Study Regulations Governing the Single-Subject Master's Degree Programme 'Quantum Engineering'

27 February 2020

Note: This translation is provided for information purposes only. In the event of any discrepancy between the translation and the original German version published in the Official Bulletin (*Dienstblatt der Hochschulen des Saarlandes*), the provisions of the latter shall take precedence.

Pursuant to Section 60 of the Saarland Higher Education Institutions Act (SHSG) (Official Gazette of Saarland I, p. 1080) of 30 November 2016 most recently amended by the Act of 10 April 2019 (Official Gazette I, p. 412) and based on the Examination Regulations governing the Master's degree programme in Quantum Engineering of 27 February 2020 (Official Bulletin, No. 30, p. 334) and with the consent of the Saarland University Senate, the Faculty of Natural Sciences and Technology at Saarland University hereby issues the following Study Regulations Governing the Single-Subject Master's Degree Programme in Quantum Engineering.

Section 1

Scope

These study regulations govern the content and structure of the single-subject Master's degree Programme in Quantum Engineering based on the Examination Regulations of the Faculty of Natural Sciences and Technology of 27 February 2020 governing the Master's degree programme in Quantum Engineering (Official Bulletin, No. 30, p. 334). The organization of the curriculum, teaching and examinations in this programme is the responsibility of the Faculty of Natural Sciences and Technology at Saarland University.

Section 2

Objectives of the degree programme and career relevance

(1) The Master's degree programme in Quantum Engineering aims to provide a research-driven education in Quantum Engineering which attaches particular importance to the interdisciplinary system concept. It imparts to students the methods and techniques used in scientific research as well as a deeper understanding of the principles of the subject and a more detailed knowledge of key research results in the chosen subject.

(2) The Master's degree programme in Quantum Engineering prepares students for challenging research and development activities in the field of physics and systems engineering, in particular in the area of quantum technologies.

(3) To achieve the specified learning outcomes, the degree programme provides students with a deeper understanding of the complementary core areas of physics and systems engineering. The subject-specific mandatory elective modules and one general mandatory

elective module enable students to further specialize and develop interdisciplinary academic skills. Students undertake subject-specific practical skills classes that help them develop group-work and interpersonal skills and to consolidate the theoretical knowledge acquired in the programme by applying it to practical projects. The Lab Project and the Master's thesis as well as any elective seminars impart to students the methods and techniques used in scientific research under supervision.

(4) Students are also encouraged to make use of other academic modules offered at Saarland University in order to become acquainted with the academic content and methodological concepts in other scientific fields and develop interdisciplinary skills.

Section 3

Start of programme

Students can begin the programme at the beginning of the winter or summer semester of each year.

Section 4

Types of academic instruction

The curriculum content is taught using the following types of academic instruction:

1. Lectures (German abbreviation: V):
   Lectures serve to introduce a particular subject area and also provide an overview of the relevant theoretical concepts and principles, methodologies and skills, technologies and practical implementations that are common to the subject. Lecture courses provide suggestions for further reading on a topic and open the way to acquiring a deeper understanding of an area through subsequent exercise and problem-solving classes, practical skills classes and self-directed study.
2. Exercise and problem-solving classes (German abbreviation: Ü):
   Exercise and problem-solving classes are small-group sessions used primarily to supplement and reinforce what was learned in the lectures. Students work on representative problems as this provides an opportunity for them to apply and deepen the knowledge they acquired in the respective lectures, to assess their personal understanding of a specific area and to clarify any questions that they may have. Students may be required to successfully complete the assigned exercises and problems in order to register for an end-of-module assessment or examination.
3. Seminars (German abbreviation: S):
   Seminars are a type of academic instruction with a limited number of participants in which students actively collaborate to generate results or share their results by participating in discussions or by giving presentations. Seminars aim to deepen student understanding of an academic field, help students acquire the skills needed for the effective presentation of scientific and academic content, and encourage students to engage in critical analysis and discussion of research results.
4. Practical skills classes (German abbreviation: P):
   Practical skills classes are a type of academic instruction in which students undertake experiments that introduce them to the specific approaches and methods used in a

particular discipline or field of study. Students acquire the theoretical knowledge that underlies the experiments by attending lectures and by studying the relevant scientific literature. The experiments are undertaken in a supervised environment and provide students, working either alone or in small groups, with the opportunity to gain practical experience with the typical instruments, laboratory equipment and systems used in this field of study. Students learn about the relationships between theory and practice not only through independent study and practice, but also through teamwork. An additional goal of the practical skills classes is to enable students to gain practical experience with computer-aided methods. Some of the specialist skills acquired in these practical classes can help prepare students for subsequent experimental scientific work. Participation in a particular practical skills class may depend on a student having first successfully completed a required course of lectures and exercise and problem-solving classes.

5. Projects (German abbreviation: PR):
   Projects are a type of academic instruction in which students work under supervision to study and develop approaches to complex issues. Projects enable students to gain the advanced methodologies required to conduct independent research activities. By encouraging a comprehensive review of the scientific literature, projects also enable students to acquire an overview of the current research being conducted in a specific area of quantum engineering.

Section 5

Structure and content of the programme

(1) The Master's degree programme in Quantum Engineering places greater emphasis on research and aims to complete the student's training in fundamentals of physics and engineering. It has been designed to provide students with a broad general education in quantum engineering and neighbouring natural sciences and engineering science disciplines. It also aims to provide students with a deeper understanding in selected specialist areas. The Master's degree programme is designed to enable students to acquire the skills necessary for independent scientific research. The supervised scientific project, which forms part of the Master's thesis module, plays an important role in this regard.

(2) Detailed information regarding the content of modules and module elements is provided in the module catalogue that will be made available in suitable form. Any changes or amendments to the information in the module catalogue that are not covered by the provisions of these regulations shall be reported to the Dean of Studies and documented appropriately.

Section 6

Academic assessments and grading/marking scale

(1) Students on the single-subject Master's degree programme in Quantum Engineering are required to earn coursework and examination credits totalling 120 ECTS credits divided into categories. These are listed in Table 1 together with the ECTS credits to be earned and how they are graded. Appendix A provides details of the modules in the categories of the programme, the type of academic instruction used, the number of credit hours per week and the ECTS credits earned, the module frequency and semester(s) for the standard period of study, the type of academic assessment and whether the module is graded.

Table 1: Categories, ECTS credits and type of grading

Category	ECTS credits	ECTS credits graded
Core subject Systems Engineering	at least 16	at least 12
Core subject Quantum Physics	at least 16	at least 12
Mandatory elective module	at least 16	at least 12
Subject-specific seminars Practical skills classes and project seminars	Total: at least 9, max. 12 max. 4 credits at least 5 credits, max. 12 credits	all credits earned
General mandatory elective module	max. 15 ECTS credits	at least 6
Master's thesis	45	30

(2) The general mandatory elective module requirement listed in Table 1 also includes tutoring and an industrial placement/internship pursuant to Section 18 of the examination regulations. 2 ECTS credits are earned for tutoring when the student carries out one hour of such work during each week of a semester and a maximum of 4 ungraded credits may count towards the study programme. An industrial placement/internship may count towards the study programme up to a maximum of 9 ungraded credits.

(3) The mandatory elective modules, subject-specific seminars and practical skills classes as well as the general mandatory elective module set out in Table 1 are offered at least once every two years. The Dean of Studies will ensure that a sufficient number of modules are offered each academic year. The modules in all other categories of the programme are offered at least once a year.

(4) The language of instruction for core subject courses is usually English. This may be different for elective modules. The language of instruction will be announced at the beginning of the module or module element.

(5) The range of modules offered in the different module categories may be broadened for one or more semesters by adding other modules which must be approved by the Examination Board. These modules, their weighting in ECTS credits and their classification within the different categories of the programme will be announced in a suitable form before the semester begins.

(6) Detailed information regarding the content of modules and the type of assessment are described in the module catalogue that will be made available in a suitable form. Any changes or amendments to the information in the module catalogue that are not covered by the provisions of these regulations shall be reported to the Dean of Studies and documented appropriately.

Section 7

Module prerequisites

Students must have earned at least 45 ECTS credits in order to be admitted to the 'Research Seminar' module and at least 60 ECTS credits for the 'Lab Project' module.
Only students who have successfully completed the module element to be tutored will be permitted to undertake tutoring activities specified in Section 6(2).

Section 8

Studying abroad

All students on the single-subject Master's degree programme in Quantum Engineering are encouraged to spend part of the programme studying abroad. Students interested in studying abroad should seek advice from a relevant source and should clarify credit transfer arrangements in accordance with the examination regulations by completing a study abroad learning agreement. Academic credits earned from student assessments and examinations during a study abroad period shall be recognized in accordance with the examination regulations governing the Master's degree programme in Quantum Engineering at Saarland University, provided that there is no significant difference in academic content when compared with the modules for which transfer credits are being accepted. Information on study abroad opportunities, exchange programmes, scholarships and administrative formalities is available from Saarland University's International Office or from teaching staff of the Physics Department and Systems Engineering Department. As foreign host universities and scholarship-awarding bodies often have early application deadlines and long application processing times, study abroad applications should normally be submitted before the student joins the Master's programme.

Section 9

Study plan

Based on these study regulations, the Dean of Studies shall compile a study plan for the study programme that includes details of the types and scope of the modules with recommendations on how students can organize and structure their studies efficiently. The study plan will be made available in suitable form. The range of modules offered in a particular semester will be published in the Saarland University course catalogue (*Vorlesungsverzeichnis*) for that semester.

Section 10

Study counselling

(1) The Central Student Advisory Service (*Zentrale Studienberatung*) at Saarland University provides counselling and guidance to prospective students and enrolled students concerning the content, structure and requirements of academic study at Saarland University. It can also

advise and assist students with respect to their study options as well as with planning and organizing their studies.

(2) The Department of Physics and the Department of Systems Engineering shall designate members of professorial staff or non-professorial academic staff to provide subject- and study-related advice during the specified office hours. Questions relating to individual modules can be addressed to the respective module coordinators.

Section 11

Commencement

These study regulations shall come into force on the day after they are announced in the Official Bulletin of the Institutions of Higher Education in Saarland (Dienstblatt der Hochschulen des Saarlandes). They are binding for all students who begin the Master's degree programme in Quantum Engineering after that date.

Saarbrücken, 5 April 2022

President of Saarland University
(Univ.-Prof. Dr. Manfred Schmitt)

Appendix A: Modules and module elements

The following abbreviations are used in the tables in this appendix:

RS Standard period of study	LV Type of academic instruction used	P Practical assignment/project	B Graded
ECTS Workload in ECTS credits (referred to in German as 'credit points' or 'CP')	V Lecture	PS Project seminar	U Ungraded
SWS Credit hrs/wk = number of class or supervised hours per week during the semester	Ü Exercise and problem-solving class	PVL Exam admission prerequisites	W Optionally either graded or ungraded
WS Winter semester	PR Project	SP Written exam	
SS Summer semester	S Seminar	MP Oral exam	

Table 2: Modules in the core subject Systems Engineering category (at least 16 ECTS credits, at least 3 modules)

Module	RS	Frequency	LV	SWS	ECTS	Grade	Assessment
Advanced Electronic Packaging	2	SS	V+Ü	3	4	B	SP or MP or PVL
Microelectronics 2	2	SS	V+Ü	3	4	B	SP
Digital Transmission, Signal Processing (Telecommunications I)	3	WS	V+Ü	6	9	B	SP or MP or PVL
Microsensors	3	WS	V+Ü	3	4	B	SP or MP or PVL
High-Frequency Engineering	3	WS	V+Ü	3	4	B	SP or MP or PVL
Antenna Theory 1	3	WS	V+Ü	3	5	B	MP

Table 3: Modules in the core subject Quantum Physics category (at least 16 ECTS credits)

Module	RS	Frequency	LV	SWS	ECTS	Grade	Assessment
Theoretical Physics IV for QE	1	WS	V+Ü	6	6 or 8	B	SP or MP or PVL
Theoretical Physics V for QE	2	SS	V+Ü	6	4 or 8	B	SP or MP
Solid State Physics II	2	SS	V+Ü	3	4	B	SP or MP
Physics of Atoms and Molecules	1	WS	V+Ü	3	4	B	SP or MP
Quantum and Modern Optics*	3	WS	V+Ü	4	5	B	MP
Physics of Nanostructures II a or b	2	WS or SS	V+S	4	5	B	MP

* = of these modules, one can be counted towards the core subject, the others (see Table 4) can be counted towards the subject-specific mandatory elective modules if necessary

Table 4: Modules in the subject-specific mandatory elective module category (at least 16 ECTS credits)

Module	RS	Frequency	LV	SWS	ECTS	Grade	Assessment
Multisensor Signal Processing	2	SS	V+S	3	4	B	MP
Microelectronics 3	3	WS	V+Ü	3	4	B	MP
Microelectronics 4	2	SS	V+Ü	3	4	B	MP
Computational Electromagnetics 1	1	WS	V+Ü	3	4	B	SP+MP
Computational Electromagnetics 2	2	SS	V+Ü	3	4	B	MP
High-Speed Electronics	2	SS	V+Ü	3	4	B	SP or MP or PVL
Reliability 1	3	WS	V+Ü	3	4	B	SP or MP
Nanomechanics	2	Every 2 years	V+S	4	5	B	SP or MP
Quantum Theory of Light*	2	Every 2 years	V+S	4	5	B	SP or MP
Particle Trapping and Laser Cooling*	2	Every 2 years	V+Ü	4	5	B	SP or MP
Computational Physics	2	Every 2 years	V+Ü	4	5	B	SP or MP
Theoretical Physics for Quantum Technologies	2	Every 2 years	V+Ü	4	5	B	SP or MP
In addition:							
- Further modules from the core subjects of Quantum Physics and Systems Engineering							
- Computer Science courses approved by the Examination Board							
- Modules approved by the Examination Board as specified in Section 6(5)							

* = of these modules, one can be counted towards the core subject, the others (see also Table 3) can be counted towards the subject-specific mandatory elective modules if necessary

Table 5: Modules in the subject-specific seminars category (max. 4 ECTS credits) and practical skills classes and project seminars (in total at least. 9 ECTS credits, max. 12 ECTS credits)

Module	RS	Frequency	LV	SWS	ECTS	Grade	Assessment
Physics or System Engineering Seminars						B	
Advanced Physics Lab Course IIa for QE	1	WS	P+S	4	7	B	MP
Advanced Physics Lab Course IIb for QE	2	SS	P+S	2	4	B	MP
Microelectronics Practical Skills Class (FPGA)**	3	WS	PS	4	4	B	SP or MP
Microcontroller Project Seminar**	3	WS	PS	2	3	B	SP or MP
Team Project (small)	3	WS or SS	PS	3	3	B	SP or MP
Team Project (large)	3	WS or SS	PS	6	6	B	SP or MP

** = these modules may only be counted towards the study programme if the module has not been counted towards the Bachelor's degree programme

Table 6: General mandatory elective module (max. 15 ECTS credits, at least 6 ECTS credits graded)

Module	Module element	RS	Frequency	LV	SWS	ECTS	Grade	Assessment
Advanced Mathematics IV (a+b)		2	SS	V+Ü	6	9	B	SP or MP or PVL
Continuum Mechanics		3	WS	V+Ü	3	4	B	SP or MP
Finite Elements in Mechanics		2	SS	V+Ü	3	4	B	SP or MP
Empirical and Statistical Modelling		2	SS	V+Ü	3	4	B	SP or MP or PVL
Studium generale, e.g.	Patent and Innovation Management, Technology Management, Project Management*		WS or SS	V+Ü			U	SP or MP or PVL
	Living Language*		WS or SS	V+Ü			U	SP or MP or PVL
	e.g. Introduction to Business Administration, Entrepreneurship*		WS or SS	V+Ü			U	SP or MP or PVL
	Core skills in accordance with Section 9 of the Examination Regulations (max. 3 ECTS credits)					max. 3 ECTS credits	U	SP or MP or PVL
All modules not taken in the categories of the core subject SE or Physics or subject-specific mandatory electives			WS or SS				B	SP or MP or PVL
Industrial Internship			WS or SS	P		max. 9 ECTS credits	U	SP or MP or PVL
Tutoring			WS or SS	P		2 per SWS, max. 4 ECTS credits	U	SP or MP or PVL
Research Seminar			WS or SS	PR		9	U	SP or MP or PVL
Project Seminar			WS or SS	PS		6	B	SP or MP or PVL

*Specific courses approved by the Examination board.

Table 7: Lab Project and Master's thesis

Module	Module element	RS	Frequency	LV	SWS	ECTS	Grade	Assessment
Laboratory Project		3	WS or SS	PR		15	U	SP and MP
Master's thesis		4	WS or SS	MA		30	B	SP and MP