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 | Quantum physics |
| 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 | Physics |
| Qualification level | Second-cycle studies |
| Profile |  |
| Study mode | Full-time |
| Year and semester of studies | Year 1, 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** |
| 1 |  | 30 |  |  |  |  |  |  | **5** |

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 CLASSICAL PHYSICS (ADVANCED), CALCULUS (ADVANCED) AND QUANTUM MECHANICS (BASICS).  2. KNOWLEDGE OF ALGEBRA (BASICS). |

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 MODERN QUANTUM PHYSICS, I.E. THE SPIN ½ THEORY, APPROXIMATION METHODS. |

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 | The graduate knows and understands in depth the issues related to spin theory and basic approximate methods used in quantum mechanics as well as concepts related to matrix theory and vector spaces to the extent necessary for the quantitative description, understanding and modelling of problems related to quantum physics, with a high level of complexity . | K\_W01, K\_W02 |
| LO\_02 | The graduate knows and understands experimental and observational techniques and methods of building mathematical models specific to quantum physics as well as the theoretical fundamentals of computational methods used in solving quantum physics problems. | K\_W03, K\_W04 |
| LO\_03 | The graduate knows and understands current development directions, the latest discoveries and fundamental dilemmas of modern quantum physics development | K\_W06, K\_W07 |
| LO\_04 | The graduate is able to critically assess the results of experiments, observations and theoretical calculations, as well as discuss measurement errors | K\_U02 |
| LO\_05 | The graduate is ready to recognize the limitations of his own knowledge and the need to consult experts in the case of difficulties in solving problems related to quantum physics | K\_K02 |
| LO\_06 | The graduate is ready to systematically familiarize himself with scientific and popular science magazines, basic for physics, in order to broaden and deepen knowledge and develop professional achievements | K\_K06 |

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

1. Lectures

|  |
| --- |
| Content outline |
| **The spin ½ theory**  - Pauli theory,  - Pauli matrices,  - spin ½ operators,  - spinors. |
| **The fundamentals of relativistic quantum physics**  - spin dynamics,  - Klein-Gordon equation,  - Dirac equation (free particle),  - electromagnetic interaction of the Dirac particle. |
| **Time-independent perturbation theory**  - nondegenerate case,  - degenerate case,  - Zeeman effect. |
| **The variational method**  - the theory,  - Helium ground state,  - Hydrogen molecule. |
| **The Wentzel-Kramers-Brillouin (WKB) approximation**  - the theory,  - tunneling phenomena. |
| **Time-dependent perturbation theory**  - two-level system,  - radiation’s emission and absorption,  - spontaneous emission. |

1. Classes (solving tasks related to the topics discussed in the lectures)

|  |
| --- |
| Content outline |
| **The spin ½ theory**  - Pauli matrices,  - spin ½ operators,  - spinors. |
| **The fundamentals of relativistic quantum physics**  - spin dynamics,  - Klein-Gordon equation,  - Dirac equation (free particle). |
| **Time-independent perturbation theory**  - nondegenerate case,  - degenerate case,  - Zeeman effect. |
| **The variational method**  - Helium ground state,  - Hydrogen molecule. |
| **The WKB approximation**  - tunneling phenomena. |
| **Time-dependent perturbation theory**  - two-level system,  - radiation’s emission and absorption,  - spontaneous emission. |

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 | classes |
| LO-o4 | observation during classes | classes |
| LO-o5 | observation during classes | classes |
| LO-o6 | 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.) | 55 |
| Total number of hours | 90 |
| Total number of ECTS credits | 5 |

\* 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