COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-II-S-24/25Z-K**	
Course title: **Alternative Cosmological Scenarios (alternatywne scenariusze kosmologiczne) (SPECJALNOŚCI / SPECJALIZACJE / MODUŁY SPECJALNOŚCIOWE)**	Course code: **SPR16AIIJ3445_32S**
Name of field of study: **fizyka**	
Mode and cycle of study: **second degree, full - time**	Profile of study: **general academic** / Specialty: **cosmology**
Course / module status **obligatory**	Language of instruction: **semester: 4 - english language**

Year	Semester	Form of instruction	No. of hours	including e-learning	Type of credit	ECTS
2	4	konwersatorium	30	0	pg	5
Total			**30**			**5**

Course / module coordinator	**dr hab. VINCENZO SALZANO**
Course instructor	**dr hab. VINCENZO SALZANO**
Course / module objectives	**The aim of the course is to familiarize students with the main theoretical achievements of modern cosmology related to theories of gravity. Upon completion of the course, students have a general understanding of the state of theoretical cosmology.**
Prerequisites	**Completed courses on "General Theory of Relativity" (optional), "Elements of Cosmology" (optional), "Theory of gravity" (optional)**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	**1**	**EP1**	**The student knows the main research methods and directions of modern theoretical cosmology**	**K_W01 K_W02 K_W05**
skills	**1**	**EP2**	**understands the relationship between local astronomical and astrophysical quantities with evolution of the universe on cosmological scales**	**K_U01 K_U02**
	2	**EP3**	**The student discusses and works in a team and maintains openness to the arguments of others**	**K_U03 K_U07**
social competences	**1**	**EP4**	**The student knows the limitations of his own knowledge and understands the need further education**	**K_K01 K_K06**
	2	**EP5**	**The student can formulate questions with precision, deepen his own understanding of the topic or finding missing pieces of reasoning**	**K_K05**

CONTENT	Semester	No. of hours	including e-learning
Subject title: **Alternative Cosmological Scenarios (alternatywne scenariusze kosmologiczne)**			
Format of instruction: **konwersatorium**			
1. **Overview of General Relativity**	4	3	0
2. **Observational motivations for alternative gravity models**	4	2	0
3. **Classification of alternative gravity models**	4	1	0
4. **Screening mechanisms**	4	2	0

5. **Alternative gravity models with additional fields**	4	6	0
6. **High derivatives and nonlocal theories**	4	6	0
7. **Multi-dimensional theories**	4	6	0
8. **Observational constraints on alternative gravity models**	4	4	0

Modes of delivery	**Lectures made using computer presentation and discussion of scientific articles**
	The course teacher shall specify how artificial intelligence should be used as part of implementation of the course according to University of Szczecin best practices and standards. The course teacher shall inform students in their first class about the scope and possibilities of using AI and shall present a catalogue of tools and applications adjusted to relevant learning outcomes and teaching needs and possibilities within a given course.

Assessment methods		No. of learning outcome from the syllabus
	EGZAMIN USTNY	**EP1,EP2,EP3,EP4,EP5**
	PROJEKT	**EP1,EP2,EP3**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	

Grading criteria	**Oral test: answering questions, presenting a project.**
	Grade calculation principles
	The grade for the course is the grade for the seminar

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	4	Alternative Cosmological Scenarios (alternatywne scenariusze kosmologiczne)		Ważona	
	4	Alternative Cosmological Scenarios (alternatywne scenariusze kosmologiczne) [konwersatorium]	zaliczenie z oceną		1,00

Basic reading	M. Ishak (2019): Testing general relativity in cosmology
	T. Clifton, P. G. Ferreira, A. Padilla & C. Skordis (2012): Modified gravity and cosmology
	zródła internetowe, artykuły naukowe
Supplementary reading	

STUDENT WORKLOAD

	No. of hours	
		including e-learning
Contact hours	**30**	**0**
Participation in test / exam	**5**	**0**
Preparation for contact hours	**20**	**0**
Private reading and studying	**23**	**0**
Participation in tutorials	**22**	**0**
Preparation of project / essay / etc.	**10**	**0**
Preparation for test / exam	**15**	**0**
TOTAL workload	**125**	
ECTS credits	**5**	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-I-S-21/22Z**		
Unit: **Astronomia [moduł]**		
Course title: **Astrobiology (astrobiologia)**		Course code: **SPR16AIJ3445_71S**
Name of field of study: **fizyka**		
Mode and cycle of study: **first-degree, full - time**	Profile of study: **general academic**	Specialty:
Course / module status **elective**	Language of instruction: **semester: 6 - polish language**	

Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS
				w tym e-learning		
3	6	konwersatorium	40	0	e	5
Total			**40**			**5**

Course / module coordinator	**prof. dr hab. EWA SZUSZKIEWICZ**
Course instructor	**prof. dr hab. EWA SZUSZKIEWICZ**
Course / module objectives	**The aim of the course is to intruduce the basic concepts of astrobiology. In the first part, the general picture of astrobiology is presented. The second part is dedicated to more advanced topics. During this course, students will have an opportunity to participate in the lectures given by the known astrobiologists from other universities and research institutions, taking place on the videoconference platforms. This will help in showing to students a wider and more complete perspective of the research in astrobiology.**
Prerequisites	**Astronomy, fundamentals of Physics and Chemistry**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	**1**	**EP1**	**Student is familiar with basic concepts, laws and theoretical formulations in the field of Astrobiology.**	**K_W01**
skills	**1**	**EP2**	**Student is able to write an essay in English presenting the physical aspects of astrobiology**	**K_U18**
	2	**EP3**	**Student is able to discuss the timely topics of the astronomical and astrobiological research**	**K_U17 K_U19**
	3	**EP4**	**Student is able to formulate basic laws of Physics using the mathematical tools**	**K_U05**
	4	**EP5**	**Student is able to evaluate physical quantities to the order of magnitude and is aware of the importance of making the approximations in the description of observed phenomena**	**K_U09**
social competences	**1**	**EP6**	**Student is ready to make effort to understand better the subject of Astrobiology and to discuss the topics with others to solve a given problem**	**K_K02 K_K05**
	2	**EP7**	**Student is ready to give her/his opinion on the basic problems and scientific theories connecting the different disciplines and being of interest to the wide audience**	**K_K05**

CONTENT	Semester	No. of hours	
			w tym e-learning
Subject title: **astrobiologia**			
Format of instruction: **konwersatorium**			

1. Part I: Basic concepts of Astrobiology	6	20	0
2. Part II: Advanced topics of Astrobiology	6	20	0

Modes of delivery	**Introduction of the new concepts illustrated by numerous examples. The team work and individual research during the excercise classes**	
Assessment methods		No. of learning outcome from the syllabus
	EGZAMIN PISEMNY	**EP3,EP4,EP5**
	KOLOKWIUM	**EP1,EP3,EP4,EP6,EP7**
	PRACA PISEMNA/ ESEJ/ RECENZJA	**EP2,EP4**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	
Grading criteria	**Written exam, essay, one test** **The final mark is a weighted average on the exam, essay and test**	
	Grade calculation principles	
	FS = 50% * SE1 + 10% SE2 + 40% * SE3 **FS = final mark, SE1 = mark of the exam, SE2 = mark on the essay,** **SE3 = mark on the test**	

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	6	astrobiologia		Ważona	
	6	astrobiologia [konwersatorium]	egzamin		1,00

Basic reading	Franco Ferrari : Slajdy i notatki z wykładów umieszczone na stronie internetowej przedmiotu: http://www.astrobiologia.pl/~ferrari/didactics
	Franco Ferrari i Ewa Szuszkiewicz (2006): Astrobiologia: Poprzez pył kosmiczny do DNA, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin
	Jonathan Irving Lunine (2005): Astrobiology : a multidisciplinary approach, Pearson Addison Wesley, San Francisco
Supplementary reading	Iain Gilmour oraz Mark A. Sephton (2005): An Introduction to Astrobiology, Cambridge University Press , Cambridge

STUDENT WORKLOAD

	No. of hours	
		W tym e-learning
Contact hours	**40**	**0**
Participation in test / exam	**2**	**0**
Preparation for contact hours	**8**	**0**
Private reading and studying	**20**	**0**
Participation in tutorials	**22**	**0**
Preparation of project / essay / etc.	**23**	**0**
Preparation for test / exam	**10**	**0**
TOTAL workload	**125**	
ECTS credits	**5**	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-I-S-22/23Z**	
Course title: **Astronomy (astronomia)**	Course code: **SPR16AIJ3445_11S**
Name of field of study: **fizyka**	
Mode and cycle of study: **first-degree, full - time**	Profile of study: **general academic** / Specialty:
Course / module status: **obligatory**	Language of instruction: **semester: 2 - english language polish language, semester: 3 - english language polish language**

Year	Semester	Form of instruction	No. of hours	w tym e-learning	Type of credit	ECTS
1	2	lecture	15	0	pg	2
2	3	konwersatorium	30	0	e	3
Total			**45**			**5**

Course / module coordinator	**prof. dr hab. EWA SZUSZKIEWICZ**
Course instructor	**prof. dr hab. EWA SZUSZKIEWICZ**
Course / module objectives	**A good understanding of the nature of astronomical phenomena and the underlying fundamental laws, correct use of astronomical terminology, acquire the ability to assess the current state of the astronomical research, develop the capacity of performing simple astronomical observations**
Prerequisites	**Familiarity with the differential calculus: derivatives and itegrals of one and more variables, basic knowledge of Algebra, necessary to describe the physical phenomena and solve physical problems; familiarity with the laws of motion of the pointlike masses and rigid bodies, as well as relativistic mechanics; knowlwdge of basic laws in electricity and magnetism; ability toformulate basic physical laws using mathematical apparatus; awareness of the limitations of the own knowledge and understanding of the need to learn more.**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	**1**	**EP1**	**A student understands the nature of astronomical phenomena and the underlying fundamental laws**	**K_W01 K_W07**
skills		**EP2**	**A student is able to use correctly the astronomical terminology,**	**K_U12 K_U16 K_U17 K_U18 K_U19 K_U22**
	2	**EP3**	**A student possesses the ability to assess the current state of the astronomical research**	**K_U12 K_U16 K_U20 K_U22**
	3	**EP4**	**A student is able to perform simple astronomical observations**	**K_U02 K_U04 K_U09 K_U13 K_U16**
	4	**EP5**	**A student is able to discuss a particular problem with a group of her/his colleagues and remain open on their argumentations**	**K_U17 K_U21**
social competences	**1**	**EP6**	**A student understands a need to disseminate the knowledge of astronomy to a wide public, is ready to take part in the organisation of the public lectures, the night sky shows or other outreach events dedicated to astronomy**	**K_K04 K_K05**

CONTENT	Semester	No. of hours	
			w tym e-learning
Subject title: **astronomia**			
Format of instruction: **lecture**			
1. **Content of the Univers**	2	1	0
2. **Astronomical instrumentation**	2	1	0
3. **The Sun**	2	1	0
4. **Last stages of the stellar evolution**	2	1	0
5. **Evolution of low-mass stars**	2	1	0
6. **Evolution of massive stars**	2	1	0
7. **Binary stars**	2	1	0
8. **Accretion discs**	2	1	0
9. **Stellar systems**	2	1	0
10. **Interstellar medium**	2	1	0
11. **Galaktyki spokojne i aktywne**	2	1	0
12. **Systems of galaxies**	2	1	0
13. **Materia międzygalaktyczna i wielkoskalowa struktura Wszechświata**	2	1	0
14. **Planety i życie**	2	1	0
15. **Esej astronomiczny**	2	1	0
Format of instruction: **konwersatorium**			
1. **Getting familiar with the night sky**	3	3	0
2. **Measuring sizes and distances in Astronomy**	3	3	0
3. **Observation of the Sun**	3	3	0
4. **Stellar prperties**	3	3	0
5. **Stella evolution**	3	3	0
6. **Accretion processes**	3	3	0
7. **Observations of stars**	3	4	0
8. **Planets**	3	4	0
9. **Observations of planets**	3	4	0

Modes of delivery	**Lecture with the multimedial presentations, astronomical observations using simple amateur telescopes, obseravions of the Sun, observations of the interesting objects at the evening sky, use of maps, atlases and catalogues**	
Assessment methods		No. of learning outcome from the syllabus
	EGZAMIN PISEMNY	**EP1,EP2,EP3,EP4,EP5,EP6**
	PROJEKT	**EP1,EP2,EP4,EP6**
	ZAJĘCIA PRAKTYCZNE (WERYFIKACJA POPRZEZ OBSERWACJĘ)	**EP5**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	

Grading criteria	**discussion session: passing the written exam** **lecture: obtaining a credit from the oral test, being active during the classes**
	Grade calculation principles
	The mark from the exam makes the final grade. There is a possibility to increase the final grade if the student is active during the classes

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	2	astronomia		Ważona	
	2	astronomia [wykład]	zaliczenie z oceną		1,00
	3	astronomia		Ważona	
	3	astronomia [konwersatorium]	egzamin		1,00

Basic reading	Shu Frank H. (2003): Galaktyki Gwiazdy Życie, Fizyka Wszechświata, Prószyński i S-ka, Warszawa
	teksty źródłowe podawane na wykładzie :
Supplementary reading	Artymowicz P. (1995): Astrofizyka układów planetarnych, PWN, Warszawa
	Jaroszyski M. (1993): Galaktyki i Budowa Wszechświata, PWN, Warszawa
	Kreiner J. M. (1992): Astronomia z astrofizyką, PWN, Warszawa
	Kubiak M. (1994): Gwiazdy i materia międzygwiazdowa, PWN, Warszawa

STUDENT WORKLOAD

	No. of hours	
		W tym e-learning
Contact hours	**45**	**0**
Participation in test / exam	**5**	**0**
Preparation for contact hours	**15**	**0**
Private reading and studying	**20**	**0**
Participation in tutorials	**15**	**0**
Preparation of project / essay / etc.	**10**	**0**
Preparation for test / exam	**15**	**0**
TOTAL workload	**125**	
ECTS credits	**5**	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-II-S-24/25Z-K**	
Course title: **Black Hole Physics (fizyka czarnych dziur) (SPECJALNOŚCI / SPECJALIZACJE / MODUŁY SPECJALNOŚCIOWE)**	Course code: **SPR16AIIJ3445_30S**
Name of field of study: **fizyka**	
Mode and cycle of study: **second degree, full - time**	Profile of study: **general academic** / Specialty: **cosmology**
Course / module status **obligatory**	Language of instruction: **semester: 3 - english language**

Year	Semester	Form of instruction	No. of hours	including e-learning	Type of credit	ECTS
2	3	konwersatorium	30	0	pg	5
Total			**30**			**5**

Course / module coordinator	**dr HUSSAIN GOHAR**
Course instructor	**dr HUSSAIN GOHAR**
Course / module objectives	**Familiarizing students with the physics of black holes - thermodynamics, issues of statistical physics and quantum effects.**
Prerequisites	**Compulsory: completion of the general theory of relativity course. Recommended: completion of the quantum field theory course.**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	**1**	**EP1**	**The student will understand the the solutions of black holes in general relativity; thermodynamic and quantum phenomena related to black holes**	**K_W01 K_W02 K_W05 K_W06**
skills	**1**	**EP2**	**The student will be able to solve the issues regarding thermodynamic, statistical and quantum processes related to black holes**	**K_U01 K_U04 K_U13**
social competences	**1**	**EP3**	**Student will be ready to popularize science in the field of cosmology**	**K_K01 K_K05**

CONTENT	Semester	No. of hours	including e-learning
Subject title: **Black Hole Physics (fizyka czarnych dziur)**			
Format of instruction: **konwersatorium**			
1. **Schwarzschild Solution, Reissner?Nordström Solution, Ker - Newman Solution, Coordinate Transformations and Penrose Diagrams**	3	9	0
2. **Hawking's Area Theorem, Bekenstein Entropy, Hawking Temperature, Laws of Black Hole Thermodynamics**	3	9	0
3. **Black Hole Entropy from Canonical Ensemble, Energy Fluctuations on the Horizon**	3	3	0
4. **Unruh Process, Hawking Process, Hawking Radiation as Quantum Tunneling, Black Hole Information Problem**	3	9	0

Modes of delivery	**conversational classes conducted using the application and problem method**
	The course teacher shall specify how artificial intelligence should be used as part of implementation of the course according to University of Szczecin best practices and standards. The course teacher shall inform students in their first class about the scope and possibilities of using AI and shall present a catalogue of tools and applications adjusted to relevant learning outcomes and teaching needs and possibilities within a given course.

Assessment methods		No. of learning outcome from the syllabus
	PRACA PISEMNA/ ESEJ/ RECENZJA	**EP1,EP2,EP3**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	
Grading criteria	**Solving a selected project and a computational one and getting a positive grade from an essay summarizing it**	
	Grade calculation principles	
	The grade for the course is the grade for the seminar	

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	3	Black Hole Physics (fizyka czarnych dziur)		Ważona	
	3	Black Hole Physics (fizyka czarnych dziur) [konwersatorium]	zaliczenie z oceną		1,00

Basic reading	S. Chandrasekhar (1998): The Mathematical Theory of Black Holes, Oxford University Press, Oxford
	Andrei Zelnikov and V. Frolov (2013): Introduction to Black Hole Physics,, Oxford University Press, Oxford
	(2009): Physics of Black Holes: A Guided Tour (Lecture Notes in Physics, 769), Springer
	, Physical Review Letters
	, Physical Review X
	, Physical Review D
	, Classical and Quantum Gravity, IOPScience
Supplementary reading	

STUDENT WORKLOAD

	No. of hours	including e-learning
Contact hours	**30**	**0**
Participation in test / exam	**0**	**0**
Preparation for contact hours	**25**	**0**
Private reading and studying	**23**	**0**
Participation in tutorials	**25**	**0**
Preparation of project / essay / etc.	**22**	**0**
Preparation for test / exam	**0**	**0**
TOTAL workload	**125**	
ECTS credits	**5**	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-I-S-21/22Z**		
Unit: **Fizyka teoretyczna [moduł]**		
Course title: **Field Theory (teoria pola)**		Course code: **SPR16AIJ3445_62S**
Name of field of study: **fizyka**		
Mode and cycle of study: **first-degree, full - time**	Profile of study: **general academic**	Specialty:
Course / module status **elective**	Language of instruction: **semester: 5 - polish language**	

Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS
				w tym e-learning		
3	5	konwersatorium	30	0	pg	4
		lecture	10	0	pg	
Total			**40**			**4**

Course / module coordinator	**dr hab. FRANCO FERRARI**
Course instructor	**dr hab. FRANCO FERRARI**
Course / module objectives	**The main concepts of field theory will be introduced by following the historical development of the subject passing from quantum mechanics to relativisting quantum mechanics and arriving to the modern field theoretical formulation. This course is dedicated to those, who want to deepen their knowledge on quantum mechanics and relativity.**
Prerequisites	**Required is the knowlledge acquired during the following courses: quantum mechanics, theoretical mechanics, statistical physics, condensed matter physics and mathematical methods of physics.**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	**1**	**EP1**	**Student posiada wiedzę szczegółową z fizyki w zakresie teorii pola oraz ich zastosowań. Rozumie znaczenie podstawowych koncepcji, zasad i teorii, a także ich historyczny rozwój i znaczenie dla postępu nauk ścisłych poznania świata i rozwoju ludzkości**	**K_W01 K_W20**
skills	**1**	**EP2**	**Student potrafi posługiwać się aparatem matematycznym w zakresie niezbędnym dla ilościowego opisu i modelowania problemów fizyki wysokich energii i fizyki statystycznej**	**K_U05**
	2	**EP4**	**Student potrafi zapoznać się z fachową literaturą naukową w ramach swojej specjalności.**	**K_U20**
	3	**EP6**	**student potrafi przygotować ustne wystąpienie dotyczące wybranego tematu z teorii pola**	**K_U19**
social competences	**1**	**EP5**	**Student jest gotów konsultować się z innymi w celu rozwiązania zadanego problemu i pogłębiać własne zrozumienie danego tematu.**	**K_K02**

CONTENT	Semester	No. of hours	
			w tym e-learning
Subject title: **teoria pola**			
Format of instruction: **lecture**			
1. **Wstęp do teorii pola**	5	1	0
2. **Zaawansowana teoria względności**	5	2	0

3. **Przypadek pola skalarnego**	5	2	0
4. **Równanie Diraca**	5	2	0
5. **Drugie kwantowanie**	5	3	0
Format of instruction: **konwersatorium**			
1. konwersatorium i ćwiczenia dotyczące zagadnień z teorii pola	5	20	0
2. dyskusje na temat teorii pola	5	7	0
3. Przygotowanie i przedstawienie prezentacji studentów	5	3	0

Modes of delivery	**Lectures will be followed by examples.** **During test classes, problems will be solved in group or individually.** **The preparation of an essay on a subject of field theory is required as an homework.**	
Assessment methods		No. of learning outcome from the syllabus
	KOLOKWIUM	**EP1,EP2**
	PREZENTACJA	**EP4,EP5,EP6**
	ZAJĘCIA PRAKTYCZNE (WERYFIKACJA POPRZEZ OBSERWACJĘ)	**EP5**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	
Grading criteria	**Wykład: uzyskanie pozytywnej oceny po przygotowaniu prezentacji oraz jej przedstawieniu** **Konwersatorium: kolokwium**	
	Grade calculation principles	
	FS = 50% * SE1 + 50% * SE2 **FS= ocena końcowa, SE1 = ocena z prezentacji, SE2 = ocena z kolokwium,**	

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	5	teoria pola		Ważona	
	5	teoria pola [wykład]	zaliczenie z oceną		0,50
	5	teoria pola [konwersatorium]	zaliczenie z oceną		0,50

Basic reading	Albert Messiah (1978): Quantum Mechanics, North-Holland, Amsterdam
	Zinn-Justin J. (1996): Quantum field theory and critical phenomena, Oxford University Press, Oxford
Supplementary reading	Bogoliubow I., Szirkow D. (1976): Wwedienie w teoriu kwantowanych pole, Nauka Moskva
	Peskin, Michael E., Daniel V. Schroeder (1996): An Introduction to Quantum Field Theory, Westview Press, Boulder, CO

STUDENT WORKLOAD

	No. of hours	
		W tym e-learning
Contact hours	**40**	**0**
Participation in test / exam	**2**	**0**
Preparation for contact hours	**16**	**0**
Private reading and studying	**10**	**0**
Participation in tutorials	**8**	**0**
Preparation of project / essay / etc.	**12**	**0**
Preparation for test / exam	**12**	**0**
TOTAL workload	**100**	
ECTS credits	**4**	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-II-N-24/25Z-K**		
Course title: **wprowadzenie do modelu standardowego cząstek elementarnych (SPECJALNOŚCI / SPECJALIZACJE / MODUŁY SPECJALNOŚCIOWE)**		Course code: **SPR16AIIJ3445_109N**
Name of field of study: **fizyka**		
Mode and cycle of study: **second degree, part-time**	Profile of study: **general academic**	Specialty: **cosmology**
Course / module status **obligatory**	Language of instruction: **semester: 2 - polish language**	

Year	Semester	Form of instruction	No. of hours	including e-learning	Type of credit	ECTS
1	2	konwersatorium	18	0	pg	5
Total			**18**			**5**

Course / module coordinator	**dr hab. MARCIN PIĄTEK**
Course instructor	**dr hab. MARCIN PIĄTEK**
Course / module objectives	**To acquaint students with the currently prevailing theory of the microscopic structure of matter and fundamental interactions. Acquiring by students the ability to use mathematical tools to solve basic tasks and problems in the field of elementary particles.**
Prerequisites	**theoretical mechanics, electrodynamics, quantum physics**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	1	EP1	**Student knows the fundamental components of matter and fundamental interactions.**	**K_W01 K_W05 K_W06**
	2	EP2	**Student understands the role of symmetry in the construction of the fundamental laws of physics and knows the basic scheme of the construction of the standard model.**	**K_W01 K_W05**
	3	EP3	**Student understands the role of mathematics in learning and describing the laws of nature**	**K_W02 K_W06**
	4	EP4	**Student is aware of the limitations of the standard model in the description of new physical phenomena.**	**K_W01 K_W02**
skills	1	EP5	**Student knows how to apply the field theory tools in the description of elementary particle physics.**	**K_U01 K_U05 K_U06**
	2	EP6	**Student uses arguments based on the conservation laws and symmetry for the analysis of physical processes.**	**K_U01 K_U05 K_U06**
social competences	1	EP7	**Student understands the need to deepen physical knowledge.**	**K_K01**
	2	EP8	**Student can search for information in the literature.**	**K_K06**

CONTENT	Semester	No. of hours	including e-learning

Subject title: **wprowadzenie do modelu standardowego cząstek elementarnych**

Format of instruction: **konwersatorium**			
1. **What is the standard model of elementary particles?**	2	1	0
2. **Spacetime geometry**	2	1	0
3. **Klein-Gordon equation**	2	2	0
4. **Dirac equation and Dirac bispinors**	2	3	0
5. **Particles with spin 0**	2	1	0
6. **Particles with spin 1/2**	2	1	0
7. **Interacting fields**	2	2	0
8. **Global gauge symmetries**	2	1	0
9. **Local gauge symmetry**	2	1	0
10. **Electroweak interactions**	2	1	0
11. **Higgs mechanism**	2	1	0
12. **Phenomenology of electroweak interactions**	2	2	0
13. **Strong interactions**	2	1	0

Modes of delivery	**solving problems and tasks based on the information and examples given during the lecture**	
	The course teacher shall specify how artificial intelligence should be used as part of implementation of the course according to University of Szczecin best practices and standards. The course teacher shall inform students in their first class about the scope and possibilities of using AI and shall present a catalogue of tools and applications adjusted to relevant learning outcomes and teaching needs and possibilities within a given course.	
Assessment methods		No. of learning outcome from the syllabus
	KOLOKWIUM	**EP1,EP2,EP3,EP4,EP5,EP6,EP7,EP8**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	
Grading criteria	**passing a test**	
	Grade calculation principles	
	według standardowych kryteriów oceny osiągniętych efektów kształcenia	

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	2	wprowadzenie do modelu standardowego cząstek elementarnych		Arytmetyczna	
	2	wprowadzenie do modelu standardowego cząstek elementarnych [konwersatorium]	zaliczenie z oceną		

Basic reading	D. H. Perkins (2004): Wstęp do fizyki wysokich energii, PWN, Warszawa
Supplementary reading	Krzysztof A. Meissner (2022): Klasyczna teoria pola, PWN, Warszawa

STUDENT WORKLOAD

	No. of hours	including e-learning
Contact hours	**18**	**0**
Participation in test / exam	**2**	**0**
Preparation for contact hours	**31**	**0**

Private reading and studying	**33**	**0**
Participation in tutorials	**18**	**0**
Preparation of project / essay / etc.	**0**	**0**
Preparation for test / exam	**23**	**0**
TOTAL workload	**125**	
ECTS credits	**5**	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-II-S-24/25Z-K**	
Course title: **matematyczne metody fizyki II (SPECJALNOŚCI / SPECJALIZACJE / MODUŁY SPECJALNOŚCIOWE)**	Course code: **SPR16AIIJ3445_49S**
Name of field of study: **fizyka**	
Mode and cycle of study: **second degree, full - time**	Profile of study: **general academic** / Specialty: **cosmology**
Course / module status: **obligatory**	Language of instruction: **semester: 2 - polish language**

Year	Semester	Form of instruction	No. of hours	including e-learning	Type of credit	ECTS
1	2	konwersatorium	30	0	e	2
Total			**30**			**2**

Course / module coordinator	**dr hab. MARCIN PIĄTEK**
Course instructor	**dr hab. MARCIN PIĄTEK**
Course / module objectives	**Mastering by the student basic tools of complex analysis, differential geometry, theory of distribution and integral operators, theory of ordinary and partial differential equations.**
Prerequisites	**basic knowledge of algebra and mathematical analysis in terms of undergraduate physics studies**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	1	EP1	**Student learns advanced methods of higher mathematics necessary for an in-depth study of physics and related disciplines.**	**K_W01 K_W02**
	2	EP2	**Student learns concepts and techniques necessary to solve ordinary and partial differential equations.**	**K_W02 K_W05 K_W06**
skills	1	EP3	**Student knows how to apply methods of higher mathematics to problems of natural sciences.**	**K_U01 K_U04**
	2	EP4	**Student has accounting skills in solving simple ordinary and partial differential equations.**	**K_U05 K_U06**
social competences	1	EP5	**Student understands the need to constantly expand their knowledge and acquire new technical skills.**	**K_K01 K_K02**

CONTENT	Semester	No. of hours	including e-learning
Subject title: **matematyczne metody fizyki II**			
Format of instruction: **konwersatorium**			
1. **Holomorphic functions**	2	5	0
2. **Elements of differential geometry**	2	5	0
3. **Second-order ordinary differential equations with varying coefficients**	2	6	0
4. **Distributions and integral operators**	2	4	0
5. **First order partial differential equations. The wave equation**	2	4	0
6. **Initial and boundary problems for different types of second-order partial differential equations**	2	6	0

Modes of delivery	**Standard form of the lecture. Students are stimulated to ask questions and discuss. In order to consolidate the processed material, they receive sets of homework and problems to solve on their own.**	
	The course teacher shall specify how artificial intelligence should be used as part of implementation of the course according to University of Szczecin best practices and standards. The course teacher shall inform students in their first class about the scope and possibilities of using AI and shall present a catalogue of tools and applications adjusted to relevant learning outcomes and teaching needs and possibilities within a given course.	
Assessment methods		No. of learning outcome from the syllabus
	EGZAMIN PISEMNY	**EP1,EP2,EP3,EP4,EP5**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	
Grading criteria	**passed test**	
	Grade calculation principles	
	arithmetic average	

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	2	matematyczne metody fizyki II		Ważona	
	2	matematyczne metody fizyki II [konwersatorium]	egzamin		1,00

Basic reading	?W. Żakowski, W. Leksiński (1984): Matematyka, część IV, WNT, Warszawa
	A. Zagórski (2007): Metody matematyczne fizyki, Oficyna Wyd. PW, Warszawa
	F. Byron, R. Fuller (1975): Matematyka w fizyce klasycznej i kwantowej, PWN, Warszawa
Supplementary reading	?B. Szabat (1974): Wstęp do analizy zespolonej, PWN, Warszawa
	L. Evans (2002): Równania różniczkowe cząstkowe, PWN, Warszawa
	W. Smirnow (1966): Matematyka wyższa, tom II,, PWN, Warszawa

STUDENT WORKLOAD

	No. of hours	
		including e-learning
Contact hours	**30**	**0**
Participation in test / exam	**3**	**0**
Preparation for contact hours	**8**	**0**
Private reading and studying	**5**	**0**
Participation in tutorials	**4**	**0**
Preparation of project / essay / etc.	**0**	**0**
Preparation for test / exam	**0**	**0**
TOTAL workload	**50**	
ECTS credits	**2**	

COURSESYLLABUSANDSPECIFICATION

Curriculum title: **USSPR-F-O-I-S-21/22Z**	
Unit: **Kosmologia [moduł]**	
Course title: **Modern observational probes of cosmology (współczesne testy obserwacyjne kosmologii)**	Course code: **SPR16AIJ3445_92S**
Name of field of study: **fizyka**	
Mode and cycle of study: **first-degree, full - time**	Profile of study: **general academic** / Specialty:
Course / module status: **elective**	Language of instruction: **semester: 6 - polish language**

Year	Semester	Form of instruction	No. of hours	w tym e-learning	Type of credit	ECTS
3	6	konwersatorium	40	0	pg	5
Total			**40**			**5**

Course / module coordinator	**dr hab. VINCENZO SALZANO**
Course instructor	**dr hab. VINCENZO SALZANO**
Course / module objectives	**The aim of the course is to familiarize students with the main observational tests that are currently used in cosmology. Students can have a general knowledge about the status of observational cosmology, be able to discuss about them, and can decide if to continue these studies in the master programme.**
Prerequisites	**Completed courses in "Astronomy" and "General Theory of Relativity" (optional), "Elements of Cosmology" (optional), "Theory of Gravity" (optional)**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	1	EP1	knows the phenomena and the basic quantities which can be measured in cosmology and can be used to understand the evolution of the Universe	K_W02 K_W05 K_W06 K_W07
skills	1	EP2	understands the connection between local astronomical and astrophysical quantities with the evolution of the Universe on cosmological scales	K_U03 K_U15 K_U16
	2	EP3	discusses and works in a team and is open on the arguments of others	K_U17 K_U21
social competences		EP4	The student knows the limits of his own knowledge and understands the need for further education	K_K01 K_K02
	2	EP5	The student can formulate precise questions to deepen his/her own understanding of a topic or to find missing pieces of reasoning	K_K05

CONTENT	Semester	No. of hours	w tym e-learning
Subject title: **współczesne testy obserwacyjne kosmologii**			
Format of instruction: **konwersatorium**			
1. **Introduction to observational cosmology**	6	3	0
2. **Cosmological distances**	6	2	0
3. **Sandage-Loeb test (redshift drift)**	6	1	0
4. **Cosmic Chronometers**	6	2	0

5. **Cosmological ladder: parallax; surface brightness method; Tully-Fisher relation; fundamental plane of elliptical galaxies**	6	2	0
6. **Cosmological ladder: Cepheids**	6	2	0
7. **Cosmological ladder: megamasers**	6	1	0
8. **Cosmological ladder: Type Ia Supernovae (SNeIa)**	6	3	0
9. **Local measurement of the Hubble constant**	6	2	0
10. **Cosmological ladder: gamma ray bursts**	6	2	0
11. **Cosmological ladder: quasars**	6	2	0
12. **Cosmic Microwave Background (CMB)**	6	5	0
13. **Baryon Acoustic Oscillation (BAO)**	6	4	0
14. **Gravitational lensing; strong lensing; weak lensing; cosmological weak lensing**	6	5	0
15. **Black hole and gravitational waves**	6	4	0

Modes of delivery	**Lectures made using computer presentation and discussion of scientific papers**	
Assessment methods		No. of learning outcome from the syllabus
	PROJEKT	**EP1,EP2,EP3,EP4,EP5**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	
Grading criteria	**Seminar: passing the project**	
	Grade calculation principles	
	Evaluation of the project presentation	

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	6	współczesne testy obserwacyjne kosmologii		Ważona	
	6	współczesne testy obserwacyjne kosmologii [konwersatorium]	zaliczenie z oceną		1,00

Basic reading	A. Liddle (2015): An Introduction to Modern Cosmology
	O. F. Piattella (2018): Lecture Notes in Cosmology
	S. Serjeant (2010): Observational Cosmology
	zródła internetowe, artykuły naukowe
Supplementary reading	R. Durrer (2008): The Cosmic Microwave Background
	Y. Wang (2010): Dark Energy

STUDENT WORKLOAD

	No. of hours	
		W tym e-learning
Contact hours	**40**	**0**
Participation in test / exam	**3**	**0**
Preparation for contact hours	**10**	**0**
Private reading and studying	**25**	**0**
Participation in tutorials	**20**	**0**

Preparation of project / essay / etc.	**25**	**0**
Preparation for test / exam	**2**	**0**
TOTAL workload	**125**	
ECTS credits	**5**	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-II-S-24/25Z-K**	
Course title: **Numerical and Statistical Methods in Cosmology (numeryczne i statystyczne metody kosmologii) (SPECJALNOŚCI / SPECJALIZACJE / MODUŁY SPECJALNOŚCIOWE)**	Course code: **SPR16AIIJ3445_31S**
Name of field of study: **fizyka**	
Mode and cycle of study: **second degree, full - time**	Profile of study: **general academic** / Specialty: **cosmology**
Course / module status: **obligatory**	Language of instruction: **semester: 2 - english language**

Year	Semester	Form of instruction	No. of hours	including e-learning	Type of credit	ECTS
1	2	laboratory	30	0	pg	4
Total			**30**			**4**

Course / module coordinator	**dr hab. VINCENZO SALZANO**
Course instructor	**dr hab. VINCENZO SALZANO**
Course / module objectives	**The aim of the course is to familiarize students with some of the methods of physics used to obtain (through reconstructions or statistics) information from experimental data. Students are able to analyze physical problems using general numerical methods written by themselves and are able to interpret the results.**
Prerequisites	**Completed courses "Analysis of measurement data" and "Numerical methods"**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	1	EP1	**Defines, describes and characterizes advanced numerical methods**	**K_W05 K_W06 K_W07**
skills	1	EP2	**The student can infer physical information from experimental data using various numerical methods**	**K_U01 K_U03**
	2	EP3	**The student can implement codes for numerical calculations**	**K_U02 K_U06**
	3	EP4	**The student is able to compare the obtained results and assess the level of their credibility**	**K_U04 K_U10**
social competences	1	EP5	**The student knows the limits of his own knowledge and understands the need for further education**	**K_K01 K_K02**
	2	EP6	**The student can formulate precise questions to deepen his or her understanding of a topic or finding missing pieces of reasoning**	**K_K06 K_K07**

CONTENT	Semester	No. of hours	including e-learning
Subject title: **Numerical and Statistical Methods in Cosmology (numeryczne i statystyczne metody kosmologii)**			
Format of instruction: **laboratory**			
1. **Interpolation and extrapolation methods: fundamental algorithms; cubic spline function; LOESS/SIMEX algorythm**	2	5	0
2. **Gaussian processes (reconstruction methods)**	2	3	0
3. **Principal Component Analysis (PCA)**	2	3	0
4. **Bayesian Statistics: Monte Carlo Markov Chains (MCMC)**	2	6	0
5. **Nested sampling**	2	5	0
6. **Fast Fourier Transform**	2	8	0

Modes of delivery	**Lecture on the blackboard and with the use of a computer. Exercises conducted with the use of computers.**	
	The course teacher shall specify how artificial intelligence should be used as part of implementation of the course according to University of Szczecin best practices and standards. The course teacher shall inform students in their first class about the scope and possibilities of using AI and shall present a catalogue of tools and applications adjusted to relevant learning outcomes and teaching needs and possibilities within a given course.	
Assessment methods		No. of learning outcome from the syllabus
	PREZENTACJA	**EP1,EP2,EP3,EP4,EP5,EP6**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	
Grading criteria	**Verification by observation. Exercises: completion of the project. (Mark from project 100%)**	
	Grade calculation principles	
	The grade for the course is the grade for the laboratory.	

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	2	Numerical and Statistical Methods in Cosmology (numeryczne i statystyczne metody kosmologii)		Ważona	
	2	Numerical and Statistical Methods in Cosmology (numeryczne i statystyczne metody kosmologii) [laboratorium]	zaliczenie z oceną		1,00

Basic reading	M. Hjorth-Jensen (2014): Computational Physics (Lecture Notes Fall 2014)
	W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery (1997): Numerical Recipes in C
	zródła internetowe, artykuły naukowe
Supplementary reading	

STUDENT WORKLOAD

	No. of hours	
		including e-learning
Contact hours	**30**	**0**
Participation in test / exam	**5**	**0**
Preparation for contact hours	**15**	**0**
Private reading and studying	**15**	**0**
Participation in tutorials	**15**	**0**
Preparation of project / essay / etc.	**10**	**0**
Preparation for test / exam	**10**	**0**
TOTAL workload	**100**	
ECTS credits	**4**	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: **USSPR-F-O-I-S-22/23Z**						
Unit: **Fizyka teoretyczna [moduł]**						
Course title: **Statistical Physics (fizyka statystyczna))**					Course code: **SPR16AIJ3445_41S**	
Name of field of study: **fizyka**						
Mode and cycle of study: **first-degree, full - time**		Profile of study: **general academic**			Specialty:	
Course / module status **elective**			Language of instruction: **semester: 4 - polish language**			

Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS
				w tym e-learning		
2	4	konwersatorium	15	0	pg	2
Total			**15**			**2**

Course / module coordinator	**dr hab. FRANCO FERRARI**
Course instructor	**dr hab. FRANCO FERRARI**
Course / module objectives	**The purpose of this course is to deepen the student's knowledge in the subject of statistical physics and its applications. The student should be able to use mathematical tools and the methods of statistical physics in order to describe physical phenomena and processes of systems containing a large number of particles, atoms or molecules. The students understands the necessity of further education and is ready to a critical evaluation of the received information.**
Prerequisites	**knowledge of thermodynamics, quantum mechanics and theoretical mechanics. The student should have passed a course on the principles of thermodynamics and statistical physics**

LEARNING OUTCOMES

Category	No.	Code	Description	Ref. to programme benchmarks
knowledge	**1**	**EP1**	**student pogłębia wiedzę w zakresie fizyki statystycznej, zna podstawowe pojęcia i prawa termodynamiki, potrafi opisać zjawiska i procesy na gruncie termodynamiki i fizyki statystycznej, potrafi rozwiązać analitycznie zagadnienia dla prostych układów kwantowych posługiwając się metodami fizyki statystycznej, posiada szczegółową wiedzę fizyczną w zakresie fizyki statystycznej**	**K_W11 K_W14 K_W20**
skills	**1**	**EP2**	**Student potrafi posługiwać się aparatem matematycznym i metodami matematycznymi w opisie i modelowaniu zjawisk i procesów fizycznych, potrafi przygotować ustne wystąpienia w języku polskim i czytać ze zrozumienie teksty naukowe.**	**K_U05 K_U19 K_U20**
social competences	**1**	**EP3**	**Student rozumie potrzebę dalszego kształcenia się i jest gotów do krytycznej oceny docierających do niego informacji; student jest gotów pogłębiać własne zrozumienie danego tematu i odnaleźć brakujące elementy własnego rozumowania**	**K_K01 K_K02**

CONTENT	Semester	No. of hours	w tym e-learning
Subject title: **fizyka statystyczna**			
Format of instruction: **konwersatorium**			
1. Classical statistical mechanics with applications to polymer physics	4	4	0
2. Bose-Einstein and Fermi-Dirac distributions	4	6	0

3. procesy stochastyczne	4	3	0
4. prezentacja	4	2	0

Modes of delivery	**theoretical classes consisting of a brief (about 30 minutes) introduction to a given subject followed by an hour of exercises on that subject..** **numerical exercises consisting of a brief (about 30 minutes) introduction to a given subject followed by two hours to solve numerical problems that are relevant to that subject.** **Presentation: Students will prepare as a homework a presentation on a subject of statistical physics that they find particularly interesting and will present it during the lectures.**

Assessment methods		No. of learning outcome from the syllabus
	KOLOKWIUM	**EP1,EP2**
	PREZENTACJA	**EP1,EP3**
	ZAJĘCIA PRAKTYCZNE (WERYFIKACJA POPRZEZ OBSERWACJĘ)	**EP3**
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.	

Grading criteria	**ćwiczenia: zaliczenie kolokwium** **prezentacja: jakość odpowiedzi na pytania, które odbędą się po przedstawieniu prezentacji**
	Grade calculation principles
	OC=OK*80 + OP*20 **gdzie** **OC=ocena koncowa** **OK=ocena z kolokwium** **OP= ocena z prezentacji**

Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	4	fizyka statystyczna		Nieobliczana	
	4	fizyka statystyczna [konwersatorium]	zaliczenie z oceną		

Basic reading	Franco Ferrari : slajdy i notatki wstępów umieszczone na stronie internetowej przedmiotu
	Kerson Huang (2006): Podstawy Fizyki Statystycznej, Wydawnictwo Naukowe PWN, Warszawa
Supplementary reading	

STUDENT WORKLOAD

	No. of hours	W tym e-learning
Contact hours	**15**	**0**
Participation in test / exam	**2**	**0**
Preparation for contact hours	**4**	**0**
Private reading and studying	**6**	**0**
Participation in tutorials	**8**	**0**
Preparation of project / essay / etc.	**6**	**0**
Preparation for test / exam	**9**	**0**
TOTAL workload	**50**	
ECTS credits	**2**	