Subject card

<table>
<tr><td>Subject name and code</td><td colspan="6">Field Theory, PG_00182569</td></tr>
<tr><td>Field of study</td><td colspan="6">Physics</td></tr>
<tr><td>Date of commencement of studies</td><td colspan="2">October 2026</td><td colspan="2">Academic year of realisation of subject</td><td colspan="2">2026/2027</td></tr>
<tr><td>Education level</td><td colspan="2">Master’s studies</td><td colspan="2">Subject group</td><td colspan="2">Obligatory subject group in the field of study
Optional subject group
Subject group related to scientific research in the field of study</td></tr>
<tr><td>Mode of study</td><td colspan="2">full-time studies</td><td colspan="2">Mode of delivery</td><td colspan="2">at the university</td></tr>
<tr><td>Year of study</td><td colspan="2">1</td><td colspan="2">Language of instruction</td><td colspan="2">Polish</td></tr>
<tr><td>Semester of study</td><td colspan="2">1</td><td colspan="2">ECTS credits</td><td colspan="2">8.0</td></tr>
<tr><td>Learning profile</td><td colspan="2">academic</td><td colspan="2">Assessment form</td><td colspan="2">exam</td></tr>
<tr><td>Conducting unit</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Name and surname of lecturer (lecturers)</td><td colspan="2">Subject supervisor</td><td colspan="4">prof. dr hab. Michał Horodecki</td></tr>
<tr><td colspan="2">Teachers</td><td colspan="4"></td></tr>
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<tr><td rowspan="3">Lesson types</td><td>Lesson type</td><td>Lecture</td><td>Tutorial</td><td>Laboratory</td><td>Project</td><td>Seminar</td><td>SUM</td></tr>
<tr><td>Number of study hours</td><td>45.0</td><td>45.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>90</td></tr>
<tr><td colspan="7">E-learning hours included: 0.0</td></tr>
<tr><td rowspan="2">Learning activity and number of study hours</td><td>Learning activity</td><td>Participation in didactic classes included in study plan</td><td>Participation in consultation hours</td><td>Self-study</td><td>SUM</td></tr>
<tr><td>Number of study hours</td><td>90</td><td>0.0</td><td>110.0</td><td>200</td></tr>
<tr><td>Subject objectives</td><td colspan="7">Learning basics of quantum and classical field theory</td></tr>
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Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZMU2_U01] is able to apply the scientific method in solving physical problems, conducting experiments and reasoning	FIZMU2_U01 U1: The student can apply the formalism of second quantization and Green's functions to analyze many-body systems. U2: The student can perform basic calculations in quantum field theory, including the use of Feynman diagrams and renormalization methods. U3: The student can analyze the Lagrangian of the Standard Model and identify symmetries and mass generation mechanisms.	[SU2] presentation/project/paper/report [SU3] text preparation/written work [SU4] test/exam - oral or written
	[FIZMU2_K01] knows the limitations of his own knowledge and skills; can formulate questions precisely; understands the need for further education and other	K1: The student is aware of the importance of rigorous mathematical foundations in describing physical phenomena and can critically evaluate results. K2: The student understands the significance of field theory and many-body theory as the foundations of modern theoretical physics and is prepared to further develop knowledge in this field.	[SK2] presentation/project/paper/report [SK3] text preparation/written work [SK4] test/exam - oral or written
	[FIZMU2_W02] has in-depth knowledge in mathematics as well as mathematical and computational methods, necessary to solve physical problems of high complexity and in-depth in the selected area of physics	The student becomes acquainted with various mathematical methods applied to physics, such as Lie group representations, the formalism of creation and annihilation operators, the Green's function formalism, and Feynman diagrams.	[SW4] test/exam - oral or written [SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[FIZMU2_U09] can work independently or in a team	The student prepares a term paper in the field of classical field theory; delivers a seminar on many-body theory; and takes an exam consisting of problems testing the understanding of field quantization, Feynman diagrams, and scattering amplitudes for interacting fields	[SU2] presentation/project/paper/report [SU3] text preparation/written work [SU4] test/exam - oral or written
	[FIZMU2_W01] has advanced knowledge of general physics and in-depth knowledge of various areas of physics; knows the history of the development of physics and its importance for the progress of exact and natural sciences, cognition of the world and social development	W1: The student knows the Lagrangian formalism in field theory and understands the application of Noether's theorem to conservation laws. W2: The student has advanced knowledge of scalar, spinor, and vector fields and their role in relativistic field theory. W3: The student is familiar with the fundamentals of many-body theory: second quantization, Green's functions, approximations, and diagrammatic methods. W4: The student understands the process of field quantization, the spin-statistics connection, the construction of the S-matrix, and renormalization methods.	[SW4] test/exam - oral or written [SW2] presentation/project/paper/report [SW3] text preparation/written work

Subject contents	1. Relativistic classical field theory: Lagrangian formalism, Noethers theorem, scalar, spinor, and vector fields; internal symmetries, gauge field theory, spontaneous symmetry breaking, mass generation, Lagrangian of the Standard Model. 2. Many-body theory: second quantization, Greens functions, exactly solvable fermionic model, Feynman diagrams for the electron gas with Coulomb interaction, divergences, random phase approximation. 3. Field quantization: relativistic quantum free fields, spinstatistics theorem (sketch), S-matrix, Feynman diagrams, renormalization.
Prerequisites and co-requisites	Knowledge of quantum mechanics, classical mechanics in the Lagrangian formulation, and classical electrodynamics.

Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	written exam	51.0%	33.0%
	presentation	51.0%	33.0%
	term paper	51.0%	34.0%

Recommended reading	Basic literature	1. No-Nonsense Quantum Field Theory: A Student-Friendly Introduction, Jakob Schwichtenberg 2. Quantum Field Theory for the Gifted Amateur, by Tom Lancaster, Stephen J. Blundell 3. An Introduction To Quantum Field Theory, Michael E. Peskin, Daniel V. Schroeder 4. Many-body quantum theory in condensed matter physics, Henrik Bruus and Karsten Flensberg
	Supplementary literature	1. A Modern Introduction to Quantum Field Theory, Michele Maggiore 2. Quantum Theory of Many-particle Systems, Alexander L. Fetter, John Dirk Walecka
	eResources addresses	Supplementary https://www.youtube.com/watch?v=qBoNQJdI4Qc&t=69s - youtube: Luis Gregorio Dias, Course on Quantum Many-Body Physics. Note: the provided link is to the first lecture. For the course, the entire lecture series is relevant, except for the lectures on interaction with phonons.
Example issues/ example questions/ tasks being completed		
Work placement	Not applicable	