#### **COURSE OFFERED**

	Polish	Wprowadzenie do ogólnej teorii względności i zastosowań w
Name of the		astrofizyce i kosmologii
course	English	Introduction to general relativity and applications to
		astrophysics and cosmology

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

1.1. Section <sup>1</sup>	Section of Exact and Natural Sciences
1.2. Discipline <sup>2</sup>	Physical Sciences
1.3. Type of education	Stationary
1.4. Level of education	PhD School/ 3 year
1.5. Person preparing the course	Francesco Giacosa
description	
1.6. Contact	fgiacosa@ujk.edu.pl

### 2. GENERAL CHARACTERISTICS OF THE COURSE OF STUDY

2.1. Type of course <sup>3</sup>	Specialized Subjects in the Discipline of Physical
	Sciences
2.2. Language of the course	English

#### 3. DETAILED CHARACTERISTICS OF THE COURSE OF STUDY

3.1. Type of classes <sup>4</sup>		Lecture, Excercises					
3.2. The number of hours <sup>5</sup>		30h, (15h Lecture + 15h Excercises)					
3.3. Location of classes		UJK, WNSiP					
3.4. Type of assessment		Lecture – Exam, Excercises - 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					
	sunnlementary	Ouantum field theory in a nutshell A. Zee					
	Supplementary	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.

<sup>&</sup>lt;sup>1</sup> Section of Humanities:, Social Sciences, Section of Exact and Natural Sciences, Section of Medical and Health Sciences, Section of Arts.

<sup>&</sup>lt;sup>2</sup> 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.

<sup>&</sup>lt;sup>3</sup> General courses, domain specific subjects in the section, disciplinary subjects in the sections, specialized subjects in the discipline. <sup>4</sup> Excercises, lecture, seminar.

<sup>&</sup>lt;sup>5</sup> Consistent with the education program at the Doctoral School

Jan Kochanowski University in Kielce.

Understanding the mathematical tools related to special and general relativity. Developing skills to solve exercises and to understand the ongoing research on these topics. 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 - Schwarzshild'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

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Learning outcomes	A doctoral student who has passed the subject:	Reference to the learning outcomes o Doctoral School (according to the training program at the Doctoral School		
	in the area of KNOWLEDGE:			
W01	W01 The doctoral student possesses in-depth knowledge of the latest scientific achievements, encompassing theoretical foundations, general issues, and selected specific topics relevant to the scientific discipline in which the doctoral dissertation is being prepared			
	in the area of SKILLS:			
U01	The doctoral student is capable of utilizing knowledge from various disciplines to identify, formulate, and creatively solve complex problems or undertake research tasks	SD_U03		
	in the area of SOCIAL COMPETENCE:			
К01	The doctoral demonstrates entrepreneurial thinking and actively takes initiative.	SD_K04		

## 6. METHODS OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

		METHOD OF ASSESSMENT (+/-)																			
SUBJECT LEARNING OUTCOMES	Oral/writte n exam			Kolokwiu m			Project			activity in class			Own work			Group work			Others		
	The type of classes		Th cl	The type of classes		Th cl	The type of classes														
	L	Ε	S	L	Ε	S	L	Ε	S	L	Ε	S	L	Ε	S	L	Ε	S	L	Ε	S
W01	x	x																			
U01	x	x																			
K01	x	x																			

## 7. CRITERIA OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

Form of classes	Grade	Criterion of assessment						
9	3,0	1-60% correct exercises						
(r)	3,5	01-70% correct exercises						
ure	4,0	71-80% correct exercises						
ecti	4,5	1-90% correct exercises						
Ľ	5,0	91-100% correct exercises						
	3,0	51-60% correct exercises						
ses	3,5	61-70% correct exercises						
erci (E)	4,0	71-80% correct exercises						
EXC	4,5	81-90% correct exercises						
	5,0	91-100% correct exercises						

# Accepted for execution

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<sup>&</sup>lt;sup>6</sup> Niepotrzebne usunąć.