COURSE OFFERED

Name of the course	Polish	**Wprowadzenie do standardowego modelu fizyki cząstek elementarnych**
	English	**Introduction to the Standard Model of Particle Physics**

1 LOCATION OF THE COURSE WITHIN THE EDUCATION SYSTEM

1.1. Section [1]	Section of Exact and Natural Sciences
1.2. Discipline[2]	Physical Sciences
1.3. Type of education	Full-time
1.4. Level of education	Doctoral School (PQF Level 8)
1.5. Person preparing the course description	prof. dr hab. Francesco Giacosa
1.6. Contact	fgiacosa@ujk.edu.pl

2 GENERAL CHARACTERISTICS OF THE COURSE

2.1. Type of course [3]	Specialised subject in the discipline (elective)
2.2. Language of the course	English

3 DETAILED CHARACTERISTICS OF THE COURSE

3.1. Type of classes[4]		Lecture (L)
3.2. Number of hours[5]		15 hours of lectures
3.3. Location of classes		Classroom at Jan Kochanowski University in Kielce
3.4. Type of assessment		Graded pass based on an oral assessment with problem-solving tasks
3.5. Didactic methods		Problem-based lectures, derivations and worked examples; guided discussion and independent reading
3.6. Literature	basic	1. M. Thomson, Modern Particle Physics, Cambridge University Press, 2013. 2. B. Povh, K. Rith, C. Scholz, F. Zetsche and W. Rodejohann, Particles and Nuclei: An Introduction to the Physical Concepts, 7th edition, Springer, 2015.
	supplementary	Particle Data Group, Review of Particle Physics, 2026. Selected reviews and particle listings; pdg.lbl.gov/2026.

1 Sections: Humanities; Social Sciences; Exact and Natural Sciences; Medical and Health Sciences; Arts.

2 Discipline as specified in the curriculum of the Doctoral School.

3 General subjects; general subjects in the discipline; specialised subjects in the discipline.

4 Classes, lecture or seminar.

5 Consistent with the curriculum of the Doctoral School of Jan Kochanowski University in Kielce.

4 OBJECTIVES SYLLABUS CONTENT AND INTENDED LEARNING OUTCOMES

4.1. Course objectives (lecture)

C01 Explain the particle content and theoretical structure of the Standard Model.
C02 Apply QED, QCD, the quark model and chiral meson theories to elementary physical processes.
C03 Solve selected problems, assess assumptions and use scientific literature in English.

4.2. Syllabus content (15 hours in total)

1. Standard Model overview: fermions and bosons, spin and statistics, quark and lepton generations, gauge symmetries and interactions. (1 h)
2. QED review: the Lagrangian, gauge invariance, Feynman diagrams and elementary electromagnetic processes. (1 h)
3. Renormalisation in QED: running coupling, renormalisability and scale dependence. Infrared divergences, real and virtual corrections, and inclusive observables. (2 h)
4. QCD: the Lagrangian, colour and non-Abelian gauge symmetry, quark-gluon and gluon self-interactions, running coupling, asymptotic freedom and confinement. (2 h)
5. Quark model and hadron classification: mesons and baryons, flavour multiplets, spin, parity and, where applicable, charge conjugation; construction of hadronic quantum numbers. (2 h)
6. Effective theories of mesons: approximate chiral symmetry, spontaneous and explicit symmetry breaking, Goldstone bosons and the linear sigma model as an example. (2 h)
7. Glueballs: gluonic bound states, quantum numbers, mixing with quark-antiquark mesons and identification. (1 h)
8. Weak interactions: W and Z bosons, charged and neutral currents, the chiral structure of the weak sector and quark mixing. (1 h)
9. Higgs sector: electroweak symmetry breaking, the origin of gauge-boson and fermion masses, Higgs couplings and selected production and decay channels. (2 h)
10. Neutrinos: masses, flavour and mass eigenstates, PMNS mixing and oscillations; implications for the minimal Standard Model. (1 h)

4.3 SUBJECT LEARNING OUTCOMES

Learning outcome	A doctoral student who has passed the course	Reference to Doctoral School learning outcomes
In the area of KNOWLEDGE		
W01	Explains the foundations and selected developments of the Standard Model, including QED, QCD, hadron structure, weak interactions, the Higgs sector and neutrino mixing.	SD_W01 SD_W02
W02	Identifies limitations and open problems of the minimal Standard Model, including neutrino masses, confinement and glueball identification.	SD_W07
In the area of SKILLS		
U01	Formulates particle-physics problems and combines quantum mechanics, field theory and symmetry arguments to analyse particle properties and processes and critically assess assumptions and results.	SD_U01 SD_U03
U02	Uses scientific literature and discusses particle-physics concepts and reasoning in English.	SD_U07
In the area of SOCIAL COMPETENCE		
K01	Shows initiative in planning independent work, selecting methods and sources, and proposing approaches to particle-physics problems.	SD_K04

4.4 METHODS OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

SUBJECT LEARNING OUTCOMES	METHOD OF ASSESSMENT (+ / -)																				
	Oral / written exam			Test (oral assessment)			Project			Activity in class			Own work			Group work			Other		
	Type of classes			Type of classes			Type of classes			Type of classes			Type of classes			Type of classes			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	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
W02	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
U01	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
U02	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
K01	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-

L = lecture; C = classes; S = seminar. + = method used; - = method not used.

The oral assessment covers conceptual questions and short problem-solving tasks, including Feynman diagrams, particle quantum numbers, symmetry arguments and interpretation of elementary processes. English communication is assessed throughout. Class discussion and independently prepared tasks verify the recognition of the value of knowledge and initiative in selecting methods and sources.

4.5 CRITERIA OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

Form of classes	Grade	Criterion of assessment
Lecture (L)	3.0	51-60% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.
	3.5	61-70% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.
	4.0	71-80% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.
	4.5	81-90% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.
	5.0	91-100% of the maximum points in the final oral assessment, including conceptual questions and problem-solving tasks.

Grade 2.0 (fail): fewer than 51% of the maximum points.

Accepted for implementation

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(date and signature of the lecturer)