UNIVERSITÀ DEGLI STUDI DELLA BASILICATA

DIPARTIMENTO DI MATEMATICA, INFORMATICA ED ECONOMIA

COURSE:

AN INTRODUCTION TO RELATIVITY THEORY

For Mathematicians and Theoretical Physicists

ACADEMIC YEAR: 2018/2019

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 theory of relativity and its basic mathematical aspects.

PRE-REQUIREMENTS

(1) Basics in linear and multilinear algebra
(2) Basics in differential and integral calculus
(3) Basics in general topology
(4) Basics in classical mechanics and electrodynamics

SYLLABUS

AN INTRODUCTION TO THE THEORY OF RELATIVITY

Part 1 – The Principle of Relativity in Classical Physics

1. The principle of inertia in Newton's mechanics
2. The principle of relativity of Galilei
3. Some theoretical aspects of the electrodynamics of Maxwell and Lorentz
4. Contradictions between classical mechanics and electrodynamics
5. The rise of the theory of relativity

Part 2 – Special Relativity for Mathematicians

1. The Minkowski space-time
2. Kinematics of particles and extended systems
3. Dynamics of particles and extended systems
4. Relativistic electrodynamics
5. The causal structure of Minkowski space-time

6*. On the relativistic dynamics of continuous media

Mathematical Tools 1 – Linear Algebra, Classical Groups and Affine Geometry

1. Vector spaces 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 affine spaces
7. Euclidean tensor calculus

8*. Exterior algebra and the exterior differential calculus

Complementary Topics 1 – Mathematical Tools*

1. Differentiable manifolds
2. Fiber bundles associated to a manifold
3. Differential calculus on manifolds
4. Riemannian manifolds
5. Theory of linear connections
6. Space forms

Complementary Topics 2 – Introduction to General Relativity*

1. A review of Newton's theory of gravitation
2. Inertia and gravitation
3. Physical motivations for a non-flat geometry
4. The metric as gravitational potential
5. The Levi-Civita connection as gravitational field
6. The Riemann curvature tensor as tidal force field
7. The equations of Einstein
8. The causal structure of a general space-time
9. Frontiers

Complementary Topics 3 – Introduction to Space-Time Structures: a Non-Intrinsic Approach*

1. Phenomena and events
2. Reference frames and the kinematic equivalence relation
3. Space-time structures
4. The Ignatowsky classification of relativistic space-time structures
5. Kinematics and dynamics in a space-time structure

Complementary Topics 4 – Introduction to Space-Time Structures: an Intrinsic Approach*

1. On the geometry of regular convex cones
2. The causal structure determined by a regular convex cone distribution
3. The intrinsic geometric model of a space-time structure
4. On the topological stability of space-time structures
5. The Alexandrov-Zeeman theorem and its generalisations
6.Kinematics and dynamics in a space-time structure

[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. *Classical Electrodynamics*. Wiley
3. V. Barone. *Relatività*. Bollati Boringhieri

On the Princilpe of Relativity

1. G. Barton. *Introduction to the Relativity Principle*. Wiley
2. A. Einstein. *Opere scelte*. *A cura di E. 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

The theory of Relativity

1. G. I. Naber. *The Geometry of Minkowski Spacetime*. Springer-Verlag
2. W. Rindler. *Essential Relativity*. Springer-Verlag
3. R. K. Sachs, H. Wu. *General Relativity for Mathematicians*. Springer-Verlag
4. B. O'Neill. *Semi-Riemannian Geometry*. *With Applications to Relativity*. Academic Press

Electrodynamics

1. S. Parrott. *Relativistic Electrodynamics and Differential Geometry*. Sprimger-Verlag
2. F. Rohrlich. *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. T. Yokonuma. *Tensor Spaces and Exterior Algebra*. AMS Transl. Math. Monographs
3. W. Greub. *Multilinear Algebra*. Springer-Verlag
4. A. Trautman. *Fiber Bundles Associated with Space-Time*. Rep. Math. Phys. **1**(1970)29-62
5. F. W. Warner. *Foundations of Differentiable Manifolds and Lie Groups*. 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]

14.02.2019; 14.03.2019; 11.04.2019; 9.05.2019; 13.06.2019; 18.07.2019; 12.09.2019; 10.10.2019; 14.11.2019; 12.12.2019.

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.