UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Fisica e Chimica - Emilio Segrè
ACADEMIC YEAR	2020/2021
MASTER'S DEGREE (MSC)	PHYSICS
SUBJECT	THEORY OF RELATIVITY
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50338-Astrofisico, geofisico e spaziale
CODE	07411
SCIENTIFIC SECTOR(S)	FIS/05
HEAD PROFESSOR(S)	PERES GIOVANNI Cultore della Materia Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	102
COURSE ACTIVITY (Hrs)	48
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**PERES GIOVANNI** Monday 15:30 17:30 Specola Universitaria (Dip. Fisica e Chimica) - Piazza Parlamento 1 - Studio del Prof. Peres (Stanza nr. 15) Tuesday 15:30 17:30 Specola Universitaria (Dip. Fisica e Chimica) - Piazza Parlamento 1 - Studio del Prof. Peres (Stanza nr. 15)

DOCENTE: Prof. GIOVANNI PERES

PREREQUISITES	General physics (with specific attention to mechanics, gravitation and electromagnetism) and special relativity; basic knowledge of astronomy and cosmology is recommended (but not mandatory) for the final part of the course.
LEARNING OUTCOMES	Knowledge and Understanding. Students have to learn basic aspects of General Relativity, of relativistic cosmology and some related fundamental results. We aim at their understanding of: tensor calculus, some aspects of differential geometry, the invariance principles and their importance, the geometric and physical properties of space-time in several physical problems. Students will have to understand the conceptual path leading to the derivation of field equations and equations of dynamics as well as to some reference solutions. Applying knowledge and understanding The student has to apply physical or mathematical methods learnt during the course to reference physical cases (basic aspects and specific problems) like, for instance, has to apply reference frame transformations to identify and analyze physical and mathematical aspects of a system. Making judgements. The student has to attack problems with autonomous evaluation, and with the ability to discuss characteristics and limitations of General Relativity, of its physical foundations and its range of applications. Students are required to evaluate physical conditions and to perform order of magnitude calculations, to tackle questions autonomously and to evaluate qualitatively and quantitatively various aspects of Relativity. Communication skills The student has to expose autonomously the several problems of Relativity studied during the course. The student will have to apprehend the language and the method typical of Relativity. Students, during the lessons, are asked to expose and comment problems either basic or typical of specific contests and they are asked to expose autonomously the various subjects. Learning skills Students are suggested to study in detail the various subjects mainly through the additional textbooks and texts suggested as well as additional books, papers or information available on the web (obvioulsy through an accurate and extensive critical analysis of the sources) and/or additional mathematical material or computing codes. Students are encouraged to look autonomously for additional sources and texts.
ASSESSMENT METHODS	Oral exam. The exam is dedicated to evaluate the understanding both of the general problems and of the specific aspects (including phenomenology) of General Relativity and of Cosmology; there is specific attention to important results (e.g Schwarzschild metric, FRW metric or evolution of the density of various components of the Universe). Usually we do not require a detailed (typically complicated) derivation of formulae but rather the understanding and exposure of most crucial and most conceptual aspects of the derivation. We also require that the student exposes the general aspects of General Relativity and Cosmology, of related problems and o f the relevant solutions. It is also important that the student understands the geometric treatment of physical reality, so typical of General relativity, its implications and its applications. The final marks will be scaled according to the following conditions: a)Only basic knowledge of Relativity and limited ability to expose subjects and the related derivations, just sufficient ability to expose and to analyze phenomena, problems and solutions (grade 18–21); b)Good knowledge of Relativity and good ability to develop analyses or derivations, good ability to expose and analyze phenomena as well as conceptual problems and related solutions (grade 22-25) c)deep (but not full) knowledge of the concepts and problems of General Relativity, detailed exposure and analysis, albeit with some uncertainty, of phenomena, problems and related solutions (grade 26-28); d)deep and full knowledge of the concepts and problems of General Relativity, full mastering exposure and analysis, even with original criticisms, of phenomena, problems and related solutions, in the best cases with original contributions and original analysis as well as with excellent ability to communicate (grade 29-30L);
EDUCATIONAL OBJECTIVES	Learning General Relativity, with particular emphasis on covariance e the transformation of reference frames. It is important to learn concepts and methods for the derivation of the Einstein field equations, as well as for important application as the physics of Schwarzschild black holes and relativistic cosmology. In order to achieve these tasks it is also important to learn several aspects of vector and tensor calculus on differentiable manifolds.
TEACHING METHODS	Lectures. Lessons are given by the teacher treating subjects and performing calculations on the board: this approach allows a better and gradual

	understanding of the subject by the students and a better interaction with them. The approach is highly interactive: contributions and questions from the students in the course of lessons are welcome and, often, questions are posed by the teacher to th students. Critical parts of the course (e.g. deriving the field equations) are the typical opportunity for discussions and questions.
SUGGESTED BIBLIOGRAPHY	MP. Hobson, G. Efstathiou and A. N. Lasenby – General Relativity, An Introduction for Physicists – Cambridge U. P Consultazione: H. C. Ohanian, R. Ruffini - Gravitazione e Spazio-Tempo – Zanichelli Salvatore Capozziello e Maria Funaro - Introduzione alla relativita' generale. Con applicazioni all'astrofisica relativistica e alla cosmologia - Liguori S. Weinberg- Gravitation and Cosmology – J. Wiley C.W. Misner, K.S. Thorne, J.A. Wheeler – Gravitation - Freeman Ta-Pei Cheng - Relativity, Gravitation and Cosmology - Oxford University Press M. Guidry - Modern General Relativity - Cambridge University Press

SYLLABUS

Hrs	Frontal teaching
2	Refresh Special Relativity, Lorentz trasformations, four-vectors, relativistic dynamics. Short mention of Relativistic Electrodynamics.
3	Equivalence principle, Experimental and phoenomenological aspects of General Relativity.
3	Differential Manifolds
5	Vector calculus on differentiable manifolds
4	Tensor calculus on differential manifolds
5	Gravity and space-time curvature.
5	Einstein field equations.
2	Experimental tests of general relativity and relativistic astronomical phoenomena
5	Schwarzschild black holes.
1	Recent tests and proofs of General Relativity
3	Friedman-Robertson-Walker metrics.
6	Cosmological models.
4	Linearization of General Relativity equations and gravitational waves.