

COURSE OFFERED

Name of the course	Polish	Wstęp do ogólnej teorii względności
	English	Introduction to the General Theory of Relativity

1. LOCATION OF THE COURSE OF STUDY WITHIN THE EDUCATION SYSTEM

1.1. Section ¹	Section of Exact and Natural Sciences
1.2. Discipline²	Physical Sciences
1.3. Type of education	Stationary
1.4. Level of education	PhD School
1.5. Person preparing the course description	Francesco Giacosa
1.6. Contact	fgiacosa@ujk.edu.pl

2. GENERAL CHARACTERISTICS OF THE COURSE OF STUDY

2.1. Type of course ³	Specialized Subjects in the Discipline
2.2. Language of the course	English

3. DETAILED CHARACTERISTICS OF THE COURSE OF STUDY

3.1. Type of classes⁴		Lecture, Classes
3.2. The number of hours⁵		15h (Lecture), 15h (Classes)
3.3. Location of classes		UJK, WNSiP
3.4. Type of assessment		Lecture – Exam, Classes - Credit with a Grade
3.5. Didactic methods		Oral lectures, problem solving
3.6. Literature	basic	Sean Carroll, Spacetime and Geometry: An Introduction to General Relativity Carlo Rovelli, General Relativity: The Essentials A. Zee, Einstein Gravity in a nutshell Tomislav Prokopec, Lecture notes for Cosmology
	supplementary	Quantum field theory in a nutshell, A. Zee. J. A. Peacock, cosmological physics

4. OBJECTIVES, SYLLABUS CONTENT AND INTENDEND LEARNING OUTCOMES

4.1. Course objectives (including the form of classes)
Description of the most important features and formalism of modern special and general relativity. Understanding the mathematical tools related to special and general relativity. Developing skills to solve exercises and to understand the ongoing research on these topics.

¹ Section of Humanities:, Social Sciences, Section of Exact and Natural Sciences, Section of Medical and Health Sciences, Section of Arts.

² History,Linguistics, Literary Studies, Medical Sciences, Health Sciences, Political and Administrative Sciences, Legal Sciences, Security Sciences, Pedagogy, Communication and Media Studies, Management and Quality Studies, Biological Sciences, Chemical Sciences, Physical Sciences, Earth and related Environmental Sciences, Visual Arts and Artwork Conservation, Musical Arts.

³ General courses, domain specific subjects in the section, disciplinary subjects in the sections, specialized subjects in the discipline.

⁴ Excercises, lecture, seminar.

⁵ Consistent with the education program at the Doctoral School
Jan Kochanowski University in Kielce.

Syllabus content

1. Principles of special relativity- flat space-time geometry, time dilation, Lorentz transformations, Lorentz contraction, the principle of adding velocity
2. Mathematical aspects of STR - four vectors, four velocity, dot product, single-form, gradient, tensors, metric
3. Relativistic dynamics - four vectors of acceleration, force and energy-momentum, Faraday tensor, principle of least action
4. Curvilinear coordinate systems - curvilinear coordinates and Christoffel symbols
5. Gravity as a geometry - the principle of equivalence, clocks in a gravitational field, Newtonian gravity as the curvature of space-time
6. Curved manifolds - Riemann manifolds, parallel transfer, geodetic curves, mathematical description of curvature, Riemann tensor, Ricci tensor, Einstein tensor
7. Einstein's equations
8. Spacetime around a spherically symmetric star - Schwarzschild's metric, gravitational redshift, particle orbits, trajectories of light rays
9. Gravitational collapse of bodies and black holes
10. Cosmology - structure of the Universe, expansion of the Universe, Robertson-Walker metric, Friedmann equation.

5. SUBJECT LEARNING OUTCOMES

Learning outcomes	A doctoral student who has passed the subject:	Reference to the learning outcomes of Doctoral School (according to the training program at the Doctoral School)
in the area of KNOWLEDGE:		
W01	Demonstrates knowledge and understanding at a level enabling the critical revision of existing paradigms of the global body of scholarship in general relativity, encompassing theoretical foundations, general principles, and selected advanced topics.	SD_W01
W02	Understands the main developmental trends in scientific disciplines—particularly in general relativity and gravitation theory—relevant to the field of study and closely aligned with the pursued research topic.	SD_W02
W03	Understands the fundamental dilemmas of contemporary physics and is able to formulate significant, current, and unresolved problems within the field of general relativity, and can articulate these issues effectively in a foreign language.	SD_W07
in the area of SKILLS:		
U01	The doctoral student is able to define the aim and subject of scientific research, formulate research hypotheses in general relativity, and critically analyze and	SD_U01

	evaluate research results, expert activities, and other scholarly or creative works, including their contribution to the advancement of knowledge.	
U02	The doctoral student is capable of utilizing knowledge from various disciplines to identify, formulate, and creatively solve complex problems in general relativity.	SD_U03
U03	Is able to use a foreign language at the B2 level of the Common European Framework of Reference for Languages (CEFR), enabling effective participation in an international professional environment, particularly in the field of general relativity.	SD_U07
in the area of SOCIAL COMPETENCE:		
K01	Is ready to recognize the importance of knowledge in solving cognitive and practical problems.	SD_K02
K02	Is prepared to think and act in an entrepreneurial manner	SD_K04

6. METHODS OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

SUBJECT LEARNING OUTCOMES	METHOD OF ASSESSMENT (+/-)																				
	Oral/written exam			Test			Project			activity in class			Own work			Group work			Others		
	The type of classes			The type of classes			The type of classes			The type of classes			The type of classes			The type of classes			The type of classes		
	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S
W01	x				x																
W02	x				x																
W03	x				x																
U01	x				x																
U02	x				x																
U03	x				x																
K01	x				x																
K02	x				x																

7. CRITERIA OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

Form of classes	Grade	Criterion of assessment
Lecture (L) ⁶	3,0	51-60% correct exercises with exam
	3,5	61-70% correct exercises with exam
	4,0	71-80% correct exercises with exam
	4,5	81-90% correct exercises with exam
	5,0	91-100% correct exercises with exam
Classes (C)	3,0	51-60% correct exercises with test
	3,5	61-70% correct exercises with test
	4,0	71-80% correct exercises with test

⁶ Niepotrzebne usunąć.

	4,5	81-90% correct exercises
	5,0	91-100% correct exercises

Accepted for execution

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