UNIVERSITÀ DEGLI STUDI DELLA BASILICATA

DIPARTIMENTO DI MATEMATICA, INFORMATICA ED ECONOMIA

COURSE: ***AN INTRODUCTION TO RELATIVITY THEORY – For Mathematicians and Theoretical Physicists***

ACADEMIC YEAR: 2017/2018			
TYPE OF EDUCATIONAL ACTIVITY: Characterizing			
TEACHER: Ermenegildo Caccese			
e-mail: ermenegildo.caccese@unibas.it; ermenegildo.caccese@gmail.com		website:	
phone: +39 0971 205884		mobile (optional):	
Language: ITALIAN			
ECTS: 6	n. of hours: 48	Campus: Potenza Deptartment of Mathematics, Computer Science and Economics	Semester: First

EDUCATIONAL GOALS AND EXPECTED LEARNING OUTCOMES

Knowledge of the foundations of the physical theory of relativity and its basic mathematical aspects.

PRE-REQUIREMENTS

Linear and multilinear algebra

Differential and integral calculus

General topology

Basics in classical mechanics and electrodynamics

SYLLABUS

AN INTRODUCTION TO RELATIVITY THEORY – For Mathematicians and Theoretical Physicists

Part 1 – *The Principle of Relativity in Classical Physics*

1. The principle of inertia and the other Newton laws. 2. Galilei's principle of relativity. 3. Some theoretical aspects of Maxwell's electrodynamics. 4. The search for relative motion of matter and aether. 5. The 'relativity' theory of Lorentz, of Poincaré, and of Minkowski. 6. Einstein's special relativity, 1905

Part 2 – *Special relativity for mathematicians*

1. Minkowski space-time. 2. On the causal structure of Minkowski space-time. 3. Particles' dynamics. 4. Electrodynamics in special relativity. 5. Relativistic field theories. 6*. Continuous media in special relativity

Mathematical methods 1: *Linear algebra, classical groups, and affine geometry*

1. Vector space and the general linear group. 2. Affine geometry. 3. Tensors. 4. Euclidean spaces and the orthogonal group. 5. Lorentz spaces and the Lorentz group. 6. Tensor calculus on an affine space. 7. Tensor calculus on an Euclidean space. 8*. Exterior algebra and exterior calculus on affine and Euclidean spaces

Mathematical methods 2*: *Topics in differential geometry*

1. Differentiable manifolds. 2. Fiber bundles associated with a manifold. 3. Differential operators and differential calculus on a manifold. 4. Linear connections and absolute differential calculus in a manifold. 5. Riemannian manifolds. 6. Curvature and space forms.

Special Topics[*]

Topic 1: *An introduction to General Relativity*

1. On the Newton's theory of gravitation. 2. Gravitation and inertia. 3. Arguments for a non-flat geometry of the universe. 4. Space-time: the metric as gravitational potential. 5. The Levi-Civita connection as gravitational field. 6. The Riemann tensor as tidal force. 7. The Einstein's equations. 8. Some classical exact solutions. 9. Gravitational waves. 10. On the causal structure of space-time. 11. Further topics

Topic 2: *Space-time structures, a non-intrinsic approach*

1. Events and phenomena. 2. Reference frames and the *kinematic equivalence* relation. 3. *Inertia equivalence* relation in a kinematic class and space-time structures. 4. A classification of space-time structures. 5. Kinematics and dynamics in a space-time structure: a non-intrinsic approach

Topic 3: *Space-time structures, an intrinsic approach*

1. On the structure of regular convex cones. 2. Causal structure induced on space-time by a regular convex cone distribution. 3. The intrinsic form of a space-time structure. 4. Examples. 5. On the topological stability of a space-time structure. 6. The Alexandrov-Zeeman theorem and its generalisations. 7. Kinematics and dynamics in a space-time structure: the intrinsic approach

[Arguments marked with an asterisk are optional]

TEACHING METHODS
Lectures and periodic collective discussions

EVALUATION METHODS
Oral examination

TEXTBOOKS AND ON-LINE EDUCATIONAL MATERIAL

Basics
1. *Lecture Notes*. 2. J. D. Jackson. *Elettrodinamica classica*. Zanichelli. 3. V. Barone. *Relatività*. Bollati-Boringhieri

On the Principle of Relativity
1. G. Barton. *Introduction to the Relativity Principle*. Wiley. 2. A. Einstein. *Opere scelte. A cura di Enrico Bellone*. Bollati Boringhieri. 3. A. I. Miller. *Albert Einstein's Special Theory of Relativity*. Addison-Wesley. 4. E. Whittaker. *A History of the Theories of Aether and Electricity*. Dover. 5. Y. Z. Zhang. *Special Relativity and Its Experimental Foundations*. World Scientific

Relativity Theory
1. R. d'Inverno. *Introduzione alla Relatività di Einstein*. CLUEB. 2. G. L. Naber. *The Geometry of Minkowski Spacetime*. Springer-Verlag. 3. W. Rindler. *Essential Relativity*. Springer-Verlag

Electrodynamics
1. S. Parrott. *Relativistic Electrodynamics and Differential Geometry*. Springer-Verlag. 2. F. Rorhlich. *Classical Charged Particles*. Addison-Wesley. 3. G. Toraldo di Francia, P. Bruscaglioni. *Onde elettromagnetiche*. Zanichelli

Mathematical Methods
1. V. I. Arnol'd. *Metodi geometrici nella teoria delle equazioni differenziali ordinarie*. Editori Riuniti. 2. M. Crampin, F. A. E. Pirani. *Applicable Differential Geometry*. Cambridge University Press. 3. W. Greub. *Multilinear Algebra*. Springer-Verlag. 4. T. Yokonuma. *Tensor Spaces and Exterior Algebra*. AMS Transl. Math. Monographs. 5. A. Trautman. *Fibre bundles associated with space-time*. Rep. Math. Phys.

1(1970)29-62. 6. M. Golubitsky, V. Guillemin. *Stable Mappings and Their Singularities*. Springer-Verlag

INTERACTION WITH STUDENTS

Direct meetings. Short communications by e-mail or telephone.

Office hours: Wednesday, 10.30-12.30 a. m.; Thursday, 3.00-5.00 p. m.

EXAMINATION SESSIONS (FORECAST)[1]

07/02/2018; 07/03/2018; 04/04/2018; 09/05/2018; 06/06/2018; 11/07/2018; 12/09/2018; 10.10.2018; 14.11.2018; 12.12.2018

SEMINARS BY EXTERNAL EXPERTS NO

FURTHER INFORMATION

[1] Subject to possible changes: check the web site of the Teacher or the Department/School for updates.