COURSE SHEET

1. Information on the study programme

1.1. Higher education institution	West University of Timisoara
1.2. Faculty	Physics
1.3. Department	Physics
1.4. Study cycle	Master
1.5. Study programme / Qualification	Astrophysics, elementary particles and computational physics / according to COR: Physicist (211101); Research assistant in physics (248102); Teacher (232201); Education reviewer (235204)

2. Information on the course

2.1. Course title			Symmetries in Physics **PTAM 1105**				
2.2. Lecture instructor			Nistor Nicolaevici				
2.3. Seminar / laboratory instructor			Nistor Nicolaevici				
2.4. Study year	I	2.5. Semester	I	2.6.Examination type	End paper	2.7. Course type	DS, DOP

3. Estimated study time (number of hours per semester)

3.1. Attendance hours per week	4	out of which: 2 lecture	2 seminar	
3.2. Attendance hours per semester	56	out of which: 28 lecture	28 seminar	
3.3 Distribution of the allocated amount of time				**hours**
Study of literature, course handbook and personal notes				60
Supplementary documentation at library or using electronic repositories				15
Preparing for laboratories, homework, reports etc.				15
Exams				6
Tutoring				4

3.4. Total number of hours per semester	100
3.5. Number of credits (ECTS)	7

4. Prerequisites

curriculum	Analytical mechanics; Electrodynamics; Quantum mechanics; Elementary algebra;

5. Course objectives

- to provide the basic notions of group theory with applications in physics
- to enable the student to solve various problems in classical mechanics, relativity, quantum mechanics and particle physics using group theoretical methods
- to offer a unified view on physical theories based on symmetry principles

6. Content

6.1. Lectures	**Teaching methods**	**References**
1. Basic notions of abstract group theory	lectures classroom discussions	[1] Chap.2 [2] Chaps. 1, 2
2. Group representations		[1, 2] Chap. 3 [3] Chap. II
3. Representations of the symmetric group; Young diagrams		[1] Chap. 5 [6] Chaps. 1.21-24
4. Lie groups		[4] Chap. 2 [7] Chap. 5
5. The rotation group and the group SU(2)		[1] Chaps. 7, 8 [2] Chaps. 6, 8 [3] Chap. IV
6. The translation and the rotation group in quantum mechanics		[1] Chap. 9
7. The Lorentz and Poincare groups		[1, 2] Chap. 10.1-3 [3] Chap. VII.2
8. Unitary representations of the Poincare group		[1, 2] Chap. 10.4
9. Discrete symmetries; Representations of the full Poincare group		[1] Chap. 11
10. Symmetries and conserved quantities		[3] Chap. III.3 [5] Chap. 4
11. The group SU(3); Young diagrams; Roots and weight vectors		[2] Chap. 8 [6] Chap. 7
12. Quarks and the eight-fold way		[3] Chap. V.2 [6] Chap.11
13. Gauge theories of elementary particles		[2] Chap.11 [7] Chaps. 3, 4
14. Instantons and monopols		[7] Chap. 5

6.**2. Seminars**	**Teaching methods**	**References**
1. Representations of simple finite groups	blackboard calculations term papers	[1,2,3] - problem sets
2. Decompositions of representations		
3. Splitting of energy levels and selection rules		
4. Tensorial operators; Wigner-Eckart theorem and applications		
5. Representations of SU(2)		
6. The hidden SO(4) symmetry of the hydrogen atom		
7. Thomas precession and the spin-orbit coupling		
9. Representations of the Lorentz group and fundamental fields		
9. Conserved operators in relativistic field theories		
10. Decomposition of representations of the gropup SU(3)		
11. Mass fomulas and relations between scattering amplitudes		
12. Gauge models		[7] Chaps. 3, 4
13. Aharonov-Bohm effect; The Dirac monopole		[7] Chap. 5
14. SU(2) instantons and monopole solutions		[7] Chaps. 5, 8

7. Recommended literature

[1] Wu-Ki Tung, *Group theory in physics* (World Scientific, 1985)

[2] H. Jones, *Groups, representations and physics* (Adam Hilger, 1990)

[3] A. Zee, *Group theory in a nutshell for physicists* (Princeton University Press, 2016)

[4] R. Gilmore, *Lie group, physics and gemetry* (Cambridge, 2008)

[5] J. Schwichtenberg, *Physics from symmetry* (Springer, 2015)

[6] H. Georgi, *Lie algebras in particle physics* (Westview Pres, 1999)

[7] K. Huang, *Quarks, leptons and gauge fields* (World Scientific, 1992)

8. Evaluation

Activity	Weight in the final mark
Lectures (regular attendance)	20%
Homework	30%
End paper	50%
Minimum mark for passing	6

Date of completion
29.09.2022

Head of Discipline:
Nistor Nicolaevici

Head of Department:
Associate Professor Catalin Marin