Essential Course Information	
Course title	FUNDAMENTAL INTERACTIONS PHENOMENOLOGY
Degree Course title	PHYSICS
ECTS	6
Compulsory attendance	YES
Course teaching language	ENGLISH

Teacher	Pietro Colangelo	Pietro.Colangelo@ba.infn.it

ECTS Details	Disciplinary area	SSD	ECTS
	Characterizing	FIS/01	6

Time management and teaching activity type	Period	Year	Lesson type
	2nd semester	1st	Lectures (40h) Exercises (15h)

Time management	Total hours	In-class/in-lab study hours	Out-of-class study hours
	150	55	95

Course calendar	Starting date	Ending date
	March 2021	June 2021

Syllabus	
Prerequisites	**Non Relativistic Quantum Mechanics, Special Relativity, Quantum Field Theory I**
Expected learning outcomes (according to Dublin Descriptors)	The course aims at providing a 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. - *Knowledge and understanding:* 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 during the course are important to achieve such an understanding. - *Applying knowledge and understanding:*

	Acquisition of competences useful for research work and, importantly, development of learning, understanding and reasoning methods useful for work activities far from research. - *Making Judgments:* Development of the individual critical skills, ingenuity and capability of autonomously getting conclusions and opinions about the various aspects of the fundamental interactions and more in general. - *Transferable communication skills:* Capability of communicating scientific concepts in direct, complete and precise way, avoiding any jargon and shortcomings. - *Lifelong learning skills:* Capability of approaching problems in an open minded, critical and creative way.
Course contents summary	
Detailed syllabus	**Generalities:** (Classical and quantum) scattering of electrons by a heavy nucleus. Scattering matrix and scattering cross section: Unitarity relations and consequences. Overview of total pp and ppbar cross sections. Decay rate of an unstable particle. **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 a_s and its running. Violations of the Bjorken scaling in DIS. Altarelli-Parisi equation. Comparison of DIS data with QCD. Naive jet model. Asymptotic freedom vs confinement in QCD. Quarkonium. Advanced topics in strong interaction Physics: QCD in extreme conditions of temperature and baryon density, QCD phase diagram. Implications for astrophysics. Multiquark states and exotica. **EW Interaction Physics:** Gauge group of the Electroweak interactions. Description of the first lepton family and of its interactions. Spontaneous breaking of a physical system symmetry. SSB of a continuous global symmetry and Goldstone bosons. Higgs field and SSB of a gauge symmetry. Description of three lepton and quark families. Fermi theory recovered as a low energy limit. Yukawa interaction terms. Fermion masses and mixing. Lagrangian density of the Standard EW model. Higgs boson properties. Computation of basic processes (e.g. h ->f bar f, Z0-> f bar f) and comparison with data.

	SM description of CP violation in the quark sector. Measurement of the CKM matrix elements. Issues concerning the lepton sector. Advanced topics: Problems the SM is not able to face. Possible scenarios beyond SM.
Books	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 exercises: N. Cartiglia, Manuale di esercizi di fisica delle particelle, Levrotto & Bella 2015.
Notes	On particular issues about current research.
Teaching methods	Classroom lectures at the blackboard. Guided exercises.
Assessment of final mark	Oral examination
Evaluation criteria	The student is required to - **know** the mains aspects of the strong and electroweak interactions; - **know** the principles and the phenomenological consequences; - **know** the limits and the open issues in the present description of fundamental interactions; - **know how** to make simple numerical exercises about basic physical processes; - **know how** to present scientific concepts and results in precise, careful and direct way.
Other	