A COURSE SYLLABUS – DOCTORAL SCHOOL

REGARDING THE QUALIFICATION CYCLE FROM 2022TO 2026

GENERAL INFORMATION ABOUT COURSE	
Course title	Applied quantum mechanics
Name of the unit running the course	Doctoral School at the University of Rzeszow
Type of course *(obligatory, optional)*	*obligatory, optional*
Year and semester of studies	Year I/semester II
Discipline	Physical sciences
Language of Course	Polish
Name of Course coordinator	Dr hab. Paweł Jakubczyk, prof. UR
Name of Course lecturer	Dr hab. Paweł Jakubczyk, prof. UR
Prerequisites	Knowledge of physics and mathematics at the university level.

BRIEF DESCRIPTION OF COURSE
(100-200 words)

The content of the course deals with the application of quantum mechanics to the solution of complex multiparticle systems. Selected closed and open systems and their application in quantum optics and condensed matter will be analysed. The Matlab/Simulink environment will be used for the numerical analysis.

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)**			
K1	Understands the context of quantum mechanics in relation to the rest of classical physics and can recognise promising directions for its development.	**P8S-WG/1, P8S-WG/2, P8S-KK/3, P8S-WK/1**	Conversation/Laboratory	direct observation
K2	Knows the basic mathematical formalism and mathematical methods to describe some quantum mechanics issues for selected quantum systems	**P8S-WG/3, P8S-WK/3**	Conversation/Laboratory	direct observation
Skills (no.)	**(Able to)**			
S1	Able to use basic computational methods of quantum mechanics and implement them in a computer.	**P8S-UW/1**	Conversation/Laboratory	direct observation

S2	Be able to critically analyse the results obtained from calculations and evaluate their usefulness in classical physics	**P8S-UW/2, P8S-KK/1**	Conversation/Laboratory	direct observation
S3	Be able to explain the purpose of the calculations carried out and assess the chance of successfully completing the calculations	**P8S-UK/3, P8S-UK/4**	Conversation/Laboratory	direct observation
Social competence (no.)	**(Ready to)**			
SC1	Can edit part of a scientific article related to quantum mechanics issues	**P8S-WG/4, P8S-WK/3, P8S-UW/3**	Conversation/Laboratory	direct observation
SC2	Is ready to publicly present the results of his calculations in a popular scientific form	**P8S-UK/1, P8S-UK/2, P8S-UK/5, P8S-KO/2, P8S-UK/6**	Conversation/Laboratory	direct observation

LEARNING FORMAT – NUMBER OF HOURS

Semester (no.)	Lectures	Seminars	Lab classes	Internships	others	ECTS
II	—	15	——	—	—	0

METHODS OF INSTRUCTION

Individual work at a desk using paper and pen, dry-erase board and computer equipment (computer programmes).

COURSE CONTENT

Conversation/Laboratory:

1. Closed systems
2 The Ising model
3 The Jaynes-Cumming-Hubbard model
4 Markovian open systems
5 Open Ising model
6. Two-level system coupled to a reservoir

COURSE ASSESSMENT CRITERIA

Due to the individual nature of the classes (very small group), the assessment and evaluation of learning outcomes is done on an ongoing basis. During the current assessment, the ability to analyze and solve the models being considered in terms of analytical and numerical aspects will be taken into account. Additionally, the completion of a project solving one of the quantum models numerically is necessary. The final grade is determined as the average of the grade obtained based on observations during class and the grade from the project. It is determined based on a percentage scoring system:
dst. (51 - 60)% scr.,
+dst. (61 - 70)% scr.,
db (71 - 80)% scr.,

+db (81 - 90)% scr.,
bdb (91 - 100)% scr.

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	15
Other contact hours involving the teacher (consultation hours, examinations)	2
Non-contact hours – student`s own work (preparation for classes or examinations, project, etc.)	13
Total number of hours	30
Total number of ECTS credits	

INSTRUCTIONAL MATERIALS	
Compulsory literature:	1. Breuer, Heinz-Peter, and Francesco Petruccione, The Theory of Open Quantum Systems (Oxford, 2007; online edn, Oxford Academic, 1 Feb. 2010) 2. Porras D and Cirac J I 2004 Effective quantum spin systems with trapped ions Phys. Rev. Lett. 92 207901. 3. Schmidt S and Blatter G 2009 Strong coupling theory for the Jaynes–Cummings–Hubbard model Phys. Rev. Lett. 103 086403 4. Rose D C, Macieszczak K, Lesanovsky I and Garrahan J P 2016 Metastability in an open quantum Ising model Phys. Rev. E 94 052132
Complementary literature:	1. Schmidt B and Lorenz U 2017 WavePacket: A Matlab package for numerical quantum dynamics. I: Closed quantum systems and discrete variable representations Comput. Phys. Commun. 213 223 2. Schmidt B and Hartmann C 2018 WavePacket: A Matlab package for numerical quantum dynamics. II: Open quantum systems, optimal control, and model reduction Comput. Phys. Commun. 228 229 3. Schmidt B, Klein R and Araujo L C 2019 WavePacket: A Matlab package for numerical quantum dynamics. III: Quantum-classical simulations and surface hopping trajectories J. Comput. Chem. 40 2677

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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