COURSE DESCRIPTION CARD - SYLLABUS

Course name

Experimental methods of quantum engineering [S2FT2>MEIK]

Course

Field of study

Technical Physics

Year/Semester

1/2

Area of study (specialization)

–

Profile of study

general academic

Level of study

second-cycle

Course offered in

Polish

Form of study

full-time

Requirements

compulsory

Number of hours

Lecture

30

Laboratory classes

0

Other

0

Tutorials

0

Projects/seminars

15

Number of credit points

3,00

Coordinators

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Lecturers

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. has in-depth, theoretically based knowledge of selected techniques for synthesizing microwave and optical radiation and methods of spectral and time analysis.
2. has in-depth, theoretically based knowledge of selected experimental methods of quantum engineering and its practical applications, is able to indicate, characterize and explain selected methods of quantum engineering in implementations and applications specified in the program content.

Skills:
1. is able to plan and conduct research leading to the characterization of functional materials, selected quantum processes, atomic, molecular systems and condensed phase; is able to analyze and document research results; is able to refer to measurement standards and standards in measurements.
2. is able to select advanced and new materials with appropriate physicochemical and structural properties for standard and non-standard laboratory and engineering applications within the scope appropriate for the Technical Physics major.
3. is able to configure complex measurement and technical systems, from modules and functional components and develop control software using standard devices and modules.
4. is able to obtain information on physical and technical issues from literature and databases, perform their critical analysis, integrate them and formulate opinions within the scope appropriate for the Technical Physics major.

Social competences:
1. understands the need and knows the possibilities of continuous education - improving professional, personal and social competences; is aware of the need to use the knowledge of experts when solving engineering tasks in a scope exceeding one's own competences.
2. is able to work responsibly on a designated multi-threaded task, independently and in a team; is able to properly define priorities for the implementation of tasks defined by oneself or others.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

In terms of the methods used to verify the achieved learning outcomes, the following grading thresholds are applied:
50.1-60% - satisfactory;
60.1-70% - satisfactory plus;
70.1-80% - good;
80.1-90% - good plus;
from 90.1% - very good.
The grade is based on an individual written assignment and/or the assessment of an oral response.
The assessment of the project is influenced by the assessment of the seminar presentations describing the implementation of subsequent stages of the project and the assessment of the entire project submitted in written form.

Programme content

Presentation of experiments that use the quantum properties of matter to obtain materials and devices that are otherwise inaccessible.

Course topics

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	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00