SYLLABUS

1. Information about the study programme

1.1 Institution of higher education	West University of Timisoara
1.2 Faculty	Physics and Mathematics
1.3 Department of	Physics
1.4 Field of study	Physics
1.5 Study cycle	Master
1.6 Study programme	**Advanced research methods in physics**

2. Information about the subject/discipline

2.1 Name	**Advanced methods in computational physics ARMP2304**						
2.2 Course coordinator	Lect. dr. Alexandra Popescu						
2.3 Seminar coordinator	Lect. dr. Alexandra Popescu						
2.4 Year of study	II	**2.5 Semester**	1	**2.6 Type of assessment**	E[1]	**2.7 Type of discipline**	DS DOP

3. Total estimated time (hours of teaching per semester)[2]

3.1 Number of hours per week	**3**	**3.2 course**	**2**	**3.3 seminar/laboratory**	**1**
3.4 Total hours in the curriculum	**42**	**3.5 course**	**28**	**3.6 seminar/laboratory**	**14**
Distribution of time:					**hours**
Study based on Instructions, course materials, bibliography and notes					**60**
Additional documentation library, specialized electronic platforms / field					**45**
Training seminars / laboratories, homework, essays, portfolios and essays					**18**
Tutoring					
Examinations[3]					**10**
Other activities					

3.7 Total hours of individual study	**123**
3.8 Total hours per semester[4]	**175**
3.9 Number of credits	**7**

[1] According to article 37, paragraph (1) of the Higher Education Law no. 199/2023, with subsequent amendments and additions, "the academic success of a student during a study program is determined by verifying the acquisition of the expected learning outcomes through exam-type evaluations and evaluation throughout the semester".

[2] The total number of contact hours and individual study hours will be aligned with the number of credits allocated to the course. One credit corresponds to a total between 25 and 30 hours of teaching activities and individual study. At the level of academic departments may establish, by discipline categories, the exact equivalence between one credit and the number of hours.

[3] The hours corresponding to examinations are added only to the point 3.8 – The total hours per semester, not to be added to the point 3.7 – Total hours of individual study.

[4] Total hours per semester = total hours in the curriculum + total hours of individual study + hours allocated to examinations.

4. Prerequisites (where applicable)

4.1 of curriculum	• Algorithms and programming • Introduction in programming • Computational physics (undergraduate level)
4.2 of skills	• General skills: the ability to gain general basic knowledge; proper usage of computer science terminology; basic programming skills

5. Conditions (where applicable)

5.1 for the course	Laptop/workstation with a working compiler for C, C++, Fortran etc.
5.2 for the seminar	

6. Discipline objectives - expected learning outcomes which contribute to the completion and passing the discipline

Knowledge	After successful completion of this course students can represent problems of various areas of application simplified, by means of mathematical models, describe and simulate numerically
Skills	The ability to use modelling software to solve numerical problems in the field of physics
Responsibility and autonomy	• Development of a multi- and interdisciplinary way of thinking • Efficient usage of information sources and communication resources both in Romanian and in a foreign language (English)

7. Contents

The platform through which the course materials in electronic format and other learning/bibliographic resources can be accessed: Google Classroom

7.1 Course	Teaching methods	Comments
1. Monte Carlo methods and statistical physics.	lecture, conversation, exemplification	Bibliographic resources [1]-[3]
2. Monte Carlo importance sampling. Simple sampling. Biased sampling (2h)		Bibliographic resources [1]-[3]
3. Monte Carlo Translational moves. Orientational moves.		Bibliographic resources [1]-[3]
4. MC methods and random numbers		Bibliographic resources [1]-[3]
5. Molecular dynamics. Basic steps in bulling a MD program. Forces computation and integration of motion equations		Bibliographic resources [1]-[3]
6. Molecular dynamics. Integration of the Newton's equation of motion. Verlet algorithm and predictor-corrector scheme. (2h)		Bibliographic resource [4]
7. MD. Integration of the Newton's equation of motion. Leapfrog scheme and Velocity-Stormer-Verlet method. (2h)		Bibliographic resource [5]

8. Computational fluid dynamics. Basic steps for numerical methods (mathematical model, numerical grid, discretization approaches)		Bibliographic resource [5]
9. Finite difference methods in fluid dynamics. Approximation of first and second derivative of PDEs. Boundary conditions		Bibliographic resource [5]
10. Finite Volume Methods in fluid dynamics. Approximations of surface and volume integrals		Bibliographic resource [5]
11. Fluid dynamics. Lattice Boltzmann method		Bibliographic resource [6]

Bibliography:

1. K. Binder, D.W. Heermann – Monte Carlo Simulation in Statistical Physics. An introduction. Springer, 2002
2. D. Frenkel, B. Smit – Understanding Molecular Simulation. From Algorithms to Applications, Academic Press, 2002
3. M. E. J Newman, G. T. Barkema – Monte Carlo Methods in Statistical Physics, Claredon Press, Oxford, 1998
4. M. Griebel, S. Knapek, G. Zumbusch – Numerical Simulation in Molecular Dynamics. Numerics, Algorithms, Parallelization, Applications, Springer 2007
5. J. H. Ferziger, M. Peric, R. L. Street – Computational Methods for Fluid Dynamics, Springer 2020
6. Krüger, T., Kusumaatmaja, H., Kuzmin, A., Shardt, O., Silva, G., Viggen, E.M., 2017. The lattice Boltzmann method. Springer International Publishing 10 (978-3).

7.2. Seminar	Teaching methods	Comments
1. Monte Carlo methods and statistical physics – Random walk; non-reversal random walk; Self-avoiding random walk	Conversation and individual work under the guidance of the lecturer	The students, using the lecture notes, will discuss with the lecturer about the algorithms of the numerical methods. Using a language program (C, C++, Fortran etc.) the students will write programs based on the algorithms.
2. Monte Carlo methods. Ising model		
3. Monte Carlo simulation of a Lennard Jones system		
4. Molecular Dynamics. Diffusion. Static and dynamic properties of the Lennard Jones fluid.		
5. Molecular Dynamics simplified simulation of the orbit of Halley's Comet.		
6. Computational fluid dynamics. 1D convection-diffusion equation with Dirichlet boundary conditions at both ends		
7. Computational fluid dynamics. Numerical diffusion		
Bibliography: lecture notes		

8. Corroboration of the course contents with the epistemic expectations of the community representative, professional associations and representative employers of the programme itself

The computation physics course comes as a complement for the theoretical and experimental physics courses offering a future physicist an increased ability to understand the physical phenomena and to offer a numerical solution for solving specific physics problems.

9. Use of tools based on generative artificial intelligence

To complete the laboratory tasks the students are allowed to use generative AII tools for checking the consistency of the programs written based on the discussed algorithms.
Each student will specify, in a statement written separately for each assignment, according to the model in Annex 3 of the Regulation on the use of generative artificial intelligence in the educational process at UVT, the tool they used, how it was used, and the part of the assignment in which it was used.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of the final mark
10.4 Course	The assimilation level of the gained knowledge	Individual project (based on topics discussed during lectures + tutorials).	100 %
10.5 Seminar	Capacity of solving specific problems and implementing an algorithm.		
10.6 Minimum performance standards			
Presenting an algorithm with its associated program.			

Date of submission:
16.09.2026

Titular of the course: Lect. Dr. Alexandra Popescu
Signature: [redacted]

Date of approval in department:

Seminary titular: Lect. Dr. Alexandra Popescu
Signature: [redacted]

HEAD OF THE DEPARTMENT:
Conf. Dr. Nicoleta Ștefu