**SYLLABUS**

**regarding the qualification cycle FROM 2023 TO 2024**

1. Basic Course/Module Information

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| Course/Module title | Physics Laboratory |
| 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 | General |
| Study mode | Full-time studies |
| Year and semester of studies | Year I, winter and/or summer semester |
| Course type |  |
| Language of instruction | English |
| Coordinator | dr hab. Rafał Hakalla, prof. UR |
| Course instructor | dr hab. Rafał Hakalla, prof. UR, dr Mirosław Łabuz, dr hab. Wojciech Szajna, prof. UR, dr Izabela Piotrowska, dr hab. Przemysław Kolek, prof. UR |

\* - as agreed at the faculty

1.1.Learning format – number of hours and ECTS credits

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Semester(no.) | Lectures | Classes | Colloquia | Lab classes | Seminars | Practical classes | Internships | others | **ECTS credits**  |
| winter / summer |  |  |  | 30 |  |  |  |  | 6 |

1.2. Course delivery methods

Classes carried out in traditional way.

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

 Credit with assessment

**2. Prerequisites**

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| In order to implement the content of the subject, it is required to pass the basic courses in advance: * Basics of physics: Mechanics, Electricity and magnetism, Optics.
* Basic statistical methods for the development of measurements or metrology.
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3. Objectives, Learning Outcomes, Course Content, and Instructional Methods

3.1. Course/Module objectives

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| C1  | *To become familiar with the basic investigation methods of:* *- atomic and molecular spectra;* *- structures of molecules and organic compounds;* *- ionizing radiation;* *- physicochemical: water, soil and air;* *- objects and astronomical phenomena;**and learn about the principles of modern measuring instruments.*  |
| C2  | *Acquisition of practical skills in the use of measuring instruments and assembly of an experimental stand for independent experimental work related to the subject of laboratory experiment.*  |
| C3  | *Improving the ability to use the computer in both measuring systems and in analysing the results of the experiment.*  |
| C4  | *Awareness of the role and practical application of physics in the modern world.*  |

**3.2. Course/Module learning outcomes**

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| 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 of experimental physics as well as its historical development and significance for the progress of science and natural sciences, knowledge of the world and the development of humanity. | K\_W01  |
| LO\_02  | They know and understand experimental, observational and numerical techniques and methods of constructing mathematical models specific to experimental physics. | K\_W03  |
| LO\_03  | They know and understand the theoretical basics of computational methods and it techniques used to solve common problems in the field of experimental physics.  | K\_W04  |
| LO\_04  | They know and understand the theoretical foundations of the operation of scientific apparatus in the field of experimental physics. | K\_W05  |
| LO\_05  | The graduate can plan and perform research, experience or observations on the content of education in experimental physics.  | K\_U01  |
| LO\_06  | The graduate can critically assess the results of experiments, observations and theoretical calculations as well as discuss the measurement uncertainties.  | K\_U02  |
| LO\_07  | They can find the required information in professional literature, databases and other sources.  | K\_U03  |
| LO\_08  | They can present the results of the research in the form of a self-prepared report containing a description and justification of the purpose of the work, the methodology adopted, the results and their significance in comparison to other similar studies. | K\_U04  |
| LO\_09  | They are capable of responsible individual and team work. | K\_U08  |
| LO\_10  | The graduate is ready to recognize the limitations of his own knowledge and the need to consult experts in the event of difficulties in solving the problem of experimental physics on their own. | K\_K02  |

**3.3. Course content (Laboratories)**

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| Content outline |
| **Analysis of hydrogen spectrum and determination of the Rydberg constant based on Balmer series lines.** *Quantum theory of atomic construction. Line spectra. Hydrogen atom spectrum. Spectral instruments – prism spectrographs. Spectral instrument parameters.*  |
| **Spectra testing of the various light sources** (e.g. fluorescent lamps, LED bulbs, energy saving bulb, sodium lamp, neon lamp, hydrogen lamps, etc.) **using a plane-grating spectrometer.** *Atomic and molecular emission spectra. Qualitative spectral analysis. Spectrometer dispersion curve. Identification of spectral lines based on the NIST database.*  |
| **Determination of the diatomic molecule parameters by the method of analysis of the vibrational-rotational spectrum.** *Spectra. Absorption spectrum. Electronic-vibrational-rotational**spectrum. Parameters of diatomic molecule. Methods for determining molecular parameters.*  |
| **Testing of transient metals by UV/vis absorption spectroscopy and fluorimetry methods.** *Electron structure of molecules, molecular orbitals theory. Electronic transitions in polyatomic molecules. Diagram of Jabłoński. Vibrational structure of electron transitions, Fanck-Condon rule. Radiative and non-radiative processes: fluorescence and phosphorescence. Calibration of analytical methods.*  |
| **Detection, identification and testing of organic compounds structure by method of infrared absorption spectroscopy.** *Characteristic bands of function groups – characteristic frequencies. Methodology of IR spectra analysis. Apparatus for measuring infrared light:* * 1. *infrared radiation sources,*
	2. *transparent materials for infrared radiation,*
	3. *infrared monochromators,*
	4. *infrared detectors,*
	5. *infrared spectrophotometers,*
	6. *Fourier-transform spectrophotometers.*
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| **Physicochemical studies of water.** *Measurement of pH, oxygen concentration and salt content in water using a universal measuring instrument, analysis of water samples using tests and photometric method (ammonia, phosphorus, iron, potassium).* |
| **Measurement of physical properties of soils.** *Density, humidity, pH, granulometric composition (sedimentation methods), photometric measurements (ammonia, phosphorus, iron, potassium).*  |
| **Analysis of air pollution using mass spectrometer.** *Analysis of the spectrum of the air sample.*  |
| **Determination of air pollutants in the form of NO, CO and PM10 in correlation to weather conditions (wind force and direction, temperature, pressure) and time of day and year.** *Determination of the content of selected gases in Rzeszów, including, at the most vulnerable points, using a portable gas sensor.*  |
| **Study of the Geiger-Müller counter properties**. *Obtaining of the counter characteristics, dead time measurement, testing of the counter capability, methods for the measurement results analysis.* |
| **Investigation of the radioactive sources**. *Background measurements, study of the activity of a weak radioactive sample with a long half-life, determination of the activity of selected radioactive samples, study of γ-radiation weakening at the passage of matter.* |
| **Analysis of the radon content in the air, fertilizers, building materials, industrial waste, etc**. *Determination of the content of individual radioactive elements in the samples. Measurement of radon activity in the air using a radon counter equipped with a Lucas chamber.* |
| **Testing the content of radioisotopes in fluid samples.** *Characteristics of ionizing radiation and its properties. The radioactive decay law, activity. Natural radioactivity. Methods for detecting of a ionizing radiation. Types of detectors.*  |
| **Testing the content of radioisotopes in solid samples (soil, ceramic building materials, etc.)** *Types of ionizing radiation and its properties. Natural radioactivity. Methods of detection of ionizing radiation. Types of detectors.*  |
| **Determination of the dispersion refractive index of a thin layer**. *UV-vis-NIR spectrometer, refractive index method, Swanepoel method of determining the refractive index of a layer.*  |
| **Study of the influence of thin layer heating on its optical parameters.** *The effect of heat on the transmission spectrum, forbidden gap, refractive index. Determination of the heating kinetics.*  |
| **The use of infrared spectroscopy in the analysis of polymer materials**. *Analysis of samples of different polymers, identification of polymer based on the obtained spectrum.*  |
| **Processes of applying gas phase coatings on the example of PVD** **(physical deposition from the gas phase).** *Physical bases, process parameters, apparatus.*  |

3.4. Methods of Instruction

Laboratory: Performing experiments, designing experiments

4. Assessment techniques and criteria

4.1 Methods of evaluating learning outcomes

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| 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  | Colloquium  | lab.  |
| LO\_02  | Colloquium, observation during classes  | lab. |
| LO\_03  | Colloquium, observation during classes  | lab. |
| LO\_04  | Colloquium, observation during classes  | lab. |
| LO\_05  | Colloquium, observation during classes  | lab.  |
| LO\_06  | Colloquium, report  | lab. |
| LO\_07  | Observation during classes, report  | lab. |
| LO\_08  | Observation during classes, report  | lab. |
| LO\_09  | Observation during classes, report  | lab.  |
| LO\_10  | Observation during classes  | lab. |

4.2 Course assessment criteria

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| The prerequisite for passing is: Performing and passing the selected laboratory classes provided in the plan (minimum 3 per each semester). The students pass the course if: they pass the theoretical test, complete the exercise practically during the classes and present the appropriate report. The student receives assessments based on theoretical (or oral) tests, observations of the student’s performance during the experiments and reports presented: * the arithmetic mean of the assessments obtained from the theoretical tests is 20% of the final evaluation from the course;
* the rest of the assessment (80%) is the arithmetic mean of the assessments received on the basis of observations of the student’s performance during the experiments and reports presented.
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5. Total student workload needed to achieve the intended learning outcomes

– number of hours and ECTS credits

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| --- | --- |
| Activity | Number of hours |
| Scheduled course contact hours | 30 |
| Other contact hours involving the teacher (consultation hours, examinations) | 10 |
| Non-contact hours - student's own work (preparation for classes or examinations, projects, etc.) | 60 |
| Total number of hours | 100 |
| 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

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| Number of hours | - |
| Internship regulations and procedures | - |

7. Instructional materials

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| Compulsory literature:1. R. Resnick, D. Halliday, “Physics, parts I-V”, New York, London, and Sydney: John Wiley & Sons, 2022.
2. H. Haken, H. Ch. Wolf, “Molecular Physics and Elements of Quantum Chemistry: Introduction to Experiments and Theory”, Springer Berlin Heidelberg, 2014.
3. F. E. Close, “Nuclear Physics: A Very Short Introduction”, Oxford University Press, 2015.
4. P. Andreo, ‎D. T. Burns, ‎A. E. Nahum, “Fundamentals of Ionizing Radiation Dosimetry”, Wiley-VCH Verlag GmbH, Weinheim, 2017.
5. P. W. Atkins „Physical Chemistry”, Oxford University Press, Oxford, 2022.
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| Complementary literature: 1. D. W. Preston and E. R. Dietz, "The Art of Experimental Physics", John Wiley and Sons, New York, 1991.
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Approved by the Head of the Department or an authorised person