COURSE DESCRIPTION

1. Programme Identification Data

1.1 Higher Education Institution	**„ALEXANDRU IOAN CUZA” UNIVERSITY OF IAŞI**
1.2 Faculty	**FACULTY OF CHEMISTRY**
1.3 Department / Doctoral School	**DOCTORAL SCHOOL OF CHEMISTRY**
1.4 Field of Study	**CHEMISTRY**
1.5 Cycle of Studies	**DOCTORATE**
1.6 Study Programme / Qualification	**ADVANCED UNIVERSITY STUDIES – DOCTORAL SCHOOL OF CHEMISTRY / PhD IN CHEMISTRY**

2. Course Identification Data

2.1 Course Title			**MANAGEMENT OF INNOVATIVE RESEARCH METHODOLOGIES IN CHEMISTRY – MODULE II**				
2.2 Course coordinator (lectures)			**Prof. univ. dr. Aurel PUI** **Prof. univ. dr. Ionel MANGALAGIU** **Prof. univ. dr. habil. Mihail Lucian BIRSA** **Prof. univ. dr. habil. Gheorghiță ZBANCIOC**				
2.3 Seminar coordinator							
2.4 Year of study	**I**	**2.5** Semester	**1**	**2.6** Type of assessment	***C**	**2.7** Disciple regime	****CC**

*[E – exam / C – colloquium] **[CC = Compulsory Course / OC = Optional Course]

3. Estimated Total Workload (hours per semester)

3.1 Hours per week	**1**	**3.2** Lectures	**1**	**3.3** Seminars	**-**
3.4 Total hours according to the curriculum	**14**	**3.5** Lectures	**14**	**3.6** Seminars	**-**

Time allocation	hours
Study based on textbooks, course materials, bibliographic sources, and other relevant resources	24
Additional research in the library, on specialized electronic platforms, and in the field	46
Preparation for seminars, assignments, papers, portfolios, essays	14
Academic tutoring	-
Assessment activities	2
Other activities	-

3.7 Total hours of individual study	86
3.8 Total hours per semester	100
3.9 Number of credits	**4**

4. Preconditions (if applicable)

4.1 Curriculum prerequisites	Completion of a Master’s degree (or equivalent) and enrolment in the doctoral study programme in Chemistry, in accordance with the regulations of the Doctoral School, as well as successful completion of Module I – Management of Innovative Research Methodologies in Chemistry.
4.2 Competences prerequisites	Basic and intermediate competencies in the use of scientific language specific to the field of Chemistry, the ability to analyze and interpret information from the scientific literature, competencies in documenting, synthesizing, and arguing a research approach, as well as digital competencies related to the use of personal computers and standard software applications (e.g., Microsoft Office: Word, PowerPoint, Excel).

5. Conditions (if applicable)

5.1 Conditions for lectures	Appropriate facilities for the conduct of doctoral teaching activities, equipped with multimedia equipment (video projector, PC), with access to the internet, the institutional IT infrastructure, and bibliographic resources and scientific databases relevant to the

	field of Chemistry. Compliance with institutional regulations regarding the organization of doctoral studies.
5.2 Conditions for seminars	-

6. Specific competences accumulated

Professional competences	• Integration and optimization of innovative research methodologies in the field of Chemistry, in relation to the complex objectives of doctoral research and existing experimental constraints. • Critical and comparative evaluation of advanced analytical and characterization methodologies with respect to performance, reliability, and scientific relevance. • Advanced selection and adaptation of experimental and statistical methods, including data optimization and validation techniques, to ensure reproducible and robust results. • Design and management of complex experimental strategies, including experiment planning and control of experimental variables. • In-depth knowledge of innovative research methodologies and current trends in chemical analysis, as well as the ability to communicate effectively with specialists in related fields.
Transversal competences	• Assumption of responsibility and autonomy in methodological decision-making within doctoral research activities. • Coordination and integration of research activities in interdisciplinary and collaborative contexts. • Initiation and development of innovative research approaches in compliance with good methodological practices and scientific quality standards.

7. Course Objectives (derived from the acquired competences)

7.1. General objective	The course aims to deepen and strengthen competencies related to the integration, optimization, and advanced management of innovative research methodologies in the field of Chemistry, through the use of complex experimental strategies and advanced statistical tools, in support of efficient and rigorous doctoral research.
7.2. Specific objectives	Upon completion of the course, the doctoral student will be able to: • integrate and optimize innovative research methodologies in accordance with the objectives and constraints of doctoral research; • critically and comparatively evaluate experimental and statistical methods in order to select appropriate analytical strategies; • design and manage complex experimental strategies, including experiment planning and optimization of analytical processes; • apply advanced techniques for data processing, validation, and interpretation; • demonstrate autonomy, responsibility, and scientific rigor in methodological decision-making for advanced research.

8. Content

8.1	**Lecture Topics**	**Teaching methods***	**Notes** (hours / references)
1.	Techniques for preparing samples for analysis and instrumental methods of analysis (chromatographic, spectrometric, etc.)	Interactive lecture, explanation, conversation, applicative analysis, problematization	(3.5 hours, [1÷2]) C-TEP&IRC-01
2.	Methods for investigating the structure of inorganic compounds and materials	Interactive lecture, explanation, conversation, applicative analysis, problematization	(3.5 hours, [3÷4])
3.	Management of Unconventional Chemical Synthesis Methods	Interactive lecture, explanation, conversation, applicative analysis, problematization	(3.5 hours, [5]) C-TEP&IRC-11
4.	Standard operating procedures in chemistry. Basic concepts in statistics. Investigating the level of correlation between the data	Interactive lecture, explanation, conversation, applicative analysis, problematization	(3.5 hours, [6÷7]) C-TEP&IRC-07

*In cases of force majeure, teaching activities may be conducted online, in accordance with current legislation

Bibliography:

1. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis. Cengage Learning, Boston, USA, **2016**.
2. Rouessac, F.; Rouessac, A. Chemical Analysis: Modern Instrumental Methods and Techniques. Wiley, **2007**.
3. Lalena, J. L.; Cleary, D. A.; Carpenter, E. E.; Dean, N. F. Inorganic Materials. Synthesis and Fabrication. Wiley-Interscience, **2008**.
4. Bruce, D. W.; O'Hare, D. Inorganic Materials. John Wiley & Sons, **1997**.
5. Kappe, O. C.; Stadler, A. Microwaves in Organic and Medicinal Chemistry. Wiley, Weinheim, Germany, **2005**.
6. Arsene, C.; Olariu, R. I. Analytical and statistical methods in the investigation of chemical systems. Performantica, Iași, **2009**.
7. Otto, M. Chemometrics. Statistics and Computer Application in Analytical Chemistry. Wiley-VCH, **2017**.

9. Learning Outcomes

Knowledge and understanding	• Advanced understanding of concepts and principles related to the management of research methodologies in modern chemistry. • Knowledge and comparative understanding of advanced instrumental chemical analysis methods and their role in the acquisition, validation, and interpretation of experimental results. • In-depth understanding of operating principles, advantages, limitations, and applicability of chromatographic, spectrometric, electrochemical, and statistical methods used in advanced chemical research. • Understanding of the role of advanced methodological management in ensuring research quality, reproducibility, and robustness.
Application and analysis	• Integrated application of advanced methodologies and techniques for sample preparation and chemical analysis in relation to complex research objectives. • Use of advanced instrumental and statistical methods for data analysis, interpretation, validation, and optimization. • Critical analysis of the performance, adequacy, and limitations of analytical methods in case studies and applied research. • Correlation of experimental data with methodological strategies aimed at optimizing the experimental process.
Critical Assessment and Accountability	• Critical and comparative evaluation of research methodologies in relation to research objectives and available methodological alternatives. • Justification of methodological decisions with respect to their impact on the validity, robustness, and interpretability of scientific results. • Autonomous and responsible management of advanced methodological strategies, including experimental design optimization and control of critical variables. • Integration of good methodological practices and quality standards in the development and implementation of doctoral research in complex scientific contexts.
Academic Communication	• Coherent and well-argued oral and written communication of advanced methodological aspects and chemical research results. • Appropriate use of scientific language and terminology specific to chemistry and advanced data analysis methods. • Active and reasoned participation in academic discussions on the selection, integration, and optimization of research methodologies. • Clear and critical presentation of complex methodological strategies and experimental results in academic and scientific contexts.

10. Correlation of the course content with the expectations of community representatives, professional associations, and representative employers in the field related to the program.

The content of the course *Management of Innovative Research Methodologies in Chemistry – Module II* is aligned with the expectations of the academic and research community, professional associations, and representative employers by developing advanced competencies in the selection, integration, and optimization of experimental and statistical methodologies used in chemical research.

Upon completion of the course, doctoral students acquire the ability to select and justify appropriate experimental techniques in relation to research objectives, as well as to apply advanced statistical concepts and tools for the processing, interpretation, and validation of experimental data

11. Assessment

Activity	**11.1 Assessment criteria**	**11.2 Assessment methods**	**11.3 Weight in final grade (%)**
11.4 Lectures	Accuracy, completeness, and coherence of knowledge, demonstrating understanding and advanced application of course content; appropriate use of specialized terminology	Colloquium: oral and reasoned presentation of a research topic, with emphasis on methodological justification.	100
11.5 Seminars			
11.6 Minimum Performance Standard			
In order to pass the discipline, the doctoral student must demonstrate: • knowledge of key statistical concepts used in the analysis of experimental data (e.g., discrete and random variables, probability distributions, mean, variance, sample size, sampling distributions, sample parameters); • the ability to process and interpret experimental data using appropriate statistical methods; • the ability to identify and eliminate erroneous or outlier data through the application of suitable statistical procedures.			

Completion date
26.09.2025

Course coordinator

Prof. univ. dr. Aurel PUI

Prof. univ. dr. Ionel MANGALAGIU

Prof. univ. dr. habil. Dr. Mihail Lucian BIRSA

Prof. univ. dr. habil. Gheorghiță ZBANCIOC

Seminar coordinator

Date of approval
29.09.2025

Director of the Doctoral School of Chemistry
Prof. univ. dr. habil. Cecilia ARSENE