COURSE DESCRIPTION CARD - SYLLABUS

Course name

Quantum Physics [S1IZarz1E>FK]

Course

Field of study

Engineering Management

Year/Semester

2/4

Area of study (specialization)

–

Profile of study

general academic

Level of study

first-cycle

Course offered in

English

Form of study

full-time

Requirements

elective

Number of hours

Lecture

15

Laboratory classes

15

Other (e.g. online)

0

Tutorials

0

Projects/seminars

0

Number of credit points

2,00

Coordinators

dr hab. inż. Przemysław Głowacki
przemyslaw.glowacki@put.poznan.pl

Lecturers

Prerequisites

A student starting this subject should have basic knowledge in mathematics and physics at the level of the first level of education. The student has the ability to deepen understanding and interpretation of messages and effective self- education in the field related to the chosen field of study. Ability to work individually and work in a team. Student has broadened awareness of the need to broaden his competences, readiness for individual work and cooperation within the team.

Course objective

Knowledge of phenomena and experiments confirming the quantum nature of radiation and the wave nature of matter (photoelectric effect, Compton phenomenon, de Broglie hypothesis). Familiarized with the history of the formation of atom models (with particular emphasis on the description of the atomic structure by Bohr) and with the modern model. Understanding Pauli exclusion principle for quantum objects and its consequences. Familiarization with quantum numbers describing the electron states of the atom and the description used in atomic physics. Presentation of the probalistic nature of quantum physics. Familiarization with the structure and principle of operation of the laser, as the main tool for studying objects in the quantum world, their excitation, detection, cooling and manipulation of quantum states on the example of free atoms and ions. Understanding the practical application of these phenomena and discoveries in quantum physics in technology and engineering on examples modern devices, such as a scanning tunnel microscope, atomic force microscope, quantum computer, CCD detectors, magnetic resonance, etc. Introduction to nuclear physics.

Course-related learning outcomes

Knowledge:
The student describes the basic principles of quantum physics, including Planck's formula and the birth of quantum physics, and explains its significance for describing the behavior of matter and radiation. [P6S_WG_16]
The student names and identifies key experiments and experiences that confirm the quantum nature of radiation and the wave nature of matter. [P6S_WG_16]
The student characterizes various atomic models, such as the Thomson, Bohr, and contemporary models, and explains the concepts underlying these models. [P6S_WG_16]
The student explains Pauli's exclusion principle and its consequences for atomic structure. [P6S_WG_16]
The student names and identifies properties of atoms, atomic spectra, and quantum numbers describing the electronic states of an atom. [P6S_WG_16]
The student characterizes X-ray radiation and its applications. [P6S_WG_16]
The student describes the principle of laser operation, types of lasers, and their applications in science, engineering, and industry. [P6S_WG_17]
The student identifies and explains concepts related to nuclear physics, such as the description of the atomic nucleus, isotopes, binding energy of the atomic nucleus, and radioactive decays. [P6S_WG_17]

Skills:
The student prepares and conducts laboratory experiments in mechanics, electromagnetism, and optics, and interprets the results. [P6S_UW_14]
The student uses various analytical and experimental methods to solve problems in the field of quantum physics, including calculating and analyzing experiment results. [P6S_UW_15]

Social competences:
The student is aware of the importance and understanding of the non-technical aspects and consequences of the development of quantum physics and its impact on the advancement of science and technology, as well as on the natural environment. [P6S_KR_01]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
- assessment of knowledge and skills demonstrated on the written test of quantum physics issues to the extent covered by program content. Passing threshold 50% of points. Final issues on the basis of which questions are prepared will be sent to students by e-mail using the university e-mail system.
Laboratory exercises:
testing and rewarding the knowledge necessary to implement the set problems in a given area of laboratory tasks,
assessment of knowledge and skills related to the implementation of the exercise task, evaluation of the report from the exercise.
Obtaining additional points for activity during classes, and especially for:
- correct answers to questions asked during lectures,
- effectiveness of using the acquired knowledge while solving a given problem,
- remarks related to the improvement of didactic materials,

- aesthetic diligence of reports on laboratory exercises carried out as part of their own studies.

Programme content

The lecture covers issues related to the birth of quantum physics and an introduction to quantum physics. Students learn about Plank's formula, phenomena (experiments) confirming the quantum nature of radiation and the wave nature of matter. Models of atomic structure Pauli exclusion principle and its consequences. Proballistic nature of quantum physics. Properties of atoms, atomic spectra, quantum numbers describing the electronic states of the atom. Magnetic resonance imaging, magnetic imaging - MRI. Principle of laser operation, types of lasers depending on their properties (power, method of operation, generated radiation spectrum, active medium, application), classes of lasers in terms of operational safety, use of lasers in science, technology and industry.

Laboratory:
Laboratory exercises will be performed in three main sections: mechanics, electromagnetism and optics. A set of exercises selected specifically for the curriculum content - students perform experiments related to the phenomena of quantum physics.

Course topics

Lectures:
Black body radiation - Planck's formula and the birth of quantum physics. Phenomena (experiments) confirming the quantum nature of radiation and the wave nature of matter. Models of the atomic structure (Kelvin, Thomson, Nicholson, Rutherford, Bohr and the contemporary model). The Pauli exclusion principle and its consequences. The probalistic nature of quantum physics (Schrödinger equation, Heisenberg’s uncertainty principle, electron in a trap). Properties of atoms, atomic spectra, quantum numbers describing electron states of an atom. X-rays. Magnetic resonance imaging, magnetic imaging - MRI. Principle of laser operation, types of lasers due to their properties (power, mode of operation, generated radiation spectrum, active medium, application), laser class due to work safety, the use of lasers in science, technology and industry. Isotopes and methods for their separation. Selected issues of nuclear physics (description of the atomic nucleus, isotopes, atomic nucleus binding energy, radioactive decays).
Laboratory:
Laboratory exercises will be performed in three main departments: mechanics, electromagnetism and optics. From each department, students working in 2-person teams will have at least 2 exercises to complete. Exercise sets are presented in detail on the website of the physical laboratory (https://www.phys.put.poznan.pl/).

Teaching methods

Lectures: lecture with multimedia presentation (including drawings, photos, animations, video materials) supplemented with examples given on the blackboard, taking into account different aspects of the issues presented, including economic, environmental, legal and social issues, presenting a new topic preceded by a reminder of related content, known to students from other subjects.
Laboratory: detailed reviewing of reports by the laboratory's leaders and discussions on comments, demonstrations, work in teams.

Bibliography

Basic:
1. D. Halliday, R. Resnick, J. Walker, „Podstawy fizyki, tom 5", PWN, Warszawa 2003
2. P. A. Tipler, R .A. Llewellyn, „Fizyka współczesna", PWN, Warszawa 2012
3.H. Haken, H. Ch. Wolf, „Atomy i kwanty - Wprowadzenie do współczesnej spektroskopii atomowej", PWN, Warszawa 2002
4. R. P. Feynman, R. B. Leighton, M. Sands, „Feynmana wykłady z fizyki. T. 3. Mechanika kwantowa", PWN, Warszawa 2014
5. St. Szuba, Ćwiczenia laboratoryjne z fizyki, Wydawnictwo Politechniki Poznańskiej, Poznań 2007
6. K. Łapsa, Ćwiczenia laboratoryjne z fizyki, Wydawnictwo Politechniki Poznańskiej, Poznań 2008

Additional:
1. G. K. Woodgate, „Struktura atomu”, PWN, Warszawa 1974.

2. R. Eisberg, R. Resnick, „Fizyka kwantowa”, PWN, Warszawa 1983
3. A. K. Wróblewski, „Historia fizyki", PWN, Warszawa 2007

Breakdown of average student's workload

	Hours	ECTS
Total workload	60	2,00
Classes requiring direct contact with the teacher	35	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00