COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2024-2025*

ACADEMIC SUBJECT *Fundamental Interactions*

General information	
Year of the course	1st
Academic calendar (starting and ending date)	2nd semester: March - May 2025
Credits (CFU/ECTS):	6
SSD	FIS/04
Language	English
Mode of attendance	Recommended, not compulsory

Professor/ Lecturer	
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Department and address	Room 135 - Dipartimento Interateneo di Fisica – Campus Universitario – Via Amendola 173 - 70125 Bari
Virtual room	MS Teams Virtual Classroom
Office Hours (and modalities: e.g., by appointment, on line, etc.)	By appointment

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	Deep and extended knowledge of the phenomenological aspects of the physics of the interactions among the elementary constituents of the matter (gravity excluded), of the interpretation schemes, of the basic principles, of the accuracy of the description, of present limitations, unsolved problems, and perspectives for new developments. The capability of making computations and quantitative comparisons between theory and experiment will be developed, together with the understanding the main issues involved in the high energy physics analyses.
Course prerequisites	Basic Special Relativity, Basic Quantum Field Theory

Teaching strategie	• Classroom lectures at the blackboard. • Guided exercises. • Dedicated lectures to a few topical arguments related to recent developments in physics of fundamental interactions.
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

	• Knowledge of elementary particle physics • Deep understanding of the main aspects of the fundamental interactions, of their mutual correlations, of their ordering principles, of their experimental aspects and confirmations, of the unsolved issues and of the limitations of the present descriptions. The exercises made during the course are important to achieve such an understanding.
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 • Acquisition of competences useful for research work. • Development of learning, understanding, and reasoning methods useful for working activities far from research.
Soft skills	**Making informed judgments and choices** • Ability to work with increasing levels of autonomy, including taking responsibility in project planning and managing facilities. • Development of the individual critical skills, ingenuity, and capability of autonomously reaching conclusions and getting opinions about the various aspects of the fundamental interactions, and more in general. **Communicating knowledge and understanding** • Competence in communication in Italian and English in advanced fields of Physics • Capability of communicating scientific concepts in direct, complete, and precise way, avoiding any jargon and logical shortcomings. **Capacities to continue learning** • Acquisition of basic knowledge tools for continuous learning and knowledge updates • Capability of approaching problems in an open minded, critical and innovative way.
Syllabus	
Content knowledge	**Strong Interaction Physics** • Multiparticle production at high energy, multiplicity, (pseudo)-rapidity. • Naive parton model: Deep inelastic scattering of electrons and neutrinos. Evidence of neutral flavourless partons. Drell-Yan process. Factorization formulae. • SU(2) and SU(3) groups in a nutshell. • Gauge principle. Lagrangian density of Quantum ChromoDynamics. Vacuum charge screening vs antiscreening, strong coupling constant and its running. • Asymptotic freedom vs confinement in QCD. • Jet physics • Charmonium spectrum. Exotic hadrons • Quark-gluon plasma **EW Interaction Physics** • Spontaneous breaking of a physical system symmetry. SSB of a continuous global symmetry and Goldstone bosons. Higgs field and the EW symmetry breaking. • Description of the three lepton and quark families. Fermi theory recovered at low energy. Yukawa interaction terms. Fermion masses and mixings. • Higgs boson properties. • SM description of CP violation. Measurement of the CKM matrix elements. • Advanced topics: Problems the SM is not able to face. Examples of scenarios beyond SM.

Texts and readings	O. Nachtmann. Elementary particle Physics. Concepts and Phenomena. Springer 1990 (main) G. Kane. Modern elementary particle physics. Cambridge University Press 2017 P. Langacker. The Standard Model and beyond. CRC Press 2017 For the exercises: N. Cartiglia. Manuale di esercizi di fisica delle particelle, Levrotto & Bella 2015
Notes, additional materials	
Repository	

Assessment	
Assessment methods	Oral examination
Assessment criteria	• **Knowledge and understanding** The student is required to ○ know the mains aspects of the strong and electroweak interactions. ○ know the physical principles and the phenomenological consequences. • **Applying knowledge and understanding** The student is required to know how to make numerical exercises about simple physical processes. • **Autonomy of judgment** The student is required to know and judge the limits and the open issues in the present description of fundamental interactions. • **Communicating knowledge and understanding** The student is required to know how to present scientific concepts and results in precise, careful, and direct way. • **Communication skills** The clarity and the precision of the language are considered. • **Capacities to continue learning** The capacity to autonomously collect relevant new information from books, articles and other sources is considered.
Final exam and grading criteria	The oral examination aims at assessing the preparation of the candidate based on the above listed criteria. The final mark is attributed consequently.
Further information	