DO.203.2.HEP Computational frameworks for particle physics theoretical models

1. Study program

1.1. University	University of Bucharest
1.2. Faculty	Faculty of Physics
1.3. Department	Department of Theoretical Physics, Mathematics, Optics, Plasma and Lasers (Bucharest), Department of Physics (Iasi)
1.4. Field of study	Physics
1.5. Course of study	Master of Science
1.6. Study program	High Energy Physics (in English)
1.7. Study mode	Full-time study

2. Course unit

2.1. Course unit title	Computational frameworks for particle physics theoretical models							
2.2. Teacher				Lect. dr. Mihai Marciu				
2.3. Tutorials/Practicals instructor(s)				Lect.dr. Mihai Marciu				
2.4. Year of study	II	2.5. Semester	2	2.6. Type of evaluation	E	2.7. Type of course unit	Content[1)]	**DS**
							Type[2)]	**DO**

[1)] fundamental (DF), specialized (DS); complementary (DC)
[2)] compulsory (DI), elective (DO), noncompulsory disciplines (DFC)

3. Total estimated time (hours/semester)

3.1. Hours per week in curriculum	**4**	distribution: Lecture	**2**	Practicals/Tutorials	**2**
3.2. Total hours per semester	**56**	Lecture	**28**	Practicals/Tutorials	**28**

Distribution of estimated time for study	**hours**
3.2.1. Learning by using one's own course notes, manuals, lecture notes, bibliography	**20**
3.2.2. Research in library, study of electronic resources, field research	**40**
3.2.3. Preparation for practicals/tutorials/projects/reports/homeworks	**32**
3.2.4. Preparation for exam	**4**
3.2.5. Other activities	**0**

3.3. Total hours of individual study	**96**
3.4. Total hours per semester	**150**
3.5. ECTS	**6**

4. Prerequisites (if necessary)

4.1. curriculum	Algebra, Analysis, Quantum mechanics
4.2. competences	Knowledge about: mechanics, solving differential equations

5. Conditions/Infrastructure (if necessary)

5.1. for lecture	Video projector
5.2. for practicals/tutorials	

6. Specific competences acquired

Professional competences	- understanding the dynamics of nuclear systems and elementary particles with realistic numerical methods; - developing abilities to apply appropriate numerical methods for modelling physical systems - ability to analyze and interpret relevant numerical results and to formulate rigorous conclusions
Transversal competences	• Efficient use of sources of information and communication resources and training assistance in a foreign language • Efficient and responsible implementation of professional tasks, with observance of the laws, ethics and deontology.

7. Course objectives

7.1. General objective	Describing and understanding of the structure of the nuclear and subnuclear systems based on numerical investigations;
7.2. Specific objectives	Development of the skill to apply mathematical models for modelling various physical processes Acquire the appropriate understanding of the connections between computational methods and physics

8. Contents

8.1. Lecture [chapters]	Teaching techniques	Observations/ hours
Computational methods in nuclear structure: algorithms for nuclear models, numerical solutions for the study of nuclear matter properties in Hartree-Fock theory with pairing interaction, numerical approaches in RPA theory for collective nuclear response,	Systematic exposition - lecture. Examples	8 hours
Computational methods for nuclear reactions description.	Systematic exposition - lecture. Examples	6 hours
Numerical methods for matter structure investigation. Deep inelastic scattering. Hadron-hadron scattering.	Systematic exposition - lecture. Examples	6 hours
Software packages for Feynman Diagrams	Systematic exposition - lecture. Examples	8 hours
Bibliography: 1. K. Langanke, J.A. Maruhn, S.E. Koonin, Computational Nuclear Physics, vol 1 and 2, Springer – Verlag, 1991 2. R. K. Ellis, W. J. Stirling, and B. R. Webber, QCD and collider physics, Cambridge University Press, 2003		
8.2. Tutorials/ Practicals [main themes]	Teaching and learning techniques	Observations/hours
Numerical applications to collective geometric	Problem solving	6 hours

model study and to interacting boson approximation study.		
Numerical simulations for relativistic kinematics and cross-sections for elementary particles collisions.	Problem solving	6 hours
Electron-proton collisions associated to HERA-DESY experiments.	Problem solving	4 hours
Proton-proton collisions associated to LHC-CERN experiments.	Problem solving	4 hours
Applications of software packages for Feynman Diagrams	Systematic exposition - lecture. Examples	8 hours

Bibliography:

1. T. Sjostrand, S. Mrenna, and P. Z. Skands, Comput. Phys. Commun. 178, 852 (2008), arXiv:0710.3820
2. PYTHIA http://home.thep.lu.se/~torbjorn/Pythia.html
3. ROOT http://root.cern.ch
4. FeynRules 2.0 https://library.oapen.org/bitstream/handle/20.500.12657/59108/1/9780191065453_WEB%20%28updated%29.pdf

9. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program)

This course unit develops some theoretical competences, which are fundamental for a Master student in the field of modern physics, corresponding to national and international standards. The contents is in line with the requirement of the main employers of research institutes and universities.

10. Assessment

Activity type	10.1. Assessment criteria	10.2. Assessment methods	10.3. Weight in final mark
10.4. Lecture	- Clarity and coherence of exposition - Correct use of the methods/ physical models - The ability to give specific examples	Written test and oral examination	40%
10.5.1. Tutorials	- Ability to use specific problem solving methods	Homeworks/ Presentations	60%
10.6. Minimal requirements for passing the exam			
Requirements for mark 5 (10 points scale) At least 50% of exam score and of homeworks.			

Date	Teacher's name and signature	Practicals/Tutorials instructor(s) name(s) and signature(s)
10.06.2024	Lect. dr. Mihai Marciu	Lecturer dr. Mihai Marciu
Date of approval		Head of Department Lecturer dr. Roxana Zus