Mechanical Engineering
3. cycle doctoral study programme

1 General description of the programme

The doctoral study programme of MECHANICAL ENGINEERING lasts for 3 years and students need to accumulate 180 ECTS credits for its successful completion.

The objective of the doctoral program of MECHANICAL ENGINEERING is to educate and prepare the doctoral students - young researchers to carry out independent, creative, innovative and original research work in the broad field of mechanical engineering and thereby contribute to nurturing innovative research mentality, which is a prerequisite for the development of a knowledge society. The research training within the framework of doctoral studies equips the doctoral students with superior theoretical and methodological knowledge to solve the most challenging problems in the field of mechanical engineering with completely new approaches. Through studies they develop the ability of independent and creative thinking about very complex issues, which will reinforce their innovative thinking.

The secondary objective of the doctoral study program of MECHANICAL ENGINEERING is to expose the doctoral students to work in the industrial R&D departments, institutes and universities at home and abroad. With modern study program design that derives the academic content primarily from the scientific activity of teachers, and promoting creativity and independent work of doctoral students, the programme meets the public and industry expectations from higher education institutions and highly educated young researchers who complete the doctoral study programme of MECHANICAL ENGINEERING.

The study programme includes:

- Elective scientific courses (4 with 6 ECTS each, total of 24 ECTS), which allow doctoral students to get required theoretical and also professional knowledge, skills and techniques necessary for successful research of the defined research questions;
- Transferable skills courses (3 with 3 ECTS each, total of 9 ECTS), which better prepare doctoral students for research in both the academic and industrial setting;
- Individual research work (a total of 147 ECTS, of which in organized form a total of 27 ECTS), which also includes the presentation of the research results at the responsible departments at the end of the 1st and the 2nd year, a dissertation topic application in the 3rd semester and the presentation and defense of doctoral thesis in the 6th semester of study.

The students have to choose at least 2/3 of elective courses from a list of available elective courses of the study program; the remaining 1/3 of courses can be chosen from other doctoral programmes offered at the Faculty of Mechanical Engineering, University of Maribor and other universities.

For successful completion of the study program in the set form it is imperative that every doctoral student has been assigned the research question and a mentor before enrolling in doctoral studies or one month after at the latest. Also the forms of financing the tuition fee and any material costs of individual research work at the faculty shall be agreed prior commencement of doctoral studies.

The achievement of study program objectives is primarily evaluated at the end of the study program, when doctoral students have to submit their doctoral dissertation and present and defend their research work at the public hearing in front of the examination committee.

2 Short description of the study modules

The doctoral study programme of MECHANICAL ENGINEERING does not contain study modules and doctoral students are free to choose any combination of available elective subjects to successfully solve the set research question under supervision of the mentor.

3 General learning outcomes and competencies of the students

Through studies and research the doctoral students primarily acquire in-depth theoretical knowledge from a chosen field of Mechanical Engineering, defined by the set research question. However, they also acquire the professional knowledge, skills and working methods to tackle the most challenging scientific and professional problems of modern Mechanical engineering. With in-depth study of scientific methods and a variety of professional and applied study courses, the doctoral students develop the ability of abstract and associative thinking, synthesis of knowledge from a wide field of Mechanical engineering and other disciplines, managing the most demanding work systems and scientific research projects, the transfer of research results into practice and the development of innovative processes to solve engineering problems.

The doctoral students acquire adequate skills to solve the most challenging scientific and professional problems according to high standards of performance, which are a prerequisite for their training to become highly educated scientists and experts. While studying they develop abilities to search for new sources of knowledge and new solutions in scientific and technical fields, to develop new scientific methods in the broad spectrum of problems and new or changed circumstances and to assume responsibility for managing the most complex work processes and systems that require highly educated scientists and experts. The study process is designed to provide strong support to students for their scientific development through independent scientific research work under excellent supervision.

The doctoral graduates can develop and manage the state of the art research methods and procedures in the wider field of mechanical engineering. With critical professional self-assessment and responsibility they are capable of devising, developing and designing a new (superior) technologies and products, taking into account the professional excellence social usefulness, ethical responsibility, commitment to professional ethics and criteria for the environmental integrity of their creations. They are trained to use state of the art system concepts and principles of universality. At the same time they are able to carry out independent technical assessment based on scientific analysis and synthesis.

The students also acquire other skills, values, beliefs and positive self-esteem, which helps them to contribute significantly to the efficient use of resources for successful implementation of the most demanding tasks.

4 The primary subject-specific learning outcomes and competencies of the students

The main subject-specific competencies obtained by the doctoral study programme of MECHANICAL ENGINEERING are:

- in-depth knowledge of selected scientific field of Mechanical Engineering (eg. design of engineering systems, computer modelling and simulation of engineering systems, advanced experimenting, modelling of transport phenomena, energy and process engineering, intelligent processing and control systems, advanced concepts of production management, materials technology, nonlinear mechanics etc.),
- an ability to find new sources of knowledge in the scientific and technical fields,
- an ability to plan, evaluate and produce the advanced technologies, innovative products and systems which have been or will be commercialized in the global markets,
- development and application of scientific methods in a broad spectrum of engineering problems,
- understanding of new technologies and processes,
- search for new solutions and scientific research approach to the development and production of advanced products that are associated with new techniques and cutting-edge technologies,
- an integrated approach to the development, optimization and manufacturing of most advanced products and components taking into account varying factors, e.g. functional characteristics, design, construction, installation, economics, management, maintenance, ecology etc.
- an ability to adapt the knowledge from other disciplines to the wider field of mechanical engineering,
- coherent management of the knowledge base and integrate knowledge from different fields,

- placement of new information and interpretations in the context of the fundamental discipline,
- understanding of the general structure of the basic discipline and coherence between its sub-disciplines,
- understanding and application of methods of critical analysis,
- the development and use of modern computing, information and communication technologies,
- teamwork management and control of communication within the organization and externally,
- ability for critical reflection.

5 General curriculum

The doctoral study programme of Mechanical Engineering is divided into the following three years of studies:

1. YEAR:

1. semester			**2. semester**		
Course	**Type**	**ECTS**	**Course**	**Type**	**ECTS**
Scientific and research work methods	**O**	**3**	**Elective course 3**	**I, P, M**	**6**
Elective course 1	**I**	**6**	**Individual research work 2 with presentation of 1st year research results**	**O, M**	**24 [3]**
Elective course 2	**I**	**6**			
Individual research work 1	**O**	**15**			
	TOTAL	**30**		**TOTAL**	**30**
	Organized study work	15		Organized study work	9
	Individual research work	15		Individual research work	21
Total organized study work 24 ECTS					
Total individual research work 36 ECTS					

Legend: O - compulsory; I – elective; P – transferrable skills; M - mobility

2. YEAR:

1. semester	**2. semester**

Course	Type	ECTS	Course	Type	ECTS
Publishing of scientific results	**O, P**	**3**	**Individual research work 4 with presentation of 2nd year research results**	**O, M**	**30 [3]**
Elective subject 4	**I, P, M**	**6**			
Individual research work 3 with a dissertation topic application	**O, M**	**21 [6]**			
	SKUPAJ	**30**		**SKUPAJ**	**30**
	Organized study work	15		Organized study work	3
	Individual research work	15		Individual research work	27
Total organized study work 18 ECTS					
Total individual research work 42 ECTS					

Legend: O - compulsory; I – elective; P – transferrable skills; M - mobility

3. YEAR:

1. semester			**2. semester**		
Course	**Type**	**ECTS**	**Course**	**Type**	**ECTS**
Preparation and management of research projects	**O, P**	**3**	**Individual research work 6 with doctoral dissertation**	**O, M**	**30 [15]**
Individual research work 5	**O, M**	**27**			
	SKUPAJ	**30**		**SKUPAJ**	**30**
	Organized study work	3		Organized study work	15
	Individual research work	27		Individual research work	15
Total organized study work 18 ECTS					
Total individual research work 42 ECTS					

Legend: O - compulsory; I – elective; P – transferrable skills; M - mobility

Summation of the doctoral study programme of Mechanical Engineering:

Total organized study work: 24 + 18 + 18 = 60 ECTS
Total individual research work: 36 + 42 + 42 = 120 ECTS
TOTAL STUDY PROGRAMME: 180 ECTS

Detailed curriculum

1. year								
Subject	1st semester				Cont. hours	Individ. work	Hours	ECTS
	L	S	T	K				
Elective subjects	60	60	0	0	120	240	360	12
METHODS OF SCIENTIFIC RESEARCH WORK	15	15	0	0	30	60	90	3
INDIVIDUAL RESEARCH WORK 1	0	0	0	50	50	400	450	15
Together semester:	75	75	0	50	200	700	900	30

Subject	2nd semester				Cont. hours	Individ. work	Hours	ECTS
	L	S	T	K				
Elective subject	30	30	0	0	60	120	180	6
INDIVIDUAL RESEARCH WORK 2 WITH PRESENTATION OF 1. YEAR IRW RESULTS	0	15	0	60	75	645	720	24
Together semester:	30	45	0	60	135	765	900	30
Together year:	105	120	0	110	335	1465	1800	60

2. year								
Subject	3rd semester				Cont. hours	Individ. work	Hours	ECTS
	L	S	T	K				
SCIENTIFIC PUBLISHING	15	15	0	0	30	60	90	3
Elective subject	30	30	0	0	60	120	180	6
INDIVIDUAL RESEARCH WORK 3 WITH APPROVED DOCTORAL DISSERTATION TOPIC	0	15	0	90	105	525	630	21
Together semester:	45	60	0	90	195	705	900	30

Subject	4th semester				Cont. hours	Individ. work	Hours	ECTS
	L	S	T	K				
INDIVIDUAL RESEARCH WORK 4 WITH PRESENTATION OF 2. YEAR IRW RESULTS	0	15	0	90	105	795	900	30
Together semester:	0	15	0	90	105	795	900	30
Together year:	**45**	**75**	**0**	**180**	**300**	**1500**	**1800**	**60**

	3. year

Subject	5th semester				Cont. hours	Individ. work	Hours	ECTS
	L	S	T	K				
PLANNING AND MANAGEMENT OF RESEARCH PROJECTS	15	15	0	0	30	60	90	3
INDIVIDUAL RESEARCH WORK 5	0	0	0	60	60	750	810	27
Together semester:	15	15	0	60	90	810	900	30

Subject	6th semester				Cont. hours	Individ. work	Hours	ECTS
	L	S	T	K				
INDIVIDUAL RESEARCH WORK 6 WITH DOCTORAL DISSERTATION	0	15	0	120	135	765	900	30
Together semester:	0	15	0	120	135	765	900	30
Together year:	**15**	**30**	**0**	**180**	**225**	**1575**	**1800**	**60**
Together 3 years:	**165**	**225**	**0**	**470**	**860**	**4540**	**5400**	**180**

L – lectures, S – seminar; T – tutorial; K - konsultation

Elective subjects (1st semester, 2nd semester, 3rd semester)

Subject	1st 2nd, 3rd semester			Cont. hours	Individ. work	Hours	ECTS
	L	S	T				
SELECTED TOPICS IN MATHEMATICS	30	15	15	60	120	180	6
DIMENSIONING ON THE SERVICE LIFE	30	30	0	60	120	180	6
STRUCTURE INTEGRITY	30	30	0	60	120	180	6
DESIGNING WITH MODERN MATERIALS	30	30	0	60	120	180	6
MOTOR VEHICLES	30	30	0	60	120	180	6
JOINING OF ENGINEERING MATERIALS	30	30	0	60	120	180	6
PLANNING AND REALISATION OF JOINTS BY WELDING	30	30	0	60	120	180	6
DESIGN OF TECHNICAL SYSTEMS	30	30	0	60	120	180	6
DESIGN OF MODERN MACHINE DRIVES	30	30	0	60	120	180	6
INTEGRAL TRANSPORT	30	30	0	60	120	180	6
STRATEGIES AND METHODS OF MAINTENANCE	30	30	0	60	120	180	6

FRACTURE AND DAMAGE	30	15	15	60	120	180	6
CONTACT PROBLEMS	30	30	0	60	120	180	6
THEORY OF MACHINES AND MECHANISMS	30	30	0	60	120	180	6
STABILITY AND DYNAMICS OF STRUCTURES	30	30	0	60	120	180	6
KNOWLEDGE BASED ENGINEERING	30	30	0	60	120	180	6
NONLINEAR COMPUTATIONAL ENGINEERING ANALYSES	15	15	0	30	150	180	6
ADVANCED COMPUTER AIDED TECHNOLOGIES	30	30	0	60	120	180	6
RESPONSE SIMULATION OF MULTI-BODY SYSTEMS	30	30	0	60	120	180	6
MODELLING OF STRUCTURAL NONLINEARITIES	30	30	0	60	120	180	6
NUMERICAL METHODS FOR FATIGUE ANALYSIS OF MATERIALS	30	30	0	60	120	180	6
MODELLING OF MATERIAL NONLINEARITIES	30	30	0	60	120	180	6
MODELLING OF COUPLED PROBLEMS	10	10	0	20	160	180	6
IMPACT MECHANICS	15	15	0	30	150	180	6
SELECTED CHAPTERS IN TRANSPORT PHENOMENA	30	15	15	60	120	180	6
DESIGN PROPERTIES AND APPLICATION OF POROUS MATERIALS	30	30	0	60	120	180	6
ADVANCED EXPERIMENTAL METHODS	30	15	15	60	120	180	6
ADVANCED METHODS IN CFD	20	10	0	30	150	180	6
HUMAN ERRORS IN POWER AND PROCESS ENGINEERING	30	15	15	60	120	180	6
AEROACOUSTICS	30	15	15	60	120	180	6
MODELING OF PROCESSES IN AGGREGATES OF DRIVE SYSTEMS	30	15	15	60	120	180	6
CAVITATION IN TURBOMACHINERY	30	15	15	60	120	180	6
NON-INVASIVE MEASUREMENT TECHNIQUES IN POWER AND PROCESS ENGINEERING	15	15	30	60	120	180	6
STATISTICAL THERMODYNAMICS	35	10	15	60	120	180	6
MULTIPHASE FLOW MODELING	20	5	30	55	125	180	6

ADVANCED MEASUREMENTS METHODS IN POWER AND PROCESS ENGINEERING	30	15	15	60	120	180	6
BOUNDARY AND DOMAIN APPROXIMATION METHODS	30	15	15	60	120	180	6
TURBULENT FLOW	30	15	15	60	120	180	6
DYNAMICS OF REACTING FLOW	30	20	10	60	120	180	6
RHEOLOGY OF FLUIDS	30	15	15	60	120	180	6
SELECTED CHAPTERS IN THERMODYNAMICS	30	30	0	60	120	180	6
SELECTED CHAPTERS IN FLUID MECHANICS	30	15	15	60	120	180	6
ADVANCED TOPICS IN POWER AND PROCESS ENGINEERING	30	15	15	60	120	180	6
MULTIPHASE SYSTEMS	30	15	15	60	120	180	6
INTELLIGENT MACHINES AND SYSTEMS	30	30	0	60	120	180	6
INTELLIGENT MODELLING AND OPTIMIZATION OF MACHINING PROCESSES	30	30	0	60	120	180	6
HYDRAULIC AND PNEUMATIC SERVO SYSTEMS	30	30	0	60	120	180	6
INTELLIGENT MONITORING SYSTEMS	30	30	0	60	120	180	6
SELECTED TOPICS IN INTELLIGENT MACHINES AND SYSTEMS	10	50	0	60	120	180	6
ADVANCED MEASUREMENT SYSTEMS	30	30	0	60	120	180	6
NEW TECHNOLOGIES AND SYSTEMS	30	30	0	60	120	180	6
MANUFACTURING CELLS AND SYSTEMS	30	30	0	60	120	180	6
THEORY OF TECHNICAL SYSTEMS	30	30	0	60	120	180	6
FLUID POWER MECHATRONIC SYSTEMS	30	30	0	60	120	180	6
ADVANCED PRODUCTION SYSTEMS	30	30	0	60	120	180	6
ADVANCED PRODUCTION PLANNING AND CONTROL SYSTEMS	30	15	15	60	120	180	6
KNOWLEDGE EVALUATION IN BUSINESS SYSTEMS	30	15	15	60	120	180	6
ADVANCED SIMULATION TECHNIQUES AND PRODUCTION OPTIMIZATION	30	15	15	60	120	180	6
MODERN CONCEPTS IN PRODUCTION	30	30	0	60	120	180	6

COMPUTER AIDED QUALITY MANAGEMENT	30	15	15	60	120	180	6
CREATIVITY TECHNIQUES IN KNOWLEDGE PROCESSES	30	15	15	60	120	180	6
PRODUCT DEVELOPMENT AND INNOVATION MANAGEMENT	30	30	0	60	120	180	6
PRODUCTION PROCESS REENGINEERING	30	30	0	60	120	180	6
RESEARCH METHODOLOGIES IN PRODUCTION MANAGEMENT	30	30	0	60	120	180	6
STRUCTURE OF MATERIALS	30	30	0	60	120	180	6
TESTING OF MATERIALS	30	30	0	60	120	180	6
MODELLING IN MATERIALS TECHNOLOGY	15	5	0	20	160	180	6
THERMOMECHANICAL TREATMENTS OF MATERIALS	17	3	0	20	1	180	6
DESIGNING OF MATERIALS	30	30	0	60	120	180	6
ADVANCED METAL FORMING SYSTEMS	30	30	0	60	120	180	6
PLASTICITY OF MATERIALS AND FORMING PROCESSES	30	30	0	60	120	180	6
ENVIRONMENTAL INTERACTIONS AND PROTECTION OF MATERIALS	30	30	0	60	120	180	6
FIBRES	30	30	0	60	120	180	6
NANOMATERIALS AND NANOTECHNOLOGY	30	30	0	60	120	180	6
RENEWABLE MATERIALS AND TECHNOLOGIES	30	30	0	60	120	180	6
SURFACE PROPERTIES OF POLYMER MATERIALS	30	30	0	60	120	180	6
FUNCTIONAL MATERIALS	30	30	0	60	120	180	6
CELLULOSE FIBRES AND PAPER	30	30	0	60	120	180	6
LIGHT ALLOYS	15	5	0	20	160	180	6
NONLINEAR FRACTURE MECHANICS	30	30	0	60	120	180	6
MEHANICS OF STRUCTURES AND PROCESSES	30	30	0	60	120	180	6
DYNAMICS OF ELASTIC SYSTEMS	30	30	0	60	120	180	6
NUMERICAL ANALYSIS IN NONLINEAR FRACTURE MECHANICS	30	30	0	60	120	180	6
OSCILLATIONS OF ELECTROMECHANICAL	30	30	0	60	120	180	6

SYSTEMS							
STRUCTURAL TOPOLOGY OPTIMIZATION	30	30	0	60	120	180	6
BIONICS	30	30	0	60	120	180	6
EPISTEMOLOGY OF DESIGN	30	30	0	60	120	180	6
AESTHETICS	30	45	0	75	105	180	6
COMPOSITION	30	30	0	60	120	180	6
DESIGN METHODOLOGY	30	20	40	90	90	180	6
SOLID STATE PHYSICS WITH QUANTUM MECHANICS	30	30	0	60	120	180	6
APPLIED PHYSICAL METHODS	30	30	0	60	120	180	6
X-RAY SPECTROSCOPIC METHODS	30	30	0	60	120	180	6
PARTIAL DIFFERENTIAL AND INTEGRAL EQUATIONS	30	30	0	60	120	180	6
SELECTED TOPICS IN STATISTICS	30	30	0	60	120	180	6
OPTIMIZATION METHODS	30	30	0	60	120	180	6