COURSE DESCRIPTION CARD - SYLLABUS

Course name

Experimental methods of quantum engineering

Course

Field of study	Year/Semester
Technical Physics	1/2
Area of study (specialization)	Profile of study
	general academic
Level of study	Course offered in
Second-cycle studies	Polish
Form of study	Requirements
full-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30		
Tutorials	Projects/seminars	
	15	

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

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Faculty of Materials Science and Technical Physics

Piotrowo 3, 60-965 Poznań

Responsible for the course/lecturer:

Prerequisites

Basic information on the basics of quantum engineering, condensed phase physics and optics materials, higher mathematics, i.e. differential equations in physics, elements of harmonic analysis and signal theory, technical branches: digital electronics, RF systems, high vacuum and low vacuum techniques temperatures, computer-aided experiments, laser techniques, precision mechanical structures, optoelectronics, nanotechnology. Advanced skills research infrastructure devices. Openness in acquiring new knowledge and skills

Course objective

1. To provide students with basic knowledge on experimental methods and implementation quantum processes

2. Developing the skills of algorithmic analysis, planning and implementation of experiments in students quantum, as well as designing complex modular experimental systems for implementation these experiments, to the extent determined by the programming content.

3. Shaping students' skills of creative, algorithmic behavioral actions ethical standards.

Course-related learning outcomes

Knowledge

A student who passed the course

1. is able to identify selected achievements of quantum engineering, including its practical applications;formulate assessments of limitations and problems based on the literature to recognize the main ones directions of development [K2_W07]

2. knows how to indicate, characterize and explain selected methods of quantum engineering in implementations and applications specified in the program content [K2_W10]

Skills

1. analyze and evaluate the implementations of selected quantum experiments described in the literature and make a synthetic comparison of them [K2_U02]

2. analyze the concepts of a selected quantum experiment described in the literature or a functional module / device / system identified in the programming content; technical evaluation implementation of the proposal [K2_U05]

3. Estimate / calculate / simulate the parameters of the selected quantum process (based on the data literature) and on this basis define the parameters of research infrastructure devices [K2_U12]

4.identify technical problems related to the implementation of a specific quantum experiment,design the block layout of the test stand and prepare the specification of the component modules [K2_U14]

Social competences

1. the student is able to work in a team of several people in solving specific ones problems [K2_K01]

2. the student is able to think creatively and act when solving a problem or task [K2_K02]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Effect	Form of evaluation	Assessment criteria
W01, W02,	Exam.	50.1% 70% (3)
	Oral presentation of design elements	70.1% -90.0% (4)
	Project implementation report	from 90.1% (5)
U01, U02, U03, U04,	Exam	50.1% -70.0% (3)

	Oral presentation of design elements	70.1% -90.0% (4)
	Project implementation report	from 90.1% (5)
K01, K02	Oral presentation of design elements	50.1% -70.0% (3)
	Project implementation report	70.1% -90.0% (4)
		from 90.1% (5)

Programme content

1. Classic parameters of coherent light sources and methods of controlling them for the quantum experiment

2. Experimental methods of shaping the quadrature characteristics of light. Squeezing the light

3. Optical and electronic systems of single photon detection. Homodyne detection. Pound-Drewer stabilization lasers metod.

4. Photon-matter interaction: electromagnetically forced transparency, slowing down lights.

5. Experimental setups for studying single photons in a very large resonance cavity kindness.

6. Charged particle trapping systems in Paul-type electromagnetic traps: structures and technology of producing traps of various geometries: linear, planar (2D) and 3D spatial; electronic systems for controlling the trap, optics, optoelectronics and electronic detection and observation of trapped ions, separation of masses and isotopes.

7. Controlling the quantum states of trapped ions: the interaction of single ions with light laser microwave field and magnetic field, cooling of trapped ions (collision, resistive, laser, sympathetic).

8. Charged particle trapping systems in Penning-type electromagnetic traps: experiments testing the predictions of quantum theories: Lande factor measurements.

9. Quantum processors on trapped ions: generation of quantum entanglement in the ion chain,

10. Methods of isolating and transferring atomic structures: magneto-optical trap, trap and tweezers optical, optical-gravity trap, obtaining Bose-Einstein condensate and fermionic condensate. Optical networks

11. Atomic time and frequency standards (clocks) in the microwave and optical range.

12. Thermonuclear fusion

Teaching methods

Lecture: multimedia presentation, presentation illustrated with examples given on the board.

Bibliography

Basic

1.Original and review papers published in scientific and technical periodicals

2. H.-A. Bachor, T. C. Ralph, A Guide to Experiments in Quantum Optics, Wiley-VCH 2004

3. F. G Major V. N. Gheorghe G. Werth, Charged Particle Traps. T1i2 Springer 2009, 2010

4. O. Everitt, Experimental Aspect of Quantum Computing, Springer 2005

5. W. Demtroder, PWN Laser Spectroscopy 1993 (Newer editions in English)

6. A. W. Belinskij Kwantowyje Izmierienija, BINOM-Moscow 2009

Additional

1. C. C. Gerry, P. L. Knight, Introduction to quantum optics, PWN 2007

2. R. Tanaś, Lectures on Quantum Optics, AMU 2007

3. Ch.J. Foot, Atomic Physics, Oxford University Press 2005

4. W. P. Schleich, Quantum Optics in Phase Space, Wiley 2001

5. M. Le Bellac, Introduction to quantum computing, PWN 2011

Breakdown of average student's workload

	Hours	ECTS
Total workload	77	3,0
Classes requiring direct contact with the teacher	47	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	35	1,0

[1] delete or add other activities as appropriate