COURSE OF STUDY *Physics (LM-17)*
ACADEMIC YEAR *2024-2025*
ACADEMIC SUBJECT *Standard Model*

General information	
Year of the course	2nd
Academic calendar (starting and ending date)	1st semester: September – December 2024
Credits (CFU/ECTS):	6
SSD	FIS/02
Language	English
Mode of attendance	Recommended, not compulsory

Professor/ Lecturer	
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Department and address	Room R01 – Dipartimento Interateneo di Fisica – Campus Universitario – Via E. Orabona, 4 Bari
Virtual room	
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Tuesday, from 3:00 to 5:00 pm or on appointment also in other days

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
150	40	15	95
CFU/ECTS			
6	5	1	

Learning Objectives	The goal of the teaching is to provide - the fundamental knowledge on the Standard Model of strong and electroweak interactions. - the tools to compute the Feynman rules in any gauge theory - the methodology for renormalization and the techniques related to the renormalization group. The course also aims at providing an overview of the most modern developments in the field of theoretical Physics of elementary particles.
Course prerequisites	Quantum Mechanics, Mathematical methods for Physics.

Teaching strategie	As a rule, lectures and exercises at the blackboard.
Expected learning outcomes in terms of	
Knowledge and understanding on:	● Understanding the scientific method, the nature, and the methods of research in Physics ● Knowledge in theoretical physics of fundamental interactions ● The course aims at providing the students with the modern ideas about the elementary constituents of the matter and their fundamental

	interactions. Basic principles of Quantum Field Theory will be addressed. The fundamental theoretical grounding will be provided, together with selected modern advanced developments and perspectives.
Applying knowledge and understanding on:	● Ability to identify the essential elements of a phenomenon ● Ability to use analogy to apply known solutions to new problems (problem solving) ● Ability to use analytical and numerical mathematical computation tools ● Tools for problem solving will be developed. A part of the course will be devoted to solving exercises
Soft skills	**Making informed judgments and choices** ● Ability to work with increasing levels of autonomy, including taking responsibility in project planning and managing facilities. ● The student will acquire the autonomous capability to afford problems in field theories. **Communicating knowledge and understanding** ● Competence in communication in Italian and English in advanced fields of Physics ● The proper and modern language of elementary particle Physics will be learnt. **Capacities to continue learning** ● Acquisition of basic knowledge tools for continuous learning and knowledge updates ● The student will acquire the basic tools as well as the most modern approaches to study processes involving elementary particles.
Syllabus	
Content knowledge	1. Basics of Gauge invariance: Reminders of basic elements of group theory. Gauge principle; Yang-Mills Theories. 2. Classical fields, symmetries and their breaking. The action, equations of motion. Symmetries, conservation laws, Noether's theorem. 3. Feynman rules: S matrix and Green functions; Feynman functional integral formalism; Derivation of Feynman rules. 4. Renormalization and renormalization group: Regularization; Classification of divergences; Systematics of renormalization; Renormalization group equations; Beta function in QED and QCD. 5. Quantum Chromodynamics: QCD Lagrangian density; The Fadeev-Popov Lagrangian; BRST symmetry; Operator Product Expansion; Gauge anomalies. 6. Standard Model The gauge group of electroweak interactions; The Higgs field and spontaneous symmetry breaking; The mass matrix; the Cabibbo-Kobayashi -Maskawa matrix; CP violation. 7. Effective theories: Flavour Physics and effective hamiltonians.
Texts and readings	O. Nachtmann: Elementary Particle Physics. Concepts and Phenomena. Springer 1990. T. Muta: Foundations of Quantum Chromodynamics. World Scientific 2nd Ed. 1997. M. Peskin and R. Schroeder: Introduction to Quantum Field Theory. CRC Press 1995.

	Schwartz: Quantum Field Theory and the Standard Model. Cambridge University Press 2013. A.J. Buras: Gauge Theory of Weak Decays. Cambridge University Press 2020.
Notes, additional materials	
Repository	

Assessment	
Assessment methods	Final Exam is an oral test on all the topics covered during the course. To pass the exam, students will have to demonstrate that they have well understood the contents of the course. Preliminary signing up on ESSE3 is compulsory.
Assessment criteria	• Knowledge and understanding: Students will have to demonstrate knowledge and understanding of the fundamentals of Theoretical Physics of Fundamental Interactions • Applied knowledge and understanding: Students will have to demonstrate their ability to solve problems in Theoretical Physics of Fundamental Interactions • Autonomy of judgment: Students must show that they have acquired autonomy and critical reasoning skills on the topics covered in the teaching. • Communication skills: Students should be able to present the concepts learned during the course using clear, appropriate and scientifically rigorous language. • Ability to learn: Students must be able to independently examine and deepen problems of Theoretical Physics of fundamental interactions.
Final exam and grading criteria	The grade, out of thirty, will reflect the degree of knowledge of the course contents. The exam is passed when the grade is larger than or equal to 18. Full understanding of the subject, exposure clarity, language accuracy guarantees the maximum mark, 30 cum laude.
Further information	