**SYLLABUS**

**regarding the qualification cycle 2021/2024**

1. Basic Course/Module Information

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| Course/Module title | X-ray analysis methods |
| 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 Material Engineering |
| Field of study | Material Engineering |
| Qualification level | I |
| Profile | generally academic |
| Study mode | Full time |
| Year and semester of studies | II year, IV semester |
| Course type | directional |
| Language of instruction | Polish/english |
| Coordinator | Iwona Rogalska |
| Course instructor | Iwona Rogalska |

\* - 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** |
| 4 | 15 |  |  | 15 |  |  |  |  | 5 |

1.2. Course delivery methods

- conducted in a traditional way

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

Lecture: assessment: pass without a grade

Laboratory: assessment: credit with a grade

2. Prerequisites

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| Basic knowledge of physics and construction of matter brought out from high school and gained during the first year of studies. |

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

3.1. Course/Module objectives

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| O1 | An introduction to the use of x-ray powder diffraction as an analytical method. Course will emphasize the practical use of x-ray diffraction as an analytical tool for the identification of crystalline materials in minerals, rocks, soils and engineered materials. Topics include: a non-mathematical introduction, generation of xrays, radiation safety for users of x-ray diffraction, crystallography review, the geometry of diffraction and bragg’s law, sample and specimen preparation techniques, the braggbrentano diffractometer (our scintag system), search-match and automated methods of phase identification for single and multi-phase samples, introduction to the analysis of clay minerals (dr. Dewey moore), introduction to methods for quantitative analysis |

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 | Student has knowledge about physical phenomenon’s and instrumentation used in modern analytical methods with the use of  X-rays. Student knows performance and technical parameters of methods based on x-rays. | IM\_W09  IM\_W10 |
| LO\_02 | Student is able applied computer simulations and numerical methods to solve selected problems related to applications of physical methods based on x-rays. Student is able to raise information from literature, evaluate results of measurements, prepare report from experiments, and prepare multimedia presentation. | IM\_U09  IM\_U14 |
| LO\_03 | Student is able to cooperate in team, to become involve in discussion, evaluate results of work partners, is able to express personal arguments. Student understands the need for improving the qualifications and competence. | IM\_K01  IM\_K04 |

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

1. Lectures

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| 1. X-ray: methods of x-ray generation, x-ray tube construction, processes occurring at the anode, continuous x-ray spectrum, characteristic radiation, interaction of x-rays with matter, synchrotron radiation as x-ray source, x-ray detectors, electrical, electronic and protective systems. Electrical, electronic and security systems.  2. Health and safety at work with rentgen radiation: influence of x rays on living organisms, methods of protection against harmful effects of x rays, acceptable radiation doses and their measurement, effects of interaction on cells depending on the energy of x-rays, application of x-rays in medicine.  3. Construction of the crystalline of solids: atomic structure and interatomic bonds, crystalline solids and their properties, real crystals and crystalline lattice, elementary cell and translation vectors, bravais lattice  4. Directions and plants in crystals and miller indicators: the concept of atomic straight line, the concept of atomic plane, determination of miller indicators for lattice simple - examples, determination of miller indicators for lattice planes - examples, family of planes and interplanar distance, symmetry of crystals and equivalence of simple and lattice planes  5. Reverse system: reverse lattice definition, perpendicular conditions for reverse grid vectors, reverse dimensional lattice and crystal lattice condition, reverse lattice design to the real network, interpretation of the bragg equation with the ewald sphere  6. Restige diffraction on crystals: the phenomenon of diffraction and interference for waves, reflection of x-rays from the atomic planes, atoms of a crystal like x-ray scattering centers, intensity of diffraction reflections - atomic scattering factor and structure factor  7. Braga right: the condition of interference in bragg's approach, lau's equation, the equivalence of the bragg and laue approach, the diffraction geometry and the reverse network, the systematic rule of extinction  8. Experimental diffraction methods: monocrystal testing methods: lauego method, bragg method, rotated crystal method, single crystal diffractometer, polycrystalline test methods: dsh method, radiation focusing methods, polycrystalline test using a polycrystalline diffractometer  9. Crystalographic and phase analysis of difgractographs: determination of crystal orientation, indexing of diffraction reflections, measurement of lattice constants, x-ray phase analysis, substance identification, measurement of crystallite size, determination of atom positions in a unit cell  10. Microanalism rentgenowska: analysis of chemical composition of substances - comparison of methods, mechanisms of x-ray excitation, x-ray characteristic spectrum and moseley's law, edx / eds and wds spectrometer, advantages and disadvantages of both methods  11. Restige fluorescence: physical mechanism of formation of characteristic x-ray fluorescence, construction of xrf spectrometer, method with energy dispersion and dispersion of wavelength, determination of chemical composition by xrf method, other xrf varieties: pixe, x-ray micro-florescence (xrmf) |

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

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| 1. Determination of lattice parameters using the debye-scherrer-hull (dsh) method  2. Substance identification based on interplanar distance data  3. Determination of crystal structure based on powder diffraction pattern  4. X-ray diffraction on kbr crystal |

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*

Lecture and multimedia presentation,

Exercises in the laboratory

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 | *reports, observation during classes, oral test* | lectures, classes |
| LO-02 | *reports, observation during classes, oral test* | lectures, classes |
| LO-03 | *OBSERVATION DURING CLASSES* | lectures, classes |

4.2 Course assessment criteria

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| Completion of the course will confirm the student's achievement of the intended learning outcomes. Verification of achieved learning outcomes is monitored on an ongoing basis during the course of classes. The grade obtained from passing the subject will assess the degree of effects achieved. Verification of the learning outcomes of the teacher's knowledge and skills take place through tests, reports, class participation and discussion. Verification of the learning outcomes of the classes without the participation of teachers will be based on the assessment of the student's preparation for laboratory exercises. The verification of social competences will take place through active participation in classes and participation in discussions  Lecture: Attendance at least 60% of lectures.  Laboratory: Form of credit: credit with grade  The condition of passing the course is: obtaining a grade from knowledge and substantive preparation for the exercises, and colloquia.  Ects grading scale:  A – excellent (91 – 100)%  B - very good (81 – 90)%  C – good (71 – 80)%  D – satisfactory (61 – 70)%  E – sufficient (51 – 60)%  F – fail (0 – 50)% |

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 | Lecture 15 hours  Laboratory 15 hours |
| Other contact hours involving the teacher (consultation hours, examinations) | 3 |
| Non-contact hours - student's own work (preparation for classes or examinations, projects, etc.) | 77 |
| Total number of hours | 110 |
| 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

Not applicable

7. Instructional materials

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| Compulsory literature:  1. Z. Bojarski, krystalografia : podręcznik wspomagany komputerowo (wydawnictwo naukowe pwn, warszawa, 1996).  2. J. Chojnacki, metalografia strukturalna. (wydawnictw „śląsk”, katowice, 1966).  3. Z. Bojarski i e. Łągiewka, rentgenowska analiza strukturalna (państwowe wydaw. Naukowe, warszawa, 1988).  4. Z. Kosturkiewicz, metody krystalografii (wydaw. Naukowe uam, poznań, 2004).  5. J. Jeleńkowski i k. Wesołowski, ćwiczenia z rentgenowskiej analizy strukturalnej (pwn, warszawa, 1971). |
| Complementary literature:   1. 1. Z. Bojarski i e. Łągiewka, materiały do ćwiczeń z rentgenowskiej analizy strukturalnej (uniwersytet śląski, katowice, 1988). 2. 2. Oleś, metody doświadczalne fizyki ciała stałego (wydawnictwa naukowo-techniczne, warszawa, 1998). |

Approved by the Head of the Department or an authorised person