Stampare su carta intestata del CdS

General information		
Academic subject	***Relativistic Kinematics of Particle Interactions***	
Degree course	*Physics*	
Academic Year	*2nd*	
European Credit Transfer and Accumulation System (ECTS)		4
Language	*English*	
Academic calendar (starting and ending date)	*1st semester (October 2021 – Jan 2022)*	
Attendance	*Yes*	

Professor/ Lecturer	
Name and Surname	Anna Colaleo
E-mail	Anna.Colaleo@uniba.it
Telephone	080-5442181
Department and address	Department of Physics Room 134, 1st floor
Virtual headquarters	*Teams*
Tutoring (time and day)	

Syllabus	
Learning Objectives	*The student will review the fundamental laws of special relativity and the implications and application to particle physics. He/she will learn the necessary mathematical tools and study fundamental experiments that require a relativistic description, in particular those that led to the formulation of the theory of special relativity that, together with quantum mechanics, supported to formulation of the Standard Model of the particle physics. Topics include Einstein's postulates, the Lorentz transformation, relativistic effects, an introduction to the relativistic quantum physics and applications to the particle physics. In particular the student is expected to achieve the knowledge of the formalism, be familiar with the use of the covariant formulation, conservation and symmetry laws, the use of invariants to simplify kinematic calculations in the decays and particle reactions. Basic of the particle accelerators physics will be give with some examples and applications. The goal is to develop a quantitative understanding, in order to be able solve practical problems, commonly faced in the particle physics research.*
Course prerequisites	*Institution of nuclear and subnuclear physics, special relativity, mathematical method for physics.*
Contents	- *Introduction: special relativity and particle physics.* - *Space/Time: Inertial reference frames, the synchronisation of clocks and Einstein's derivation of the Lorentz Transformations.* - *Space-Time Diagrams: The application of Minkowski diagrams to the causal connection of events, the light cone, future, past and present; length contraction and time dilation.* - *Proper Time and Four Vectors: The invariant time interval between events, the four velocity. The four velocity transformation into a second inertial frame using the Minkowski rotation matrix to give the relativistic velocity transformation.* - *Four Vectors: The product of the four velocity with mass to give four-momentum, the transformation of four momentum, the application of*

	the conservation of the four momentum. The four force, the transformation of the three-force between inertial frames. Examples and applications. - *Mass-Energy-Momentum: The application of the equation relating the total energy of a particle and its energy and momentum in particle collisions. Esempi.* - *Massless particles* - *Notation, covariant and contravariant components, metric tensor, invariants.* - *Introduction to classical field theory.* - *Relativistic action and Lagrangian for the motion of a particle, conservation laws and symmetry.* - *Frequently used reference frames: Lab frame, centre-of-mass frame; Invariant mass Minkowski metric, rapidity, pseudo-rapitidy.* - *Non-relativistic limit for a particle in a field.* - *Wave equations for fields.* - *Using invariants to simplify kinematic calculations.* - *Spin-0 relativistic particles, Klein-Gordon equation.* - *Dirac equation (relativistic spin-1/2 particles), electrons.* - *Antiparticles.* - *Feynman diagrams, Mandelstam variables, crossing symmetry.* - *Relativistic decays and reactions, Phase space calculation, Photon emission and absorption, Two-body decays, Three-body decays. Examples: Compton scattering, $p\bar{p}$ threshold in pp scattering, Kp → πΛ, H → γγ decay and other examples* - *Particle collisions: Elastic collisions. Inelastic collisions: quasi-elastic collisions, particle creation. Deep inelastic scattering.* - *Scattering with beam: linear accelerators, Collider Vs Fixed Target Experiment. Examples.*
Books and bibliography	• *Resnick, Robert.* Introduction to Special Relativity. *New York, NY: Wiley, 1968. ISBN: 9780471717256.* • *French, Anthony Philip.* Special Relativity. *New York, NY: Norton, 1968. ISBN: 9780393097931.* • *Introduction to High Energy Physics, Perkins D H (4th edn CUP 2000).*
Additional materials	*Teacher' slides and other materials on internet.*

Work schedule			
Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
	24	*15*	*61*
ECTS			
	3	*1*	
Teaching strategy			
	Lectures will be delivered in person or in streaming via Teams. A blended learning		

	approach will be adopted by combining traditional face-to-face class lectures with the use of digital technologies. Classroom lessons supported by video projector and with the help of networked PCs and, if needed, in streaming via Teams. Provision of digital content and seminar aimed at deepening the topics covered by the course, followed by a discussion in classroom.
Expected learning outcomes	
Knowledge and understanding on:	*The student will acquire:* - *Knowledge of special relativity and its implications in the formulation of the theory of elementary particles.* - *Understanding of the phenomenological aspects of the theory of elementary particle physics and the ability to put the phenomenology of elementary processes in the theoretical context.* - *Knowledge and understanding of the covariant formulation, conservation, and symmetry laws.* - *Understanding of the use of invariants to simplify kinematic calculations in particle decays and reactions, of relativistic phase space and its role in decays and two-body and many-body scattering.* - *Knowledge of the basics of accelerator physics.* - *Critical thinking, creativity, and analytical skills.*
Applying knowledge and understanding on:	*The student will develop a quantitative understanding that enables him/her to solve practical problems commonly encountered in particle physics research.* *The student will acquire the skills to carry out research work in particle physics independently.* *The student will acquire the know-how to apply knowledge in different contexts and will be able to perceive the interdisciplinary value of the theories and experimental methodologies learned.* *The student will acquire the knowledge and understanding of the experimental methods and techniques to do high-level research in any field, even in an international context.*
Soft skills	• *Making informed judgments and choices* *The student will develop the ability to analyze the phenomenology with a critical attitude, having the theoretical tools to verify the properties and foundations of the proposed theories and models. The student will learn how to analyse problems and results, and develop critical skills to get autonomously conclusions, highlighting, where possible, the approximations and assumptions and any weaknesses in the reasoning.* • *Communicating knowledge and understanding* The student will acquire skills on how to present scientific concepts and results in a precise, accurate and direct way. He/she will develop an aptitude to share the opinions with colleagues and working in groups to understand problems and to infer the solutions and the research strategies through scientific discussion. • *Capacities to continue learning* *The student will learn how to consult bibliographic material, databases, and scientific literature, in order to continue her/his studies in the field of experimental, theoretical particle physics and any other discipline with an open-minded and interdisciplinary approach.*

Assessment and feedback	
Methods of assessment	*Oral examination will consist of a colloquium typically around topics explained during the course and a question on applied aspects of the topics covered in the course.*
Evaluation criteria	• Knowledge and understanding *At the end of the course the student must demonstrate to have:* - *Basic knowledge of the theoretical aspects and an understanding of the experimental aspects of the Standard Model.* - *Understanding of the phenomenological aspects of elementary particle physics and ability to put in the proper context the phenomenology of elementary processes within the theoretical model.* - *Knowledge of the experimental observables for physics measurements and understanding of experimental methods to implement measurements.* - *Understanding of the limitations and open questions in the current description of fundamental interactions.* • Applying knowledge and understanding *The student should be able to apply the acquired knowledge to solve typical problems in particle physics, such as the production and decay of elementary particles using relativistic kinematics, calculations of cross sections, description of processes using Feynman diagrams. She/he should be able to apply the rules of composition of angular moments and isospin in Quantum Mechanics and the properties of the phenomenology discussed during the course.* *The student should be familiar with the theories underlying modern experiments and should have learned the tools to apply these theories to calculate experimentally measured observables.* *The student should have acquired the skills to carry out research work in particle physics independently.* *The student should have the knowledge and understanding of experimental methods and techniques to do high-level research in any field, including in an international context.* • Autonomy of judgment *The student should have acquired the ability to identify problems by making qualitative and quantitative observations and analyzing them critically.* *She/he should be able to identify relevant measurements to verify properties and models.* *She/he should have the ability to carry out scientific research in any field and to draw conclusions independently through the analysis and interpretation of experimental data.* • Communicating knowledge and understanding *The student must demonstrate the ability to express him/herself using the appropriate terminology, commonly used in high energy and elementary particle physics.* *She/he should be acquitted with the tools necessary for the presentation of the scientific data.* • Communication skills *The student has the skill to communicate scientific concepts in proper lexicon and*

	appropriate English language, to work in a group and to develop strategies for problem solving by comparing with colleagues and teachers. *He/she can communicate with other coworkers by asking questions and listening to answers, debating in a clear and critically way.* *The student should be able to support a scientific discussion using the topics learnt during the course.* • Capacities to continue learning *The student should demonstrate to have gained the skills to consult efficiently the bibliographic material, databases and material on internet. The student should be able to study independently, by selecting properly the sources, texts, scientific literature and web resources, with an open-minded and interdisciplinary approach. In order to expand the knowledge she/he should be able to select interesting topics, address and solve new problems, and acquire new tools.*
Criteria for assessment and attribution of the final mark	*Oral examination consisting of a colloquium typically around topics explained during the course. The final mark is given in thirtieths. The examination is considered passed when the mark is greater than or equal to 18.* *The following aspects will be assessed:* - *Acquisition of knowledge and understanding of concepts. Maximum score can be achieved if a very broad, complete, and in-depth knowledge of the contents is demonstrated.* - *Ability to relate the concepts and their implications and ability to apply the contents. Maximum score can be achieved if excellent ability to analyze, synthesize and make interdisciplinary connections is demonstrated.* - *Use of appropriate language and terminology* - *Expository skills and mastery of exposition.*
Additional information	