory and at home. Surface roughness is considered integrally, along with other parameters of the surface integrity. Students learn about the interdependence of the parameters of roughness and surface functionality. The last part is dedicated to the methodology of acceptance measurements applied to machine tools.

095_**Hydropower Systems** (4 ECTS): The course addresses the basic mechanisms of hydro-electric energy conversion systems. It presents the kinematics and dynamics in the flow field of vital elements of the hydropower plants. It delivers the basic elements, their functions and basis for a selection of the hydro-mechanical equipment according to prescribed technical requirements and given integral conditions. As a basic tool for the design of hydraulic and power characteristics of machines the similarity - augmentation methods, obtained by experimental procedure on models or prototypes of the machines, are presented. Based on this knowledge, the methodology of acceptance tests used in approval of water turbines and hydro-equipment under laboratory and built-in conditions is given. Highlight on the essential features of the installation of hydraulic machines in flow systems with respect to how the choice of machinery impacts the efficiency and reliability. Content is strongly associated with research, hydroenergetic and industrial activities in the Slovenian territory.

096_**Welded Structures** (4 ECTS): Mechanical properties of steel sheet, its dependence on the direction of measurement, thickness and temperature; criteria for selection of steel resistant to brittle fracture; sheet preparation, welded joints, classification of defects in the welds; levels of acceptability of defects in welds; statically loaded welded joints, static resistance front and other typical welds, layout and design of statically loaded welded joints, fatigue (dynamic) resistance of welded joints, design of dynamically loaded welded joints, welded beams with open or closed cross-sections; reinforcing elements in thin-walled structures, welded truss beams, welded rod holders, round and rectangular tubes, welded arc beams and frames; basics of pressure vessels, pressure vessels and risk category; design load of material for pressure vessels; test groups; determination of the minimum wall thickness for internal or external design pressure, welded pipes and pressure distribution, welding tanks and some other complex structures, deformation of welded components and structures.

097_**Basics of Laser Technology** (4 ECTS): The course deals with basics of laser technology and its application in the areas covered by the mechanical engineering. The contents consist of the following topics: Introduction to the course, fundamentals of engineering optics, basics of lasers (historical background, origins and characteristics of laser light), types of laser sources (gas, solid-state lasers; composition of lasers and their characteristics, the most important application areas), laser safety (causes and types of injuries, regulations and standards), laser machining processes (selected examples: physical base of operation, structure, key characteristics, override, management, maintenance, economic aspects of the use, practical examples of use) and measuring laser device (selected examples: physical base of operation, structure, key characteristics, override, management, maintenance, economic aspects of the use, practical examples of use).

098_**Air Navigation 2** (9 ECTS): Students learn about the basics of radio navigation aids and about the types of navigational aids. They learn also about different methods of navigation in space, active approach to a target asset and an active take-off from the departure asset.

099_**Wear Resistance Surface Engineering** (4 ECTS): Physical and tribological properties of contact surfaces wit a review of wear mechanisms. Basic characterization of contact areas with emphasis on topography, residual stress, adhesion of protective coating and tribological properties. Increasing wear resistance of contact area - the purpose, techniques of increase of wear resistance, surface preparation for application of surface layers. Overview of mechanical and chemo-thermical procedures to increase wear resistance of surfaces. Techniques of applying wear resistant surface layers. Types and properties of abrasion resistant layers. Chemical application from vapor phase, the physical

application from the vapor phase, plasma-aided coating from the vapor phase. Types and properties of wear resistant surface layers - hard coatings based on carbides, nitrides, oxides, multilayer coatings, ... Directions of the development of wear resistant surface layers – surface preparation, duplex systems, multi-component coatings, multilayer coatings. Impact of surface layer properties, including hardness, thickness, residual stress, roughness and temperature on the tribological properties of contact surfaces. Choice of the procedure and practical examples of wear resistant surface coatings in mechanical engineering.

100_**Material Handling Systems** (4 ECTS): Systematization of handling facilities, an overview of the standards and directives in this area; the main functional units (sets) of cranes: ropes, hangers, clamps, lifting units, drive units, brakes, wheels...; bridge cranes, tower cranes, mobile cranes, rack lifts, forklifts, computer-controlled conveyor systems; devices and systems for mechanical handling, classification and characteristics of bulk cargo, the classification unit loads; belt conveyors, mobile and portable belt conveyors, volume and mass capacity; force ribbon, the force required to drive a unit, chain conveyors, articulated conveyors, elevators, escalators, volume and mass capacity, driving units; snail conveyors, vibrating conveyors, feeders, volume and mass capacity, the force needed to drive a unit, pneumatic conveyor systems for granular and powdery material, piping, technical logistics basics: the definition of the technical logistics, specific logistics; handling equipment and logistics origins and destinations of transport units, length of time the movement cycle, types of transport, material flows, volume of transport, transport frequency; piece flow, marginal piece flow, time tracking clock, split the material flow; confluent material flow, warehouses and storage, storage capacity, ability to place cargo into and out of the warehouse, picking, handling equipment in warehouses, quality of handling services, maintenance and availability of handling facilities.

101_**Materials Weldability** (4 ECTS): Definition of weldability and its practical role. How the weldability is identified and how it can be improved. Theoretical and practical methods for determining the weldability. Technological, structural and metallurgical weldability. Local and global weldability. Binary and ternary solubility diagrams of commonly used metals and alloys which are welded together in practice. Review of procedures that ensure a higher or lower weldability level for a specific material. Weldability in case of welding two pieces of the same material with each other and in case of different materials with welding filler material or without it. The extent of mixing between the core and filler material. Getting understanding of the CCT and Schaeffler diagram. Calculation of the burnt items for various arc welding processes. Explanation of some basic practical experiments used to determine the weldability. Calculation of the preheating temperature by different methods. Gases, such as hydrogen, nitrogen and oxygen, and the melt pool. Neutral and active protection of the melt during welding. Weldability of micro-alloyed fine grain steels, Cr-Mo steels, tool steels, stainless ferritic, martensitic, austenitic and duplex steels and non-ferrous metals.

102_**Mechanical Process Engineering** (4 ECTS): Process engineering encompasses a broad field of industrial manufacturing and processing of substances, classified according to the type of process (mechanical, thermal, chemical, electrochemical, biologic). In this course, the students learn about mechanical operation such as: mechanical processes of surface enlargement: characterisation of disperse systems, crushing, grinding and pulverisation technologies, technical realisations of devices. Mechanical processes of surface reduction: mechanisms of substance binding, agglomeration devices. This is followed by mechanical processes including mixing of substance, and mixing of substances in different states of matter: mixing of bulk materials, dissolving, mixing of inter-solvable liquids and particles, suspensions, dispersions, emulsions. Mixing devices: rotating and vibrating agitators, static agitators, jet agitators. Generally adopted correlations: minimum stirring power, time of mixing, heat transfer in mixing devices (heating, cooling), mass transfer $k_L a$. Mechanical processes for the separation of substances: definition of granularity, material screening,

technological processes (sieving, centrifugation, sedimentation, flotation, filtration) and corresponding devices. Storage and transport of bulk material (maintenance of suspensions, emulsions, dispersions). In the context of environmental protection, the estimations of minimum specific power consumption are given for the operations mentioned above. A part of the content is dedicated to the mechanical cleaning of liquids and gases, and to regulations and recommendations in this field.

103_**Machine Tool Design** (4 ECTS): The basic principles of machine building and design. Characteristics of lathes, milling machines, boring machines, grinding machines, machining centres, hybrid machines for simultaneous machining, forming machines for die casting, injection moulding machinery etc. Modular approach towards machine design, based on the inclusion of individual units offered on the market. Analysis of individual modules such as: machine foundation, machine bad, main spindle, sliding and roller guides, ball bearing spindle, drive units etc. Machine loads and their influence on the precision of machining. Description of static, dynamic and thermal loads. Computer-aided machine design. Fundamentals of finite element method. Cases studies, such as optimisation of machine bed topology, optimisation of thickness of reinforcing elements on the machine column, simulation of natural frequencies and thermal loads. Experimental methods, measuring systems and control system design. Decision strategy for the selection and purchase of machines according to the requirements (product shape, batch sizes, price etc.), machine acceptance protocol.

104_ **Aircraft Performance** (5 ECTS): The students learn how the position of centre of gravity affects the balance and flight of an aircraft. Aircraft performance for different categories is discussed: light single-engine and two-engine aircrafts, jet aircrafts. They learn to evaluate the influence of flight parameters on the aircraft performance. They learn in detail about flight planning for light single-engine and two-engine aircrafts, and for jet aircrafts. The knowledge is used for jet aircraft flight planning in remote areas and over the sea.

105_ **Helicopter Performance** (5 ECTS): The students learn how the position of centre of gravity affects the balance and the flight of a helicopter. Helicopter performance for different categories is discussed: A and B category. They learn to evaluate the influence of flight parameters on the helicopter performance. They learn in detail about the flight planning for A and B category helicopters. Helicopter performance in case of engine failure is discussed.

106_**Material Handling and Warehousing** (4 ECTS): Classification of handling devices, characteristics of handling devices for interrupted handling: overhead and gantry cranes, high-bay rack servicing cranes, computer-controlled manipulators; characteristics of continuous handling devices; belt conveyors; chain conveyors, elevators; circulating conveyors, power and free systems; screw and vibration conveyors, roller conveyors; characteristics of flow transporters; warehouse classification and basics, high-bay racking: design, functional areas, warehousing capacity, input/output capacity, management; transport equipment in warehouses, basics of technical logistics: basic terms, area logistics; handling-warehousing unit sources and sinks; material flows; handling cycles; handling volume; necessary handling equipment, handling types; part flow, part flow fork; material flow confluence; handling service quality; maintenance and availability of handling devices.

107_**Vehicle Transmissions** (4 ECTS): The role of vehicle transmissions (external transformation, elasticity and vehicle steering). Classification of transmissions (mechanical, hydromechanical, electric). Transmissions in road and rail vehicles (2x4, 4x4, all-wheel drive AWD). Drive units and transmissions. Elements of transmission: clutches, gearboxes, balancing mechanisms (drive shafts, constant-speed universal joints), angular gears, differential, half shaft, transaxle, wheel assembly. Interface between the vehicle and the roadway: wheels, rims (designs, designation), tyres (designs, designation). Traction control, tyre life in different operating conditions. Ecological aspects (noise, wear, recycling).

108_**Sanitary and Fire Protection Engineering** (4 ECTS): Introduction to topics, aims of the course and program, competences. Water properties: chemical, physiologic and bacteriological composition of drinking water, required characteristics of drinking water, characteristics of rainwater. Drinking water supply: water quantity and pressure, distribution network, sizing the water pipeline systems, sanitary objects and fittings. High-pressure water pipeline: pressure-boosting devices, direct and indirect connections, designs, sizing, fittings. Preparation of warm water: local warm water preparation, central warm water preparation. Heat sources: electricity, gas, solar energy, heat pump, sizing, hygiene suitability, legionella, water softening. Special cases of drinking water use: preparation of water for swimming pools, softening, flocculation, disinfection, filtration, chloration, ozonation, heating. Systems for rainwater use: drinking water savings, cleaning and collecting rainwater, distribution, system sizing, analysing the existing systems. Drainage systems: separated system, mixed system, drainage, system elements, sizing, waste water treatment. Automatic extinguishing devices: water spraying systems, wet and dry systems, foam extinguishing devices, powder extinguishing systems, devices for CO2 extinguishing, automated CO2 extinguishing systems, extinguishing system equipment, installations, sizing, system balance.

109_**Materials and Material Investigations in Power and Process Engineering** (4 ECTS): Mechanical and physical material properties in power and process engineering: material selection, material states, internal and residual stresses in materials and products. Material fatigue: materials and investigations in power and process engineering, crack nucleation and growth, the impact of surface shape and state on fatigue, the impact of dislocation density on crack growth, external and internal impacts on material fatigue. Material creep: the influence of temperature and pressure on creeping, external and internal influences on creeping, creep-resistant materials, tracking the creeping process and life prediction. Quantitative representations of creep process, indicators of mechanical properties at elevated and high temperatures. Heat treatment of highly temperature-resistant austenitic steels and cast iron. Refractory steels: for heaters, valves, turbine blades, casings… Creep-resistant steels and non-ferrous alloys: high-alloyed steel, nickel, cobalt and titan-based superalloys. Corrosion damage: chemical and electrochemical corrosion, electrode potential and material compatibility in structures, corrosion prevention, corrosion protection. Corrosion and acid-resistant steels and ferrous alloys, chrome and chrome-nickel steels, ferritic and semi-ferritic (ferritic-martensitic) steels, martensitic and austenitic, austenitic-ferritic steels, heat treatment of unstabilised and stabilised steels. New developments in corrosion-resistant steels. Damages to materials during operation: Pure and shear fractures, impacts on brittle fractures, influence of alloying elements, effects of core and surface tempering on the transition between material toughness/brittleness. Material testing: visual inspections, periodic inspections, microscopic object investigations, damage evaluation and documentation. Tracking the creep process, anticipation of remaining life for thermo-mechanically strained parts, determination of surface defects and cracks in the material during operation: borescopy, penetrant testing, magnetic and magnetic-induction methods, ultrasound and radiography, replicas. Steels and non-ferrous alloys, suitable for operation at low temperatures: general classification, mechanical properties testing, toughness testing. Sintered ceramic materials and composites, porous bearings, friction materials, filters…

110_**Polymer Technology** (4 ECTS): Polymers are gaining on importance as structural materials. Their use in the industry is rapidly increasing due to the advantages offered by these materials compared to the traditional materials such as metals. Some of the main advantages are: simple processing, corrosion resistance, favourable strength-weight ratio, multi-functional use… They are expected to withstand the loads through their entire life and this requires the forecasting of long-term reliability of structural elements and, in turn, knowledge about material properties. The students will obtain the knowledge necessary to understand the interrelations between the useful properties of individual polymers and their structure. They will obtain the basic knowledge about the principles and interactions:

chemical composition/micro-macro structure/polymer properties. They will learn about polymer processing and accompanying elements, such as products, processing technologies and devices. They will grasp the know-how about economic and environmental evaluation of individual polymers in relation to their properties and structure. The students will understand and develop the criteria for selecting proper materials for different applications.

111_**Computer Data Processing Fundamentals** (4 ECTS): Basic terms, types and properties of data: (descriptive, numeric, nominal, ordinal, interval, dimensionality, variability). Basics and cases of computer organisation and presentation of data (tables, diagrams, histograms...). Description and characterisation of variable univariate data (frequency, measures of central tendency, measures of variability, asymmetry and kurtosis). Basics of probability, statistic conclusions and case studies of testing (events, empirical definition of probability, related, dependent and independent events, probability distributions, important probability distributions. Bivariate and multivariate analysis of two- and multi-dimensional data (correlation, covariance). Basics of modelling and selection of informative characteristics of measured data (linear regression, multiple linear regression, factor analysis). Basics of time series analysis (amplitude, temporal and frequency analysis). Examples of time series analysis (different cases of product state characterisation based on sensor signals). Time series analysis and tracking the quality of manufacturing processes. Using the Excel/Matlab software environment for different topics.

112_**Technical Safety** (4 ECTS): Technical safety as a general concept of assuring occupational safety and health. The role of occupational safety and health department in the company. Records related to safety. Risks. Risks in the working environment. Hazardous area. Hazardous event. Machine safety, reliability, maintainability. Unsafe operation. Intended use. Life time. Safety function. Risks. Risk elements. Methods of risk evaluation. The principle of risk reduction by planning. Safety declaration with a risk assessment. Precautionary statements. Safety manual. Instruction manual. Techniques of protection. Ergonomics. Means of protection. Personal protective equipment and particularities in its use. Human factor in provision of safety. Slovenian law. Slovenian and international standards.

113_**Aircraft Operating Procedures** (3 ECTS): ICAO Annex 6, Parts I, II and III, JAR-OPS requirements, general requirements, operator certification and control, requirements of operating procedures, procedural requirements in any weather: operations under low visibility, requirements of instruments and safety equipment, requirements of communication and navigation equipment, airplane repair, flight crew, cabin crew, conduct of the flight, transonic and polar flights, navigational requirements for long-haul flights. *Special operating procedures and hazards (general)*: minimum equipment list (MEL), de-icing on the ground, danger of bird collisions and avoiding, noise reduction, fire/smoke, cabin depressurisation, shear wind, wind gusts near CB, wake turbulence, landing in case of danger and preventive landing, fuel jettisoning, transport of hazardous material, contaminated runways.

114_**Helicopter Operating Procedures** (3 ECTS): In the general part, the students learn about ICAO Annex 6, Part III, Requirements of JAR-OPS, operator certification and control, requirements of operating procedures, procedural requirements in any weather operations under low visibility, requirements of instruments and safety equipment, requirements of communication and navigation equipment, airplane repair, flight crew, cabin crew, conduct of the flight. *Special operating procedures and dangers (general)*: minimum equipment list (MEL), de-icing on the ground, danger of bird collisions and avoiding, noise reduction, fire/smoke, cabin depressurisation, shear wind, wind gusts near CB, wake turbulence, landing in case of danger and preventive landing, fuel jettisoning, transport of hazardous material, contaminated runways, air flow near the rotor. *Emergency procedures*: engine failure, fire in cockpit/ cabin/ engine, tail rotor failure, resonance, lift failure on rotor blades, vortex ring, exceeded angle of climb, exceeded maximum velocity, sudden stop.

115_**Practical Training** (8 ECTS): The student works autonomously in scope of compulsory one-month practical training, taking an agreed position in an industrial or research institution. The work is usually focused on a narrow field of mechanical engineering, according to the selected module/sub-module of study, and professionally coached by a faculty mentor and a mentor from the industry. The work is concluded by a realised project assignment. The project assignment with attachments documenting the student's work is then presented and defended in front of the mentor at the faculty. It is desirable that the practical training is also the foundation and the starting point for the diploma thesis.

116_**Diploma Thesis** (12 ECTS): In the diploma thesis, the student elaborates on the project application-focused topic, realised in cooperation with the industry. The realisation confirms the competences gained during the studies and proves the candidate's comprehension of operation and design of engineering systems, as well as his or her ability to contribute to the technical development. It is desirable that the diploma thesis upgrades the practical realisations, gained during the practical training.