A COURSE SYLLABUS – DOCTORAL SCHOOL
regarding the qualification cycle from 2025/2026 to 2028/2029

GENERAL INFORMATION ABOUT COURSE	
Course title	***RESEARCH METHODOLOGY***
Name of the unit running the course	Doctoral School of the University of Rzeszów
Type of course *(obligatory, optional)*	compulsory
Year and semester of studies	First year/First and second semester
Discipline	**Physical sciences**
Language of Course	Polish language
Name of Course coordinator	**Dr Rafał Hakalla, Professor at the University of Rzeszów**
Name of Course lecturer	**Dr Rafał Hakalla, Professor at the University of Rzeszów**
Prerequisites	Knowledge, skills and social competences related to the methodology of conducting scientific research, achieved at level 7 of the Polish Qualifications Framework in the discipline of physical sciences, including the ability to use scientific literature in English.

BRIEF DESCRIPTION OF COURSE
(100-200 words)

As part of the course: 'Research Methodology', doctoral students will consolidate their knowledge, skills and social competences regarding the set of rules, procedures and techniques used in the process of scientific research applied in the discipline of physical sciences. The aim of the course is to prepare doctoral students to independently plan, conduct and critically analyse scientific research in the discipline of physical sciences, with particular emphasis on high-resolution molecular spectroscopy. The course covers issues related to the methodology of the research process, the formulation of research problems and hypotheses, the selection of appropriate experimental and computational methods, and the analysis and interpretation of spectroscopic data, together with a critical analysis of the results obtained. The course prepares doctoral students to publish their research results in scientific journals, present their results at international conferences, and conduct reliable scientific research in accordance with the methodological standards applicable in modern molecular spectroscopy.

COURSE LEARNING OUTCOMES AND METHODS OF EVALUATING LEARNING OUTCOMES

Learning outcome	The description of the learning outcome defined for the course	Relation to the degree programme outcomes (symbol)	Learning Format (Lectures, classes,…)	Method of assessment of learning outcomes (e.g. test, oral exam, written exam, project,…)
Knowledge (no.)	knows and understands, has knowledge			
P8S_WG/3	Knows, understands and uses specialist terminology specific to high-resolution molecular spectroscopy, used in the national and international scientific and professional environment, in their native and foreign languages.	**P8S_WG**	Conversatory	written assignments, discussion
P8S_WG/4	Has extensive knowledge of the applied methodology of scientific research in the field of high-resolution molecular spectroscopy, using interdisciplinary research tools and techniques to obtain the most reliable and objective results of research work.	**P8S_WG**	Conversatory	written assignments, project,

P8S_WK/3	Has extensive knowledge of the possibilities of transferring the results of their scientific activity in the field of physical sciences, in particular high-resolution molecular spectroscopy, to the economic and social spheres, taking into account the principles of commercialisation, intellectual property protection and cooperation with the socio-economic environment.	**P8S_WK**	Conversatory	written assignments, discussion
Skills (no.)	can			
P8S_UW/1	He is able to use interdisciplinary knowledge to identify and practically solve research problems encountered in the field of high-resolution molecular spectroscopy by: defining the research objective, subject and hypothesis, creating innovative research methods, techniques and tools, and drawing conclusions based on the research results obtained.	**P8S_UW**	Conversatory	project, discussion
P8S_UK/1	Actively participate in national and international scientific and professional communities, sharing the results of your research in the field of high-resolution molecular spectroscopy.	**P8S_UK**	Conversatory	written assignments, project,
P8S_UO/1	Through active participation in the national and international community of researchers in the field of high-resolution molecular spectroscopy, he is able to participate in individual and team scientific projects, performing various roles in them.	**P8S_UO**	Conversatory	written assignments, project,
Social competence (no.)	is ready to			
P8S_KR1	Strengthen and develop the ethos of research communities, including conducting scientific activities independently, taking into account the principles of intellectual property protection and public ownership of research results.	**P8S_KR**	Conversatory	written assignments, project, discussion

Semester (no.)	Lectures	seminar	Conversatory / Lab classes	Internships	others	ECTS
I	-	-	-	-	**30**	**3**
II	-	-	-	-	**30**	**3**
total:	-	-	-	-	**60**	**6**

METHODS OF INSTRUCTION

- *TRADITIONAL SEMINAR*;
- *SEMINAR WITH MULTIMEDIA PRESENTATION*;
- *PROJECT*;
- *DISCUSSION*;
- *INTERPRETATION AND ANALYSIS OF SOURCE TEXTS*;

- CONDUCTING RESEARCH (PERFORMING EXPERIMENTS AND TRIALS).

COURSE CONTENT

Course content

Semester I:

- Critical analysis of the state of research and available scientific literature (articles, publications, monographs) concerning a selected diatomic molecule;

- Development of an individual experimental methodology for obtaining and measuring high-resolution spectra of a selected diatomic molecule and planning procedures for analysing measurement data and compiling the results obtained, with particular emphasis on the selection of appropriate theoretical models.

Semester II:

- Preparation of a measurement station and optimisation of experimental conditions for obtaining and measuring high-resolution spectra of a selected diatomic molecule;

- Recording of a high-resolution emission spectrum of a selected diatomic molecule in the UV-VIS range;
- Identification and interpretation of the obtained spectra in the UV-VIS range.

COURSE ASSESSMENT CRITERIA

The course is taught in semesters I and II. After semester I, the course ends with a ZO1 grade, and after semester II, it ends with an E2 examination. Classes are conducted in direct contact between the doctoral student and their supervisor.

In order to pass the course after semester I, a report on the completion of the task must be submitted.

In order to pass the course after semester II, at least 51% of the points from the written work must be obtained.

In order to obtain a positive grade, the following conversion table is used for the corresponding percentage of points obtained:

- up to 50% - unsatisfactory (the doctoral student is not making progress in scientific research, is not expanding their knowledge, is not studying the literature, is not participating in substantive discussions, is not fulfilling their scientific obligations);
- 51% - 60% - satisfactory (the doctoral student makes negligible progress in scientific research, expands their knowledge, studies basic literature, the discussion is limited to a narrow range of substantive knowledge, fulfils basic scientific duties);
- 61% - 70% - satisfactory plus (the doctoral student makes progress in scientific research, expands their knowledge, studies basic literature, participates substantively in discussions, fulfils their scientific duties);
- 71% - 80% - good (the doctoral student makes significant progress in scientific research, expands their knowledge, studies basic and supplementary literature, participates substantively in discussions, fulfils all scientific duties);
- 81% - 90% - good plus (the doctoral student makes significant progress in scientific research, systematically expands their knowledge, studies basic and supplementary literature, participates substantively in discussions, fulfils all scientific obligations);
- 91% - 100% - very good (the doctoral student makes significant progress in scientific research, systematically expands their knowledge, studies basic, supplementary and advanced literature, participates substantively in discussions, fulfils all scientific obligations);

TOTAL PhD STUDENT WORKLOAD REQUIRED TO ACHIEVE THE INTENDED LEARNING OUTCOMES – NUMBER OF HOURS AND ECTS CREDITS

Activity	Number of hours
Scheduled course contact hours	**2 x 30 hrs. – 60 hrs.**
Other contact hours involving the teacher (consultation hours, examinations)	**4**

Non-contact hours – student`s own work (preparation for classes or examinations, project, etc.)	**116 hrs**
Total number of hours	**180 hrs.**
Total number of ECTS credits	**6 ECTS**

INSTRUCTIONAL MATERIALS	
Compulsory literature:	1. P. F. Bernath, *Spectra of Atoms and Molecules*, 4th Edition, Oxford University Press, 2020. 2. G. Herzberg, *Molecular Spectra and Molecular Structure, vol. I: Spectra of Diatomic Molecules*, (2nd edition), Krieger Publishing Company, Malabar, Florida, 1989. 3. J. Tennyson, *Astronomical Spectroscopy: An Introduction To The Atomic And Molecular Physics Of Astronomical Spectroscopy,* World Scientific Europe Ltd, 2019. 4. H. Lefebvre-Brion, R.W. Field, *The Spectra and Dynamics of Diatomic Molecules*, Elsevier, 2004. 5. P. Kowalczyk „Fizyka cząsteczek. Energie i widma", PWN, 1999. 6. P. W. Atkins, *Physical Chemistry*, 11th edition, Oxford University Press, 2018. 7. *Handbook of High-Resolution Spectroscopy*, Vol. 1-3, ed. by M. Quack and F. Merkt, Wiley, 2011. 8. J. T. Hougen, *The Calculation of Rotational Energy Levels and Rotational Line Intensities in Diatomic Molecules*, National Institute of Standards and Technology (NIST), Monograph 115, 1970. 9. J. M. Brown and A. Carrington, *Rotational Spectroscopy of Diatomic Molecules*, Cambridge University Press, 2003. 10. N. Colin, N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th Edition, McGraw-Hill, 2021. 11. H. Haken and H. C. Wolf, *Molecular Physics and Elements of Quantum Chemistry: Introduction to Experiments and Theory,* 2nd Edition, Springer, 2004.
Complementary literature:	1. J. Sadlej „Spektroskopia molekularna", WNT, 2002 2. W. Kołos, J. Sadlej „Atom i cząsteczka", WNT, 1998 3. W. Kołos „Chemia kwantowa", PWN, 1978 4. A. Gołębiewski „Elementy mechaniki i chemii kwantowej", PWN, 1982. 5. Z. Leś „Wstęp do spektroskopii atomowej", PWN 2014. 6. H. Haken and H. C. Wolf, *The Physics of Atoms and Quanta*, 7th Edition, Springer, 2005.

*(1 ECTS CREDIT CORRESPONDS TO 25 - 30 HOURS OF THE TOTAL WORKLOAD OF A DOCTORAL STUDENT, NEEDED TO ACHIEVE THE ESTABLISHED EFFECTS).

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Date and signature of the Course lecturer

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Approved by the Head of the Department or an authorised person