COURSE OFFERED

Name of the course	Polish	**Mechanika kwantowa relatywistyczna**
	English	**Relativistic Quantum Mechanics**

1 LOCATION OF THE COURSE WITHIN THE EDUCATION SYSTEM

1.1. Section [1]	Section of Exact and Natural Sciences
1.2. Discipline[2]	Physical Sciences
1.3. Type of education	Full-time
1.4. Level of education	Doctoral School (PQF Level 8)
1.5. Person preparing the course description	prof. dr hab. Francesco Giacosa
1.6. Contact	fgiacosa@ujk.edu.pl

2 GENERAL CHARACTERISTICS OF THE COURSE

2.1. Type of course [3]	Specialised subject in the discipline (elective)
2.2. Language of the course	English

3 DETAILED CHARACTERISTICS OF THE COURSE

3.1. Type of classes[4]		Lecture (L)
3.2. Number of hours[5]		15 hours of lectures
3.3. Location of classes		Classroom at Jan Kochanowski University in Kielce
3.4. Type of assessment		Graded pass based on an oral assessment with problem-solving tasks
3.5. Didactic methods		Problem-based lectures, derivations and worked examples; guided discussion and independent reading
3.6. Literature	basic	1. J. D. Bjorken and S. D. Drell, Relativistic Quantum Mechanics, McGraw-Hill, 1964. 2. A. Zee, Quantum Field Theory in a Nutshell, 2nd edition, Princeton University Press, 2010.
	supplementary	F. Mandl and G. Shaw, Quantum Field Theory, 2nd edition, Wiley, 2010.

1 Sections: Humanities; Social Sciences; Exact and Natural Sciences; Medical and Health Sciences; Arts.

2 Discipline as specified in the curriculum of the Doctoral School.

3 General subjects; general subjects in the discipline; specialised subjects in the discipline.

4 Classes, lecture or seminar.

5 Consistent with the curriculum of the Doctoral School of Jan Kochanowski University in Kielce.

4 OBJECTIVES SYLLABUS CONTENT AND INTENDED LEARNING OUTCOMES

4.1. Course objectives (lecture)
C01 Explain the consequences of special relativity for quantum mechanics and the need for a quantum-field description.
C02 Introduce scalar, spinor and electromagnetic fields, their quantisation and the basic methods used to describe their interactions.
C03 Develop the ability to solve elementary relativistic quantum problems and assess theoretical assumptions using scientific literature in English.

4.2. Syllabus content (15 hours in total)
1. Difficulties in formulating relativistic quantum mechanics: relativistic covariance, negative-energy solutions and antiparticles. (1 h)
2. Scalar field: the classical description, the Klein-Gordon equation and its solutions, canonical quantisation and the space of states. (2 h)
3. Spinor field: the covariant Dirac equation, transformation properties of spinors, Lagrangian and Hamiltonian formulations, free solutions, quantisation and the space of states. (3 h)
4. Spin and statistics: positivity of the Hamiltonian and microcausality. (1 h)
5. Electromagnetic field: the classical and Lagrangian descriptions, gauge invariance, canonical quantisation and photon states. (2 h)
6. Propagators of scalar, spinor and electromagnetic fields. (1 h)
7. Interacting fields: a self-interacting scalar field and the basic structure of quantum electrodynamics. (1 h)
8. Time evolution of quantum fields: scattering, the S-matrix and cross sections. (1 h)
9. Perturbation theory: Feynman rules and selected elementary scattering processes. (2 h)
10. Introduction to bound states: formulation of the problem and the relativistic description of the hydrogen atom. (1 h)

4.3 SUBJECT LEARNING OUTCOMES

Learning outcome	A doctoral student who has passed the course	Reference to Doctoral School learning outcomes
In the area of KNOWLEDGE		
W01	Explains the Klein-Gordon and Dirac equations, field quantisation and elementary interactions, and understands their role in the development of modern theoretical physics.	SD_W01 SD_W02
W02	Understands the limitations of a single-particle relativistic description, the roles of antiparticles and microcausality, and their relevance to current questions in fundamental physics.	SD_W07
In the area of SKILLS		
U01	Formulates elementary relativistic quantum problems, combines methods of quantum mechanics, special relativity and field theory to solve them, and critically evaluates the assumptions and results.	SD_U01 SD_U03
U02	Uses scientific literature and communicates reasoning on relativistic quantum mechanics in English.	SD_U07
In the area of SOCIAL COMPETENCE		
K01	Shows initiative in selecting methods and resources and proposing ways to address a physical problem independently.	SD_K04

4.4 METHODS OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

SUBJECT LEARNING OUTCOMES	METHOD OF ASSESSMENT (+ / -)																				
	Oral / written exam			Test (oral assessment)			Project			Activity in class			Own work			Group work			Other		
	Type of classes			Type of classes			Type of classes			Type of classes			Type of classes			Type of classes			Type of classes		
	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S
W01	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
W02	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
U01	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
U02	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
K01	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-

L = lecture; C = classes; S = seminar. + = method used; - = method not used.

The oral assessment covers conceptual questions and short calculations. English communication is assessed throughout. Class discussion and independent preparation verify the recognition of the value of knowledge and initiative in selecting an approach to a problem.

4.5 CRITERIA OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

Form of classes	Grade	Criterion of assessment
Lecture (L)	3.0	51-60% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.
	3.5	61-70% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.
	4.0	71-80% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.
	4.5	81-90% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.
	5.0	91-100% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.

Grade 2.0 (fail): fewer than 51% of the maximum points.

Accepted for implementation

.....

(date and signature of the lecturer)