University of Maribor
Faculty of Natural Sciences and Mathematics

Information on the postgraduate doctoral programme

PHYSICS

QUALIFICATION AWARDED

- **Doctoral study programme "Physics"**

Qualification rewarded: doktor/doktorica znanosti (dr.)
Duration of studies: 3 years

ADMISSION REQUIREMENTS

- Successfully completed graduate of the second stage university programme in physics, assessed with 300 ECTS;
- Successfully completed graduate university programme in physics, accepted before the enforcement of the Higher Education Act 2004;
- Successfully completed high school programme and finished specialisation. Candidates should pass exams of selected courses in total amount of 35 ECTS: Statistical Thermodynamics (8 ECTS), Physics of modelling (10 ECTS), Physics of Complex Systems (7 ECTS) and Introduction to scientific research work (10 ECTS).
- Successfully completed master programme in physics, accepted before the enforcement of the Higher Education Act 2004.
- Successfully completed adequate study programmes in EU.

EDUCATIONAL AND PROFESSIONAL GOALS

Basic goals of the programme

Basic goals of the programme are to qualify candidates for:

- scientific work, research and development in the fields of physics such as biophysics, physics of complex systems, technical physics, theoretical physics and educational physics as well as in other interdisciplinary fields related to physics.
- individual and group scientific work in interdisciplinary research and development groups, institutes and companies.
- advanced development of physics education at all levels of education.
- use of modern physical scientific methods including state of the art experimental and theoretical methods and procedures in known and unknown situations.
- use of modern experimental equipment, tools and software form the fields of physics and biophysics.
- assuming responsibility in managing and directing projects, systems and functions related to the fields of physics, biophysics and educational physics.
- independent and responsible managing and interlinking of group work
- development of novel knowledge and technologies in different fields of physics and their application to life sciences, computer sciences, technology, health sciences and education

Common competences achieved through the programme

- autonomy in high-end research and pretentious scientific work
- deep understanding of theoretical and methodological concepts and to be fully acquainted with top research methods, procedures and processes

- autonomy in critics in the field of science and profession
- the ability in synthesizing knowledge and its application
- independence in development of new knowledge and solutions for solving the hardest problems
- the ability to work in research groups and on research projects
- the ability to publish research results in international scientific journals
- engagement to professionalism and scientific ethics
- to take over responsibility in acceptance of scientific and professional decisions
- autonomy in managing of group research work
- the ability to tutoring younger fellows at institutes, universities, companies etc.
- effectiveness in source use

Subject specific competences achieved through the programme

- the ability of solving specific research problems from different fields of physics
- development of skills in application of knowledge to selected research in the field of physics and related disciplines
- the ability to develop and implement unique scientific solutions in given problems in the field of physics and interdisciplinary sciences
- the ability to use standard and modern empirical research methods within physics
- the ability of individual development and evaluation of modern trends in education of physics
- the ability of interconnecting scientific and educational institutions
- the ability of presentation of research work from the field of physics in the form publications in international scientific journals
- deep understanding of theoretical and methodological physical concepts
- individual development of novel physical knowledge

ACCESS TO FURTHER STUDIES

Doctoral university programme *Physics* is a supreme degree of university studies.

FINAL EXAMINATION

There is no final examination other than the defence of the doctoral thesis.

EXAMINATION AND ASSESSMENT REGULATIONS

The examinations are usually written and oral. Some of the courses involve the preparation of a seminar work which is usually defended by an oral presentation. The oral examination is usually preconditioned by the successful completion of the written exam and the seminar

work where required. In individual work, the student's successful start, one third-, two third-accomplishments and finishing of the investigations are assessed. Timetables of examinations are issued individually in a consensus between the student and the lecturers. Otherwise, timetables of examinations are issued yearly by the Faculty Senate at the beginning of the academic year and are published on the faculty web page and on the notice boards. There are at least 6 examinations for each course per academic year and students are free to choose the date of examination. The students need to register for examination 7 days before the examination date. The examination can be cancelled no later than 3 days before the examination date. The use of literature and other items during the examination is determined by the lecturer and may vary from course to course.

The presentation of Ph.D. is public; the defence of the thesis has to be performed in front of the examination board, chaired by an internationally recognized expert from the field of the thesis. The board should include the Dean of the Faculty, mentor, co-mentor and one or two internationally recognized scientists, who are experts in the field.

ECTS DEPARTMENTAL CO-ORDINATOR

ECTS departmental co-ordinator is the actual head of the department.

PROGRAMME STRUCTURE

Complete curricula in the doctoral programme *Physics* is given in the following pages. All the courses (obligatory and elective) are given together with the semester of study, the amount and type of the contact hours and the assigned number of the ECTS credits. In general, the courses with 5 ECTS have 25 contact hours with the lecturer and the courses with 10 ECTS and 15 ECTS have two and three times more contact hours, respectively.

Doctoral Programme Physics

The postgraduate doctoral programme consists of lasts 3 years or 6 semesters and consists of:
- 2 obligatory courses (15 ECTS);
- individual research work (75 ECTS),
- obligatory and/or elective courses (60 ECTS)
- preparation and defence of the Doctoral Thesis (30 ECTS)

in total sum of 180 ECTS.

Basic structure of the Programme

1. semester	Selection among modules Biophysics 1, Physics 1, Educational Physics 1	**30 ECTS**
2. semester	Selection among modules Biophysics 2, Physics 2, Educational Physics 2	**30 ECTS**
3. semester	Selection among modules Biophysics 3, Physics 3, Educational Physics 3	**30 ECTS**
4. semester	Obligatory course - Seminar Individual research work IV	10 ECTS 20 ECTS **TOTAL: 30 ECTS**
5. semester	Individual research work V	**30 ECTS**
6. semester	Doctoral Thesis	**30 ECTS**
TOTAL		**180 ECTS**

More detailed basic structure:

1. semester Obligatory course – Project Management 5 ECTS

	Obligatory or elective courses within selected module	20 ECTS
	Individual research work I	5 ECTS
		TOTAL: 30 ECTS
2. semester	Obligatory or elective courses within selected module	20 ECTS
	Individual research work II	10 ECTS
		TOTAL: 30 ECTS
3. semester	Elective courses within selected module	20 ECTS
	Individual research work III	10 ECTS
		TOTAL: 30 ECTS
4. semester	Obligatory course - Seminar	10 ECTS
	Individual research work IV	20 ECTS
		TOTAL: 30 ECTS
5. semester	Individual research work V	**30 ECTS**
6. semester	Doctoral Thesis	**30 ECTS**
TOTAL		**180 ECTS**

Detailed specification of the modules:

MODULES BIOPHYSICS:

Module Biophysics 1:

1. semester	Project Management	5 ECTS
	Biophysics I	10 ECTS
	Elective obligatory courses from the list of Biophysical Courses	10 ECTS
	Individual research work I	5 ECTS
		TOTAL: 30 ECTS

Module Biophysics 2:

2. semester	Biophysics II	10 ECTS
	Elective obligatory courses from the list of Biophysical Courses	10 ECTS
	Individual research work II	10 ECTS
		TOTAL: 30 ECTS

Module Biophysics 3:

3. semester	Elective courses from the list of Elective Courses	20 ECTS
	Individual research work III	10 ECTS
		TOTAL: 30 ECTS

MODULES PHYSICS:

Module Physics 1:

1. semester	Project Management	5 ECTS
	Elective courses from the list of Elective Courses	20 ECTS
	Individual research work I	5 ECTS
		TOTAL: 30 ECTS

Module Physics 2:

2. semester	Elective courses from the list of Elective Courses	20 ECTS
	Individual research work II	10 ECTS
		TOTAL: 30 ECTS

Module Physics 3:

3. semester	Elective courses from the list of Elective Courses	20 ECTS
	Individual research work III	10 ECTS
		TOTAL: 30 ECTS

MODULES EDUCATIONAL PHYSICS:

Module Educational Physics 1:

1. semester	Project Management	5 ECTS
	Overview of classical Physics	5 ECTS
	Overview of modern Physics	5 ECTS
	Educational Physics I	5 ECTS
	Elective courses from the list of Elective Courses	5 ECTS
	Individual research work I	5 ECTS
		TOTAL: 30 ECTS

Module Educational Physics 2:

2. semester	Educational Physics II	5 ECTS
	Methodology of pedagogical research	5 ECTS
	Modelling in Physics education	5 ECTS
	Elective-obligatory courses from the list Pedagogy-Didactics	5 ECTS
	Individual research work II	10 ECTS
		TOTAL: 30 ECTS

Module Educational Physics 3:

3. semester	Elective courses from the list of Educational Physics	10 ECTS
	Elective courses from the list of Educational Physics	10 ECTS
	Individual research work III	10 ECTS
		TOTAL: 30 ECTS

Before application student makes an agreement with his mentor about his/her orientation within the study and the choice of modules. Student can choose obligatory and elective courses from the lists of courses for particular module. Mixing of modules during the study is not desired. Student can choose courses with up to 20 ECTS within the second-degree study programme, which is implemented in the Faculty of natural sciences and mathematics (FNSM). He/she cannot choose courses that have been selected in his/her bygone study. It is admitted for students to collect up to 20 ECTS, considered as elective subjects, from other second-degree study programmes or doctoral programmes from the same faculty or from other faculties.

Students agree with mentor about the selection of courses that are running at the FNSM or other faculties In case of choosing courses from other Faculties the Committee at the Department of Physics ratifies the selection of elective subjects.

Elective courses for the modules Biophysics

List	**Course**	**ECTS**
Biophysical Courses	Advanced experimental methods in Biophysics	10
	Methods of Biophysical Modelling	10
	Interactions of nanomaterials with biological systems	10
	Nanobionics	10

Elective courses for the modules Educational Phyiscs

List	**Course**	**ECTS**
Courses: Pedagogy-Didactics	Theory of education	5
	Psychology of Education	5
	Neuropsychology of learning	5
	Overview of classical and modern didactics	5
	Special Pedagogy/Special Education	5
Courses: Educational Physics	Innovative Projects	10
	Experimental projects in Physics Education	10
	Analysis and development of teaching aids and equipment in physics	10
	Information and Communication Technologies (ICT) in Physics	10

	Correlation Projects	10
	Informal education of Physics topics	10
	Problem solving in Physics	10
	Analysis and development of curricula	10

Elective courses for the modules Biophysics, Physics and Educational Physics

List	**Course**	**ECTS**
Elective Courses	Atomic Physics	15
	Atomistic simulations of biomolecules	10
	Biophysics I	10
	Biophysics II	10
	Dynamics of stochastic processes	15
	Phase Transitions in Soft matter Physics	5
	Colloidal Interactions	10
	Physics of Polymers	15
	Physics of living beings	5
	Physical properties of materials	5
	Light, vision and colours	5
	Behavioural strategies and games in physics	5
	Interactions between nanomaterials and biological systems	10
	Differential equations: Selected topics	10
	Selected topics in soft matter physics	10
	Selected topics from environmental physics	15
	Selected topics in Biophysics	10
	Selected topics in Physics	10
	Complex mixtures	5
	Complex liquids under extreme conditions	5
	Mechanics of solid matter	5
	Methods of biophysical modelling	10
	Modelling in soft matter Physics	15
	Nanobionics	10
	Advanced experimental methods in Biophysics	10
	Advanced mathematical methods in Physics	10
	Nonlinear dynamics	10
	Nonlinear dynamic systems in physics and biology	15
	Nonequilibrium thermodynamics and generalized hydrodynamics	5
	Optical fibres and devices	15
	Optical fibre- and optoelectronic- sensors	15
	X-ray spectroscopic methods	15
	Theoretical solid state Physics	10
	Techniques of cooling	15
	Modern view to Physics	5
	Sociophysics	5
	Introduction to quantum field theory and particle physics	10

ECTS and hourly assessment of the study programme and its units

Selected modules BIOPHYSICS 1-3:

1. Semester:

Course	**LE**	**SE**	**LW**	**ME**	**Tot. no. of**	**Ind. work**	**Total**

					contact hours	of student in hours	hours/ECTS
Project Management	15	10	0	0	25	125	150/5
Biophysics I	30	20	0	0	50	250	300/10
Advanced experimental methods in Biophysics*	15	0	75	0	90	210	300/10
Individual research work I	0	0	0	10	10	140	150/5
Total per Semester	**60**	**30**	**75**	**10**	**175**	**725**	**900/30**

* or any other course within list of Biophysical couses for modules Biophysics 1, 2

2. Semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS
Biophysics II	30	20	0	0	50	250	300/10
Nanobionics*	30	20	0	0	50	250	300/10
Individual research work II	0	0	0	20	20	280	300/10
Total per Semester	**60**	**40**	**0**	**20**	**120**	**780**	**900/30**

* or any other course within list of Biophysical couses for modules Biophysics 1, 2

3. Semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS
Interaction of nanomaterials with biological systems*	30	20	0	0	50	250	300/10
Selected topics from biophysics*	30	20	0	0	50	250	300/10
Individual research work III	0	0	0	20	20	280	300/10
Total per Semester	**60**	**40**	**0**	**20**	**120**	**780**	**900/30**

*or any other course within list of Elective couses for module Biophysics 3

Selected modules PHYSICS 1-3:

1. Semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS
Project Management	15	10	0	0	25	125	150/5
Modelling in soft matter physics*	45	30	0	0	75	375	450/15
Complex mixtures*	15	10	0	0	25	125	150/5
Individual research work I	0	0	0	10	10	140	150/5
Total per Semester	**75**	**50**	**0**	**10**	**135**	**765**	**900/30**

*or any other course within list of Elective couses for modules Physics 1-3

2. Semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS
Atomistice simulations of biomolecules*	30	20	0	0	50	250	300/10
Nonlinear thermodynamics and generalised hydrodynamics*	30	20	0	0	50	250	300/10
Individual research work II	0	0	0	20	20	280	300/10
Total per Semester	**60**	**40**	**0**	**20**	**120**	**780**	**900/30**

*or any other course within list of Elective couses for modules Physics 1-3

3. Semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS

Selected topics in softmatter physics*	30	20	0	0	50	250	300/10
Koloidal interactions*	30	20	0	0	50	250	300/10
Individual research work II	0	0	0	20	20	280	300/10
Total per Semester	**60**	**40**	**0**	**20**	**120**	**780**	**900/30**

*or any other course within list of Elective courses for modules Physics 1-3

Selected modules EDUCATIONAL PHYSICS 1-3:

1. Semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS
Project Management	15	10	0	0	25	125	150/5
Overview of classical Physics	15	10	0	0	25	125	150/5
Overview modern Physics	15	10	0	0	25	125	150/5
Educational Physics I	15	10	0	0	25	125	150/5
Vision, Light, Colours*	15	10	0	0	25	125	150/5
Individual research work I	0	0	0	10	10	140	150/5
Total per Semester	**75**	**50**	**0**	**10**	**135**	**765**	**900/30**

*or any other course within list of Elective courses for module Eduactional Physics 1

2. Semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS
Educational Physics II	15	10	0	0	25	125	150/5
Methodology of pedag. research	15	10	0	0	25	125	150/5
Modelling in Physics Eduaction	15	10	0	0	25	125	150/5
Neuropsychology of learning*	15	10	0	0	25	125	150/5
Individual research work II	0	0	0	20	20	280	300/10
Total per Semester	**60**	**40**	**0**	**20**	**120**	**780**	**900/30**

*or any other course within the list of courses: Pedagogy - Didactics for module Eduactional Physics 2

3. Semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS
Analysis and development of teaching aids and equipment in Physics*	30	20	0	0	50	250	300/10
Experimental projets in Physics education*	30	20	0	0	50	250	300/10
Individual research work III	0	0	0	20	20	280	300/10
Total per Semester	**60**	**40**	**0**	**20**	**120**	**780**	**900/30**

* or any other course within the list of courses: Educational Physics for module Eduactional Physics 2

Common part of the Programme:

4. semester:

Course	LE	SE	LW	ME	Tot. no. of contact hours	Ind. work of student in hours	Total hours/ECTS
Seminar	0	50	0	0	50	250	300/10

Individual research work IV	0	0	0	40	40	560	600/20
Total per Semester	**0**	**50**	**0**	**40**	**90**	**810**	**900/30**

5. semester:

Course	**LE**	**SE**	**LW**	**ME**	**Tot. no. of contact hours**	**Ind. work of student in hours**	**Total hours/ECTS**
Individual research work V	0	0	0	60	60	840	900/30
Total per Semester	**0**	**0**	**0**	**60**	**60**	**840**	**900/30**

6. semester:

Course	**LE**	**SE**	**LW**	**ME**	**Tot. no. of contact hours**	**Ind. work of student in hours**	**Total hours/ECTS**
Doctoral disertation	0	0	0	60	60	840	900/30
Total per Semester	**0**	**0**	**0**	**60**	**60**	**840**	**900/30**

List of all elective subjects with hourly assessment:

No.	**Course**	**LE**	**SE**	**LW**	**FW**	**Ind. work**	**ECTS**
1.	Advanced experimental methods in biophysics	15		75		210	10
2.	Advanced mathematical methods in Physics	30	20			250	10
3.	Analysis and development of curricula	30	20			250	10
4.	Analysis and development of teaching aids and equipment in physics	30	20			250	10
5.	Atomic Physics	45	30			375	15
6.	Atomistic simulations of biomolecules	30	20			250	10
7.	Behavioural strategies and games in physics	15	10			125	5
8.	Biophysics I	30	20			250	10
9.	Biophysics II	30	20			250	10
10.	Colloidal Interactions	30	20			250	10
11.	Complex liquids under extreme conditions	15	10			125	5
12.	Complex mixtures	15	10			125	5
13.	Correlation projects	30	20			250	10
14.	Differential equations: Selected topics	30	20			250	10
15.	Dynamical systems in physics and biology	30	30	15		375	15
16.	Dynamics of stochastic processes	45	30			375	15
17.	Experimental Projects in Physics Education	30	20			250	10
18.	Information and Communication Technologies (ICT) in Physics	30	20			250	10
19.	Informal education of Physics topics	30	20			250	10
20.	Inovative Projects	30	20			250	10
21.	Interactions between nanomaterials and biological systems	30	20			250	10
22.	Introduction to quantum field theory and particle physics	30	20			250	10
23.	Light, vision and colours	10	5	10		125	5
24.	Mechanics of solid matter	15	10			125	5
25.	Methods of biophysical modelling	20	20	10		250	10
26.	Modelling in soft matter Physics	45	30			375	15
27.	Modern view to Physics	15	10			125	5
28.	Nanobionics	30	20			250	10
29.	Neuropsychology of learning	15	10			125	5

30.	Nonequilibrium thermodynamics and generalized hydrodynamics	15	10			125	5
31.	Nonlinear dynamics	30	20			250	10
32.	Optical fibre- and optoelectronic- sensors	45	30			375	15
33.	Optical fibres and devices	45	30			375	15
34.	Overview of classical and modern didactics	15	10			125	5
35.	Phase Transitions in Soft matter Physics	15	10			125	5
36.	Physical properties of materials	15	10			125	5
37.	Physics of living beings	15	10			125	5
38.	Physics of polymers	45	30			375	15
39.	Problem solving in Physics	30	20			250	10
40.	Psychology in education	15	10			125	5
41.	Selected topics from environmental physics	20		20	35	375	15
42.	Selected topics in Biophysics	30	20			250	10
43.	Selected topics in Physics	30	20			250	10
44.	Selected topics in soft matter physics	30	20			250	10
45.	Sociophysics	15	10			125	5
46.	Special pedagogy/Special Didactics	15	10			125	5
47.	Techniques of cooling	45	30			375	15
48.	Theoretical solid state Physics	30	20			250	10
49.	Theory of education	15	10			125	5
50.	X-ray spectroscopic methods	45	30			375	15

LE - Lectures
SE - Seminar
LW - Laboratory work
ME – Individual work with mentor

1.2.2.2 Seznam predmetov (List of Courses)

Alphabetical list of courses:

No.	Course	Module Biophysics	Module Physics	Module Educational Physics	ECTS
1.	Advanced experimental methods in biophysics	E	E	E	10
2.	Advanced mathematical methods in Physics	E	E	E	10
3.	Analysis and development of curricula	/	/	E	10
4.	Analysis and development of teaching aids and equipment in physics	/	/	E	10
5.	Atomic Physics	E	E	E	15
6.	Atomistic simulations of biomolecules	E	E	E	10
7.	Behavioural strategies and games in physics	E	E	E	5
8.	Biophysics I	O	E	E	10
9.	Biophysics II	O	E	E	10
10.	Colloidal Interactions	E	E	E	10
11.	Complex liquids under extreme conditions	E	E	E	5
12.	Complex mixtures	E	E	E	5
13.	Correlation Projects	/	/	E	10
14.	Differential equations: Selected topics	E	E	E	10
15.	Doctoral disertation	O	O	O	30

16.	Dynamical systems in physics and biology	E	E	E	15
17.	Dynamics of stochastic processes	E	E	E	15
18.	Educational Physics I	/	/	O	5
19.	Educational Physics II	/	/	O	5
20.	Experimental Projects in Physics Education	/	/	E	10
21.	Information and Communication Technologies (ICT) in Physics	/	/	E	10
22.	Individual research work I	O	O	O	5
23.	Individual research work II	O	O	O	10
24.	Individual research work III	O	O	O	10
25.	Individual research work IV	O	O	O	20
26.	Individual research work V	O	O	O	30
27.	Informal education of Physics topics	/	/	E	10
28.	Inovative Projects	/	/	/	10
29.	Interactions between nanomaterials and biological systems	E	E	E	10
30.	Introduction to quantum field theory and particle physics	E	E	E	10
31.	Light, vision and colours	E	E	E	5
32.	Mechanics of solid matter	E	E	E	5
33.	Methodology of pedagogical research	/	/	O	5
34.	Methods of biophysical modelling	E	E	E	10
35.	Modelling in Physics Eduaction	/	/	O	5
36.	Modelling in soft matter Physics	E	E	E	15
37.	Modern view to Physics	E	E	E	5
38.	Nanobionics	E	E	E	10
39.	Neuropsychology of learning	/	/	E	5
40.	Nonequilibrium thermodynamics and generalized hydrodynamics	E	E	E	5
41.	Nonlinear dynamics	E	E	E	10
42.	Optical fibre- and optoelectronic-sensors	E	E	E	15
43.	Optical fibres and devices	E	E	E	15
44.	Overview of classical and modern didactics	/	/	E	5
45.	Overview of classical physics	/	/	O	5
46.	Overview of modern physics	/	/	O	5
47.	Phase Transitions in Soft matter Physics	E	E	E	5
48.	Physical properties of materials	E	E	E	5
49.	Physics of living beings	E	E	E	5
50.	Physics of Polymers	E	E	E	15
51.	Problem solving in Physics	/	/	E	10
52.	Project management	O	O	O	5
53.	Psychology in education	/	/	E	5
54.	Selected topics from environmental physics	E	E	E	15
55.	Selected topics in Biophysics	E	E	E	10
56.	Selected topics in Physics	E	E	E	10
57.	Selected topics in soft matter physics	E	E	E	10
58.	Seminar	O	O	O	15
59.	Sociophysics	E	E	E	5
60.	Special pedagogy/Special	/	/	E	5

	didiactics				
61.	Techniques of cooling	E	E	E	15
62.	Theoretical solid state Physics	E	E	E	10
63.	Theory of education	/	/	E	5
64.	X-ray spectroscopic methods	E	E	E	15

/ – not available within the module
O – obligatory
E – elective