DO.109.1.HEP Computational approaches in high-energy physics

1. Study program

1.1. University	„Alexandru Ioan Cuza" University of Iasi, 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 approaches in high-energy physics							
2.2. Teacher				Catalin Agheorghiesei, Petronel Postolache, Octavian Rusu				
2.3. Tutorials/Practicals instructor(s)				Catalin Agheorghiesei, Petronel Postolache, Octavian Rusu				
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)]	**DF ac**

[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, Standard Model
4.2. competences	Knowledge about: mechanics, solving differential equations, Standard Model

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
Short review of UNIX, C++, ROOT, Combining languages, Cross section and branching ratio calculations, Event generators, Detector simulations, Reconstruction, Fast simulation, Grid computing, Machine Learning	Systematic exposition - lecture. Examples	28 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 for each topic of the lecture: Short review of UNIX, C++, ROOT, Combining languages, Cross section and branching ratio calculations, Event generators, Detector simulations, Reconstruction, Fast simulation, Grid computing, Machine Learning.	Problem solving	28 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

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/ Lab reports	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)
10.10.2024	Catalin Agheorghiesei, Petronel Postolache, Octavian Rusu	Catalin Agheorghiesei, Petronel Postolache, Octavian Rusu
Date of approval		Head of Department