Appendix No. 1.5 to the Resolution No. 7/2023

of the Rector of the University of Rzeszów

**SYLLABUS**

**regarding the qualification cycle FROM ………TO…..**

**Academic year 2024/2025**

1. Basic Course/Module Information

|  |  |
| --- | --- |
| Course/Module title | Fundamentals of quantum physics and structure of matter |
| Course/Module code \* |  |
| Faculty (name of the unit offering the field of study) | College of Natural Sciences |
| Name of the unit running the course | Institute of Physics |
| Field of study | Diagnostic systems in medicine |
| Qualification level | First-cycle studies |
| Profile |  |
| Study mode | Full-time |
| Year and semester of studies | Year 2, winter or summer semester |
| Course type |  |
| Language of instruction | English |
| Coordinator | Dr Krzysztof Kucab |
| Course instructor | Dr Krzysztof Kucab |

\* - as agreed at the faculty

1.1.Learning format – number of hours and ECTS credits

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Semester  (n0.) | Lectures | Classes | Colloquia | Lab classes | Seminars | Practical classes | Internships | others | **ECTS credits** |
| 3 |  | 30 |  |  |  |  |  |  | **6** |

1.2. Course delivery methods

x conducted in a traditional way

x involving distance education methods and techniques (in the case of an epidemic threat)

1.3. Course/Module assessment (exam, pass with a grade, pass without a grade)

exam, pass with a grade

2. Prerequisites

|  |
| --- |
| 1. KNOWLEDGE OF A CLASSICAL PHYSICS (BASICS) – MECHANICS, VIBRATIONS, ELECTRICITY AND MAGNETISM, MATHEMATICAL ANALYSIS (BASICS) – CALCULUS, DIFFERENTIAL EQUATIONS  2. KNOWLEDGE OF ALGEBRA (BASICS) – MATRICES, DETERMINANTS. |

3. Objectives, Learning Outcomes, Course Content, and Instructional Methods

3.1. Course/Module objectives

|  |  |
| --- | --- |
| O1 | THE AIM OF THE COURSE IS TO ACQUAINT STUDENTS WITH SELECTED TOPICS OF QUANTUM MECHANICS, I.E.: “OLD QUANTUM THEORY”, EIGENVALUE PROBLEM, SCHRÖDINGER EQUATION, HARMONIC OSCILLATOR, PERIODIC TABLE OF ELEMENTS. |

3.2. Course/Module Learning Outcomes (to be completed by the coordinator)

|  |  |  |
| --- | --- | --- |
| Learning Outcome | The description of the learning outcome  defined for the course/module | Relation to the degree programme outcomes |
| LO\_01 | student knows and understands differential and integral calculus and algebra to the extent necessary for quantitative description, understanding and modelling of problems related to the description of the micro-world discussed in class | K\_W01 |
| LO\_02 | student knows and understands the basic theorems and laws regarding the formalism of quantum physics, in particular regarding operators, quantum well and harmonic oscillator | K\_W02 |
| LO\_03 | student is able to analyse quantum physics problems (the eigenvalue problem, Schrödinger equation for potential well and harmonic oscillator) and find their solutions based on known theorems and methods | K\_U01 |
| LO\_04 | student is ready to recognize the limitations of his own knowledge and the need to consult experts in the case of difficulties in solving the problems of quantum physics by himself | K\_K01 |

**3.3. Course content (to be completed by the coordinator)**

1. Lectures

|  |
| --- |
| Content outline |
| **The “old” quantum theory**  - the black body radiation,  - the photoelectric effect,  - the Compton effect,  - wave properties of particles;  - the Franck-Hertz experiment;  - the Bohr model of an atom. |
| **A mathematical formalism of quantum mechanics**  - a vector space;  - the Hilbert space;  - operators. The eigenvalue problem;  - Hermitian operators;  - postulates of quantum mechanics;  - an interpretation of the wave function;  - time-independent Schrödinger equation;  - time-dependent Schrödinger equation;  - commutators and the uncertainty principle;  - Dirac notation (*bra* and *ket* vectors). |
| **Simple quantum problems**  - the one-dimensional potential well (finite and infinite potential barrier);  - the harmonic oscillator. |
| **The hydrogen atom in quantum mechanics.**  - the Schrödinger equation for the particle in the central field;  - the quantum numbers of the hydrogen atom;  - the role of spin in medical imaging. |
| **The periodic table of elements**  - the periodic table of elements;  - the quantum numbers. |
| **NMR and MRI**  - Nuclear Magnetic Resonance – basics;  - T1 and T2 relaxation;  - T1- and T2-weighted imaging. |

1. Classes

|  |
| --- |
| Content outline |
| **Solving the exercises regarding the topic “old quantum theory”**  - the black body radiation,  - the photoelectric effect,  - the Compton effect,  - the Bohr model of an atom. |
| **A mathematical formalism of quantum mechanics**  - operators. The eigenvalue problem;  - time-independent Schrödinger equation;  - time-dependent Schrödinger equation;  - commutators and the uncertainty principle. |
| **Simple quantum-mechanical problems**  - the one-dimensional potential well (the finite and infinite potential barrier);  - the harmonic oscillator. |
| **The hydrogen atom in quantum mechanics.**  - the quantum numbers of a hydrogen atom;  - filling of the electron shells. |

3.4. Methods of Instruction

e.g.

*Lecture: a problem-solving lecture/a lecture supported by a multimedia presentation/ distance learning*

*Classes: text analysis and discussion/project work (research project, implementation project, practical project)/ group work (problem solving, case study, discussion)/didactic games/ distance learning*

*Laboratory classes: designing and conducting experiments*

1. Lecture

2. Multimedia presentation

3. Solving theoretical and practical computational tasks

4. Discussion

4. Assessment techniques and criteria

4.1 Methods of evaluating learning outcomes

|  |  |  |
| --- | --- | --- |
| Learning outcome | Methods of assessment of learning outcomes (e.g. test, oral exam, written exam, project, report, observation during classes) | Learning format (lectures, classes,…) |
| LO-01 | observation during classes, exam, colloquium | lectures, classes |
| LO-o2 | observation during classes, exam, colloquium | lectures, classes |
| LO-o3 | observation during classes, exam, colloquium | lectures, classes |
| LO-o4 | observation during classes | classes |

4.2 Course assessment criteria

|  |
| --- |
| 1. Oral response (exercises)  2. Student’s activity in solving tasks exercises:  a. Low 2  b. Average 3  c. High 4  d. Very high 5 |

5. Total student workload needed to achieve the intended learning outcomes

– number of hours and ECTS credits

|  |  |
| --- | --- |
| Activity | Number of hours |
| Scheduled course contact hours | 30 |
| Other contact hours involving the teacher (consultation hours, examinations) | 5 |
| Non-contact hours - student's own work (preparation for classes or examinations, projects, etc.) | 85 |
| Total number of hours | 120 |
| Total number of ECTS credits | 6 |

\* One ECTS point corresponds to 25-30 hours of total student workload

6. Internships related to the course/module

|  |  |
| --- | --- |
| Number of hours | not applicable |
| Internship regulations and procedures | not applicable |

7. Instructional materials

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| Compulsory literature:  1. R. Shankar, *Quantum Mechanics*, Kluwer Academic.  2. A.S. Davydov, *Quantum Mechanics*, Pergamon Press.  3. L. Landau, E. Lifshitz, *Quantum Mechanics*, Pergamon Press. |
| Complementary literature:  1. J.J. Sakurai, Modern quantum mechanics, Addison-Wesley.  2. S. Flügge, Practical Quantum Mechanics.  3. J.-L. Basdevant, J. Dalibard, Quantum Mechanics, Springer. |

Approved by the Head of the Department or an authorised person