**SYLLABUS**

**regarding the qualification cycle FROM 2023TO 2026**

1. Basic Course/Module Information

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| Course/Module title | *Selected issues of nanotechnology* |
| Course/Module code \* |  |
| Faculty (name of the unit offering the field of study) | *College of Natural Science* |
| Name of the unit running the course | *Institute of Physics* |
| Field of study | Diagnostic systems in medicine |
| Qualification level | First-cycle studies |
| Profile | *General academic* |
| Study mode | *Full-time studies* |
| Year and semester of studies | *3rd year, winter or summer semester* |
| Course type | *Directional course* |
| Language of instruction | English |
| Coordinator | Dr hab. Małgorzata Sznajder, prof. UR |
| Course instructor | *Dr hab. Małgorzata Sznajder, prof. UR* |

\* - as agreed at the faculty

1.1.Learning format – number of hours and ECTS credits

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Semester  (n0.) | Lectures | Classes | Colloquia | Lab classes | Seminars | Practical classes | Internships | others | **ECTS credits** |
| 6 | 15 |  |  |  |  |  |  |  | 1 |

1.2. Course delivery methods

- conducted in a traditional way

- involving distance education methods and techniques

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

Pass without a grade

2. Prerequisites

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| The student has knowledge about fundamentals of physics, biophysics and fundamentals of quantum mechanics in the scope described in the syllabuses of the basic module of the first-degree study program. Student is able to search and analyze professional literature, to discuss topics related to the selected specialization, express his own opinions, and work independently. |

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

3.1. Course/Module objectives

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| O1 | *Introduce students to the basic systems of reduced dimensionality.* |
| O2 | *Provide students with selected "top-down" and "bottom-up" techniques for the production of nano-scale systems.* |
| O3 | *Provide students with selected physical properties of nanotubes, nanoparticles and quantum dots.* |
| O4 | *Provide students with the applications of nano-objects in imaging, diagnostics and detection of substances.* |

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

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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 student knows the elements of applied mathematics to the extent necessary for the quantitative description, understanding and modeling of problems in the field of methods and techniques for producing objects in the nanoscale. He knows the use of these objects in the detection of substances, labeling and diagnosis, | K\_W01 |
| LO\_02 | the student knows and understands the basic computational methods used to solve problems related to modeling the growth of systems with reduced dimensionality and examples of practical implementation of such methods using appropriate IT tools, | K\_W05 |
| LO\_03 | the student knows and understands the dilemmas related to the profession appropriate for the graduate of Diagnostic Systems in Medicine and the fundamental dilemmas of modern civilization, | K\_W08 |
| LO\_04 | the student knows and understands the economic, legal and ethical conditions related to professional activity as well as the basic concepts and principles in the field of industrial property protection and copyright law, | K\_W09 |
| LO\_05 | the student is able to analyze problems and find their solutions based on known theorems and methods, | K\_U01 |
| LO\_06 | the student is able to make a critical analysis of the functioning of existing technical solutions to create a 2D, 1D or 0D system and evaluate these solutions, | K\_U07 |
| LO\_7 | the student is ready to understand the social aspects of the practical application of the acquired knowledge and skills and the associated responsibility as well as to fulfil social obligations. | K\_K03 |

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

1. Lectures

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| Content outline |
| 1. Nanotechnology as an interdisciplinary field of science, its place and role in modern science. R. Feynmann's concept of miniaturization. Examples of systems with reduced dimensionality: 2D, 1D, 0D. |
| 2. Selected classical techniques for the production of bulk materials: the Czochralski method of single crystal growth, the Bridgmann-Stockbarger method. |
| 3. Top-down techniques: micro- and nano-scale lithography techniques (optical, UV, ion beam lithography). Bottom-up techniques: physical deposition methods (MBE, PLD, sputtering) and chemical deposition methods (CVD, MOCVD, OMBE); epitaxial layers. Langmuir-Blodgett technique for biolayers. Precipitation methods (sol-gel), electrochemical methods, hydrothermal method. |
| 4. Self-assembled growth of nanowires - catalytic VLS growth. ZnTe, TiO2 nanowires. Carbon nanotubes and their possibilities for cancer diagnosis. Nanowires and cell chips for the detection of biological and chemical particles and viruses. The idea of ​​FET transistor based on Si/Ge nanowires. Functionalization of carbon nanotubes. |
| 5. Metal nanoparticles. Reduction method. Preparation of silver nanoparticles (chemical reduction, microemulsion method, reduction: photochemical, ultrasound and gamma radiation). TiO2 nanoparticles (chlorine, sulfate and Becher process production). Mechanism of bactericidal action of nanoparticles. The use of silver and gold nanoparticles in medical procedures. |
| 6. Quantum dots. Growth modes: Stranskii-Krastanov, Volmer-Weber. Colloidal quantum dots. The use of quantum dots in light-generating elements (LEDs). Quantum dots in medicine and biology - diagnostics, labelling, imaging and treatment. |
| 7. Transport of nanoscale objects in the body. Nanosystems in medicine. "Lab on a Chip". Impact of nanotechnology on human health. |

1. Classes, tutorials/seminars, colloquia, laboratories, practical classes

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| Content outline |
| not applicable |
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3.4. Methods of Instruction

*A Lecture supported by a multimedia presentation*

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 | Observation during classes, discussion, presentation | L |
| LO-o2 | Observation during classes, discussion, presentation | L |
| LO-03 | Observation during classes, discussion, presentation | L |
| LO-o4 | Observation during classes, discussion, presentation | L |
| LO-05 | Observation during classes, discussion, presentation | L |
| LO-o6 | Observation during classes, discussion, presentation | L |
| LO-07 | Observation during classes, discussion, presentation | L |

4.2 Course assessment criteria

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| Pass without a grade. The condition for obtaining a credit is to prepare a written paper on a topic related to the discussed issues. |

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 | 15 |
| Other contact hours involving the teacher (consultation hours, examinations) | 1 |
| Non-contact hours - student's own work (preparation for classes or examinations, projects, etc.) | 14 |
| Total number of hours | 30 |
| Total number of ECTS credits | 1 |

\* 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 | not applicable |
| Internship regulations and procedures | not applicable |

7. Instructional materials

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| Compulsory literature:  1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley, Mark Geoghegan, John Wiley & Sons Ltd., 2005  2. Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, Stephane Evoy, James R. Heflin Jr. Kluver Academic Publishers, Boston, 2004  3. Nanotechnology: Principles and Practices, Kulkarni, Sulabha K., Springer Verlag 2015, ISBN 978-3-319-09171-6.  4. Buzea, C.; Pacheco, I. I.; Robbie, K. (2007). "Nanomaterials and nanoparticles: Sources and toxicity". Biointerphases. 2 (4): MR17–MR71. arXiv:0801.3280. doi:10.1116/1.2815690 |
| Complementary literature:  1. Advanced Micro & Nanosystems, Volume 8: Carbon Nanotube Devices, ed. C. Hierold, Wiley, 2008  2. NANOTECHNOLOGY IN BIOLOGY AND MEDICINE, Methods, Devices, and Applications, ed. Tuan Vo-Dinh, Taylor & Francis Group 2007  3. Quantum Dots, Applications in Biology, ed. M.P. Bruchez, Ch. Z. Hotz, Humana Press Inc. 2007  4. W. Hallstrom et al., Nano Lett., 2010, 10 (3), pp 782–787  5. F. Patolsky and Ch. M. Lieber, Materials Today, Volume 8, Issue 5, May 2005, Pages 20–28  6. S. Iijima, Nature 354, 56 (1991)  7. Angewandte Chemie, Volume44, Issue39, October 7, 2005, Pages 6358–6362  8. Chemical Physics Letters 478 (2009) 200–205  9. Angew. Chem. Int. Ed. 2004, 43, 2113 –2117  10. Nanotoday, 34 JUNE 2007 | VOLUME 2 | NUMBER 3, 34–43  11. Chem. Soc. Rev., 2012, 41, 4306–4334  12. M.L. Curri et al. / Materials Science and Engineering C 23 (2003) 285–289  13. Journal of Nanomaterials, vol. 2012, article ID: 964381, 36 pages  14. Biological Trace Element Research (2020) 193: 118–129 |

Approved by the Head of the Department or an authorised person