FIŞA DISCIPLINEI

2022/2023

1. Date despre program

1.1 Instituţia de învăţământ superior	**“Alexandru Ioan Cuza” University of Iaşi**
1.2 Facultatea	**Physics**
1.3 Departamentul	**Physics**
1.4 Domeniul de studii	**Physics**
1.5 Ciclul de studii	**Master**
1.6 Programul de studii / Calificarea	**Physics for Advanced Technologies**

2. Date despre disciplină

2.1 Denumirea disciplinei			**Physics of nonlinear phenomena**				
2.2 Titularul activităţilor de curs			**Assoc. prof. Dan-Gheorghe DIMITRIU, Assoc. prof. Sebastian POPESCU**				
2.3 Titularul activităţilor de seminar			**Assoc. prof. Dan-Gheorghe DIMITRIU, Assoc. prof. Sebastian POPESCU**				
2.4 An de studiu	**2**	**2.5** Semestru	**1**	**2.6** Tip de evaluare	**E**	**2.7** Regimul disciplinei*	**OB**

** OB – Obligatoriu / OP – Opţional*

3. Timpul total estimat (ore pe semestru şi activităţi didactice)

3.1 Număr de ore pe săptămână	**4**	din care: **3.2** curs	**2**	**3.3** seminar/laborator	**2**
3.4 Total ore din planul de învăţământ	**56**	din care: **3.5** curs	**28**	**3.6** seminar/laborator	**28**

Distribuţia fondului de timp	ore
Studiu după manual, suport de curs, bibliografie şi altele	**35**
Documentare suplimentară în bibliotecă, pe platformele electronice de specialitate şi pe teren	**35**
Pregătire seminarii/laboratoare, teme, referate, portofolii şi eseuri	**40**
Tutoriat	**30**
Examinări	**4**
Alte activităţi	**0**

3.7 Total ore studiu individual	**144**
3.8 Total ore pe semestru	**200**
3.9 Număr de credite	**8**

4. Precondiţii (dacă este cazul)

4.1 De curriculum	Mechanics, Thermodynamics, Differential Equations, Electrodynamics, Electricity and Magnetism/Plasma Physics
4.2 De competenţe	All the competences formed and consolidated by the above classes

5. Condiţii (dacă este cazul)

5.1 De desfăşurare a cursului	Online within the maximum limit of the procentage approved by the Faculty’s Council (if necessary)

5.2 De desfăşurare a seminarului/ laboratorului	Online within the maximum limit of the procentage approved by the Faculty's Council (if necessary)

6. Competenţe specifice acumulate

Competenţe profesionale	**C1.** Identification of the main subjects related to the physics of chaotic phenomena **C2.** Critical analysis of the results obtained by using the known models/theories **C3.** Explaining and interpretation of the physical phenomena and the operationality of the key concepts based on the proper use of the laboratory devices
Competenţe transversale	**CT1.** Identification of the role and responsibilities as a member of a team and the application of communication techniques and efficient teamworking **CT2.** Analysis and communication of Physics information with didactical, scientific and popularization character; **CT3.** Opening to lifelong learning; **CT4.** Language skills at academic level, in English, needed for scientific documentation; **CT5.** Use of communication and information technologies; **CT6.** Understanding and applying the principles and the values of professional and research ethics.

7. Obiectivele disciplinei (din grila competenţelor specifice acumulate)

7.1 Obiectivul general	Identification of the main characteristics of the nonlinear physics phenomena
7.2 Obiectivele specifice	At the successful finalization of this course, the students will be able to: ▪ Analyze different physical phenomena leading to similar behaviors of different nonlinear systems; ▪ Understand the self-assembling mechanisms of self-organized structures which appear in different complex systems; ▪ Use the current methods of study of self-organized systems; ▪ Formulate hypotheses and models on the obtained experimental research results ▪ Critically analyse the obtained results by using the known models/theories ▪ Explain and interpret physical phenomena and operate with the key concepts based on the proper using of the experimental results

8. Conţinut

8.1	**Curs**	**Metode de predare**	**Observaţii** (ore şi referinţe bibliografice)
1.	Main characteristics of nonlinear systems	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	2 hours [1-4]
2.	Qualitative changes in the dynamics of nonlinear systems. Bifurcations.	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	4 hours [1,3,4]
3.	Routes to chaos: by intermittency, by quasi-periodicity, by cascade of period-doubling bifurcations (Feigenbaum scenario). Crises	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	2 hours, [1-3]

4.	Quantities for chaotic states characterization: Lyapunov exponents, Kolmogorov-Sinai entropy, box-counting dimension, informational dimension, correlation dimension, generalized correlation dimension, Hausdorff dimension, Lyapunov dimension	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	4 hours, [1-3]
5.	Chaos control (by feedback methods: Ott-Grebogi-Yorke method, Pyragas methods; through synchronization; inteligent control: by neuronal networks, by adaptive fuzzy logic method; experimental chaos control)	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	2 hours, [1-3]
6.	Nonlinear oscillations	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	3 hours, [1,3,4]
7.	Complex systems; Order, organization and self-organization in complex systems; Intermittent and cascade self-organization	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	2 hours [4,5]
8.	Reaction – Diffusion systems. Turing structures. Application: The Brusselator; Turing structures in plasma systems. The ball of fire (quasi-spherical electric double layer).	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	3 hours [4,5]
9.	Negative differential resistance. S-type negative differential resistance; N-type negative differential resistance; Equivalent electrical circuit of the ball of fire in plasma; Electrical double layer and physical basis of negative differential resistances in plasma	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	3 hours [5]
10.	Self-organization in fluids and magnetofluids	Presentation, demonstration, conversation, university lecture, synthesizing analysis, computer assisted education	3 hours [5]

Bibliografie

Referinţe principale:
[1] A. H. Nayfeh, B. Balachandran – Applied Nonlinear Dynamics – Analytical, Computational, and Experimental Methods, Wiley-VCH, Weinheim, 2004;
[2] H. G. Schuster, W. Just – Deterministic chaos. An Introduction, 4th ed., Wiley-VCH, Weinheim, 2005
[3] S. H. Strogatz – Nonlinear Dynamics and Chaos, 2nd ed., Westview Press, Boulder, 2015.
[4] G. Nicolis – Introduction to Nonlinear Science, Cambridge Univ. Press, Cambridge, 1995.
[5] S. Popescu – Probleme actuale ale fizicii sistemelor autoorganizate, Tehnopress, Iași, 2003.

Referinţe suplimentare:
[1] R. C. Hilborn – Chaos and Nonlinear Dynamics – An Introduction for Scientists and Engineers, 2nd ed., Oxford University Press, Oxford, 2001;
[2] E. Lorenz – The Essence of Chaos, University of Washington Press, Seattle, 1993;
[3] J. C. Sprott – Elegant Chaos – Algebraically Simple Chaotic Flows, World Scientific, Singapore, 2010;
[4] E. Schöll, H. G. Schuster (Eds.) – Handbook of Chaos Control, 2nd ed., Wiley-VCH, Weinheim, 2008.

8.2	Seminar / Laborator	Metode de predare	Observaţii (ore şi referinţe bibliografice)
1.	Bifurcations, Symmetry-breaking	Exercise solving, discussions	2 hours [1,4] online
2.	Experimental analysis of some scenarios of transition to chaos in plasma (by cascade of sub-harmonic bifurcations, by type I intermittency, Feigenbaum scenario)	Experiment, synthesizing analysis, computer assisted education	2 hours, [1-3] onsite
3.	Turbulence analysis in plasma and liquids. Rayleigh-Bénard convection	Experiment, synthesizing analysis, computer assisted education, numerical simulation	2 hours, [1-3] onsite
4.	Analysis of chaotic time series with specialized software	Synthesizing analysis, computer assisted education, numerical simulation	2 hours, [1-3] online
5.	Chua chaotic circuit. Control of chaos. Synchronization of chaotic circuits.	Experiment, synthesizing analysis, computer assisted education	2 hours, [1-3] onsite
6.	Control of chaos in plasma by using external circuit elements	Experiment, synthesizing analysis, computer assisted education	2 hours, [1-3] onsite
7.	Analysis of uncorrelated dynamics of some complex space charge structures in plasma. Flicker noise	Experiment, synthesizing analysis, computer assisted education	2 hours, [1-3] onsite
8.	Nonlinear oscillations	Exercise solving, discussions	2 hours, [1] online
9.	Modeling nonlinear systems	Exercise solving, discussions	2 hours, [1,4] online
10.	Reaction – diffusion systems	Exercise solving, discussions	4 hours online
11.	Negative differential resistance	Exercise solving, discussions	2 hours online
12.	Self-organization in fluids and magnetofluids	Exercise solving, discussions	4 hours online

Bibliografie

[1] A. H. Nayfeh, B. Balachandran – Applied Nonlinear Dynamics – Analytical, Computational, and Experimental Methods, Wiley-VCH, Weinheim, 2004;
[2] W.-H. Steeb – The Nonlinear Workbook, 4th ed., World Scientific, Singapore, 2008;
[3] H. J. Korsch, H.-J. Jodl, T. Hartmann – Chaos – A Program Collection for the PC, 3rd ed., Springer-Verlag, Berlin, 2008.
[4] H. Haken – Advanced Synergetics – instability hierarchies of self-organizing systems and devices, Springer Verlag (Berlin, Germany) 1983.

9. Coroborarea conţinutului disciplinei cu aşteptările reprezentanţilor comunităţii, asociaţiilor profesionale şi angajatorilor reprezentativi din domeniul aferent programului

The content of the course perfectly corroborate with the expectations of the community, profesional associations, and main employers representatives from the program's domain. The content of the syllabus ensures, besides the formation of the above professional competences, the consolidation of divergent thinking, the transfer of knowledge from one area to another, and some transversal competences requested by any company hiring physicists.

10. Evaluare

Tip activitate	10.1 Criterii de evaluare	10.2 Metode de evaluare	10.3 Pondere în nota finală (%)
10.4 Curs	Project and exam	Continuous, formative, summative	50%
10.5 Seminar/ Laborator	Active participation in the class activities	Continuous, formative, summative	20 % presence 30 % seminar
10.6 Standard minim de performanţă			
Independent analysis of a typical problem from Non-linear Science, using the characteristic methods and instruments specific to Complexity Science.			

Data completării	Titular de curs	Titular de seminar/laborator
23.09.2022	Assoc. Prof. Dan-Gheorghe DIMITRIU	Assoc. Prof. Dan-Gheorghe DIMITRIU
	Assoc. Prof. Sebastian POPESCU	Assoc. Prof. Sebastian POPESCU

Data avizării în departament	Director de departament
	Assoc. Prof. Iordana AȘTEFĂNOAEI

FIŞA DISCIPLINEI

2022/2023

1. Date despre program

1.1 Instituţia de învăţământ superior	**„Alexandru Ioan Cuza" University of Iaşi**
1.2 Facultatea	**Physics**
1.3 Departamentul	**Physics**
1.4 Domeniul de studii	**Physics**
1.5 Ciclul de studii	**Master**
1.6 Programul de studii / Calificarea	**Physics for Advanced Technologies**

2. Date despre disciplină

2.1 Denumirea disciplinei	**Transfer Phenomena**						
2.2 Titularul activităţilor de curs	**Prof. dr. Diana Mihaela MARDARE, Conf. dr. Claudiu COSTIN**						
2.3 Titularul activităţilor de seminar	**Prof. dr. Diana Mihaela MARDARE, Conf. dr. Claudiu COSTIN**						
2.4 An de studiu	**II**	**2.5** Semestru	**3**	**2.6** Tip de evaluare	**E**	**2.7** Regimul disciplinei*	**OB**

** OB – Obligatoriu / OP – Opţional*

3. Timpul total estimat (ore pe semestru şi activităţi didactice)

3.1 Număr de ore pe săptămână	**4**	din care: **3.2** curs	**2**	**3.3** seminar/laborator	**2**
3.4 Total ore din planul de învăţământ	**56**	din care: **3.5** curs	**28**	**3.6** seminar/laborator	**28**

Distribuţia fondului de timp	ore
Studiu după manual, suport de curs, bibliografie şi altele	**35**
Documentare suplimentară în bibliotecă, pe platformele electronice de specialitate şi pe teren	**35**
Pregătire seminarii/laboratoare, teme, referate, portofolii şi eseuri	**35**
Tutoriat	**12**
Examinări	**2**
Alte activităţi	

3.7 Total ore studiu individual	**119**
3.8 Total ore pe semestru	**175**
3.9 Număr de credite	**7**

4. Precondiţii (dacă este cazul)

4.1 De curriculum	Mechanics, Thermodynamics, Electricity and Magnetism, Plasma Physics, Condensed Matter Physics
4.2 De competenţe	Numerical programming, Origin software operation, proficiency in written and oral English

5. Condiţii (dacă este cazul)

5.1 De desfăşurare a cursului	
5.2 De desfăşurare a seminarului/ laboratorului	Performing all practical works is mandatory.

6. Competenţe specifice acumulate

Competenţe profesionale	**C1.** Mastery of research methods and techniques, specific to the specialization *Physics for Advanced Technologies* (1 credit). **C2.** Understanding and ability to apply the principles and the values of the professional and research ethics (1 credit). **C3.** Use the software for analyzing and processing experimental data and to perform virtual experiments (1 credit). **C4.** Use of communication and information technologies (1 credit).
Competenţe transversale	**CT1.** Identification and proper use of laws, principles, notions and physical methods in various circumstances (1 credit). **CT2.** Application of Physics knowledge to practical situations (1 credit). **CT3.** Opening to lifelong learning (1 credit).

7. Obiectivele disciplinei (din grila competenţelor specifice acumulate)

7.1 Obiectivul general	Developing theoretical and experimental competences on transport and transfer phenomena in solid bodies, fluids and plasmas.
7.2 Obiectivele specifice	On successful completion of this course, the students will be able to: ▪ Understand and explain the main transport and transfer phenomena in solid bodies, fluids and plasmas. ▪ Calculate the relaxation time for different scatttering mechanisms of the charge carriers in solid bodies. ▪ Correlate the deposition conditions with the photocatalytic properties of a thin film. ▪ Apply the concepts of transfer phenomena to real life situations (estimation of mass and energy losses in experimental, industrial and current usage devices). ▪ Solve medium complexity problems on transport and transfer phenomena.

8. Conţinut

8.1	**Course**	**Metode de predare**	**Observaţii** (ore şi referinţe bibliografice)
1.	Recapitulative essential notions.	Lecture, explanation, demonstration, debate	2h / [1-3]
2.	Boltzmann transport equation. Relaxation time.	Lecture, explanation, demonstration, debate	4h / [1-3]
3.	Scatttering mechanisms of the charge carriers in solid bodies.	Lecture, explanation, demonstration, debate	2h / [1-3]
4.	Processes at different interfaces.	Lecture, explanation, demonstration, debate	3h / [1-3]
5.	Electronic processes in photocatalysis.	Lecture, explanation, demonstration	3h / [4,5]
6.	The three moments of the Boltzmann equation: mass, momentum and energy transfer equations.	Lecture, explanation, demonstration	2h / [6,7]

7.	Momentum transfer. Viscosity and the mechanism of momentum transfer. Newton's law of viscosity. Molecular theory of the viscosity of gases.	Lecture, explanation, demonstration	2h / [8,9]
8.	Momentum transfer. Generalization of Newton's law of viscosity. Navier Stokes Equation. Reynolds number. Streamlines.	Lecture, explanation, demonstration, debate	2h / [8,9]
9.	Mass transport. Fick's law of diffusion. Equation of diffusion.	Lecture, explanation, demonstration	2h / [8-10]
10.	Plasma diffusion in a magnetic field. Transport coefficients in plasmas.	Lecture, demonstration, debate	2h / [8-10]
11.	Heat transfer. Coduction. Fourier's law. Thermal conductivity.	Lecture, explanation, demonstration	2h / [8-10]
12.	Heat transfer. Convection. Radiation.	Lecture, explanation, demonstration	2h / [8-10]

Principal References

[1] Diana Mardare, Transport Phenomena in Solid Bodies, Ed. "Gh. Asachi", Iaşi, 2002
[2] P. S. Kireev, Semiconductor Physics, Ed. Şt. Enc., Bucureşti, 1977
[3] M. Balkanski (Ed.), Handbook on Semiconductors, North-Holland, Amsterdam, 1994.
[4] Diana Mardare, Polycrystalline and Amorphous Thin Films. Titanium oxide, Ed. "Politehnium", Iaşi, 2005
[5] TiO_2 PHOTOCATALYSIS. FUNDAMENTALS AND APPLICATIONS. A. Fujishima,K. Hashimoto, T. Watanabe, BKC Inc. 4-5-11 Kudanminami, Chiyoda-ku, Tokyo 102-0074 Japan
[6] M. M. Becker, D. Loffhagen, 'Derivation of Moment Equations for the Theoretical Description of Electrons in Nonthermal Plasmas', Advances in Pure Mathematics 3 (2013) 343-352
[7] S. Höfner, The equations of fluid dynamics and their connection with the Boltzmann equation, Lecture notes, Department of Physics and Astronomy, Uppsala University, http://www.astro.uu.se/~hoefner/astro/teach/adp08_L3_notes.pdf
[8] R. B. Bird, W. E. Stewart, E. N. Lightfoot, Transport Phenomena, 2nd Edition, John Wiley & Sons, NY, 2002
[9] J. R. Welty, C. E. Wicks, R. E. Wilson, G. L. Rorrer, Fundamentals of Momentum, Heat, and Mass Transfer, 5th Edition, John Wiley & Sons, USA, 2008
[10] F. P. Incropera, D. P. DeWitt, T. L. Bergman, A. S. Lavine, Fundamentals of Heat and Mass Transfer, 6th Edition, John Wiley & Sons, USA, 2007

Supplementary References

[11] Scientific papers

8.2	Seminar / Laboratory	Teaching Methods	Comments (ore şi referinţe bibliografice)
1.	The growth of a polycrystalline solid from the solution	Experiment	2h / [1,3]
2.	Effective mass of charge carriers	Problems and exercises	2h / [3,4]
3.	Demonstration of different relations presented during the course.	Problems and exercises	4h / [3]
4.	Different expressions of the relaxation time.	Problems and exercises	2h / [1]
5.	Study of the photocatalytic /hydrophilic properties of a material	Driven experiment	4h / [1,2,5]
6.	Study of the ambipolar diffusion in a non-magnetized plasma.	Laboratory experiment, observation	2h / [6]
7.	Study of the diffusion in a magnetized plasma.	Laboratory experiment	2h / [6]
8.	Solving 1D mass transfer equation using numerical methods.	Solving problems by numerical methods	2h / [7,8]

9.	Solving 1D momentum transfer equation using numerical methods.	Solving problems by numerical methods	2h / [7,8]
10.	Solving 1D energy transfer equation using numerical methods.	Solving problems by numerical methods	2h / [7,8]
8.	Computing electron drift velocity in magnetized plasmas.	Solving problems by numerical methods	2h / [9]
9.	Computing electron difusion coefficient in magnetized plasmas.	Solving problems by numerical methods	2h / [9]

References

[1] Laboratory papers
[2] Scientific papers, ISI quoted
[3] Diana Mardare, Transport Phenomena in Solid Bodies, Ed. "Gh. Asachi", Iaşi, 2002
[4] L.L.Kazmerski (Ed.) *Polycrystalline and Amorphous Thin Films and Devices,* Academic Press, New York, 1980.
[5] TiO_2 PHOTOCATALYSIS. FUNDAMENTALS AND APPLICATIONS. A. Fujishima,K. Hashimoto, T. Watanabe, BKC Inc. 4-5-11 Kudanminami, Chiyoda-ku, Tokyo 102-0074 Japan
[6] G. Popa, D. Alexandroaei, Îndrumar de lucrări practice pentru fizica plasmei, Ed. Universităţii Alexandru Ioan Cuza, Iaşi, 1991
[7] T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, Introduction to Algorithms, 3rd ed., MIT Press, Cambridge, US, 2009
[8] G. H. Golub, C. F. Van Loan, Matrix Computations, 4th ed., The Johns Hopkins University Press, Baltimore, US, 2013
[9] C. Costin, T. M. Minea, G. Popa, 'Electron transport in magnetrons by a posteriori Monte Carlo simulations', Plasma Sources Science and Technology 23(1) (2014) 015012

9. Coroborarea conţinutului disciplinei cu aşteptările reprezentanţilor comunităţii, asociaţiilor profesionale şi angajatorilor reprezentativi din domeniul aferent programului

Studying this discipline the students acquire knowledge about transfer phenomena. This allows students to apply the concepts of transfer phenomena to real life problems: design and optimization of different devices that use thin films such as optoelectronic devices, gas sensing, solar cells, etc; estimation and prediction of mass and energy losses in experimental, industrial and current usage devices. The students will be thus prepared to be integrated in research or industrial activities.

10. Evaluare

Activity	**10.1 Assesment criteria**	**10.2 Assesment methods**	**10.3 Weight in the final mark (%)**
10.4 Course	- completeness and correctness of the acquired knowledge; - capacity of operating with the acquired knowledge; - capacity of analysis, personal interpretation, originality, creativity.	Summative assessment (final) - written exam.	60 %
10.5 Seminar/ Laboratory	- active participation to practical works; - the capacity of using in practice the acquired knowledge.	Formative assessment (during the semester) - work projects.	40 %
10.6 Standard of minimum performance			
Minimum mark to both course and laboratory: 5. Independent solving of a typical problem of medium complexity using the formalism of transfer phenomena. Attendance to laboratories and seminars (100%). Written report for every practical work.			

Data completării 26.09.2022	Titular de curs, Prof. dr. Diana Mihaela MARDARE Conf. dr. Claudiu COSTIN	Titular de seminar, Prof. dr. Diana Mihaela MARDARE Conf. dr. Claudiu COSTIN

Data avizării în departament	Director de departament, Conf. dr. Iordana AŞTEFĂNOAEI

FIŞA DISCIPLINEI

2022-2023

1. Date despre program

1.1 Instituţia de învăţământ superior	**“Alexandru Ioan Cuza” University of Iaşi**
1.2 Facultatea	**Faculty of Physics**
1.3 Departamentul	**Physics**
1.4 Domeniul de studii	**Physics**
1.5 Ciclul de studii	**Master**
1.6 Programul de studii / Calificarea	**Physics for Advanced Technologies**

2. Date despre disciplină

2.1 Denumirea disciplinei	**Design of computer algorithms**						
2.2 Titularul activităţilor de curs	**Assoc. Prof. PhD. Claudiu COSTIN** **Lect. PhD. Radu TANASĂ**						
2.3 Titularul activităţilor de seminar	**Assoc. Prof. PhD. Claudiu COSTIN** **Lect. PhD. Radu TANASĂ**						
2.4 An de studiu	**2**	**2.5** Semestru	**3**	**2.6** Tip de evaluare	**EVP**	**2.7** Regimul disciplinei*	**OP**

** OB – Obligatoriu / OP – Opţional*

3. Timpul total estimat (ore pe semestru şi activităţi didactice)

3.1 Număr de ore pe săptămână	**4**	din care: **3.2** curs	**2**	**3.3** seminar/laborator	**2**
3.4 Total ore din planul de învăţământ	**56**	din care: **3.5** curs	**28**	**3.6** seminar/laborator	**28**

Distribuţia fondului de timp	ore
Studiu după manual, suport de curs, bibliografie şi altele	**21**
Documentare suplimentară în bibliotecă, pe platformele electronice de specialitate şi pe teren	**14**
Pregătire seminarii/laboratoare, teme, referate, portofolii şi eseuri	**28**
Tutoriat	**6**
Examinări	
Alte activităţi	

3.7 Total ore studiu individual	**69**
3.8 Total ore pe semestru	**125**
3.9 Număr de credite	**5**

4. Precondiţii (dacă este cazul)

4.1 De curriculum	Undergraduate course in programming languages, Modelling of physical processes.
4.2 De competenţe	Numerical programming skills; scientific graphing and data analysis software operation; proficiency in written and oral English.

5. Condiţii (dacă este cazul)

5.1 De desfăşurare a cursului	Room with access to internet, videoprojector and projection screen.
5.2 De desfăşurare a seminarului/ laboratorului	Students must have individual access to computers.

6. Competenţe specifice acumulate

Competenţe profesionale	**C1.** Mastery of research methods and techniques, specific to the specialization Physics for Advanced Technologies. (1 credit) **C2.** Use the software for analyzing and processing experimental data and to perform virtual experiments. (1 credit) **C3.** Use of communication and information technologies. (1 credit)
Competenţe transversale	**CT1.** Language skills at academic level, in foreign languages, needed for scientific documentation. (1 credit) **CT2.** Capacity of interrelationing and teamworking. (1 credit)

7. Obiectivele disciplinei (din grila competenţelor specifice acumulate)

7.1 Obiectivul general	The course aims to develop the formal thinking abilities needed for algorithm analysis and the practical skills for algorithm selection, design and implementation in real-world problem solving.
7.2 Obiectivele specifice	On successful completion of this course, students will be able to: ▪ Explain the algorithm design paradigms, randomization and dynamic programming. ▪ Describe a basic set of numerical algorithms used in Physcis. ▪ Use computing modeling tools to describe Physics problems. ▪ Develop medium-complexity algorithms for real-world problem solving.

8. Conţinut

8.1	**Curs**	**Metode de predare**	**Observaţii** (ore şi referinţe bibliografice)
1.	Introduction to numerical algorithms. Random numbers generation.	Lecture, explanation, demonstration	2h [1,2]
2.	Transformation of uniform deviates. Inverse of the Cumulative Distribution Function (ICDF) method. Acceptance-rejection method.	Lecture, explanation, demonstration	2h [1,2]
3.	Generation of random numbers with specific distributions: uniform, isotropic, normal (Gauss), cosine, Maxwell-Boltzmann.	Lecture, explanation, demonstration, debate	2h [1,2]
4.	Monte Carlo Methods. Monte Carlo Collision. Radioactive decay.	Lecture, explanation, demonstration, debate	2h [1-3]
5.	Diffusion process. Random walks algorithm.	Lecture, explanation, demonstration, debate	2h [2]
6.	Particle-In-Cell technique. The computational cycle. Space and time discretisation. Particle loading, injection, boundary conditions.	Lecture, explanation, demonstration, debate	2h [4]

7.	Particle-In-Cell technique. Particle and force to grid weighting.	Lecture, explanation, demonstration, debate	2h [4]
8.	Ising model: general presentation. 1D, 2D and 3D cases. Theoretical treatment and phase transition study in Ising models.	Lecture, exemplification	2h [5-7]
9.	Monte Carlo Metropolis dynamics. Glauber dynamics. Kawasaki dynamics.	Lecture, exemplification	2h [5-7]
10.	Special types of Ising models: Random Anizotropy Ising, Random Field Ising, Spin glasses. Edward Anderson Spin Glass model.	Lecture, exemplification	2h [5-7]
11.	Cellular automaton.	Lecture, exemplification	2h [5-7]
12.	Introduction to finite element method (FEM). Brief history. Applications and advantages of FEM. Interpolation methods.	Lecture, exemplification	2h [8]
13.	Weak formulation of the partial differential equations. Principle of FEM. Comparison with finite difference method. Interpretation of the approximate solution.	Lecture, exemplification	2h [8]
14.	Fast Fourier Method (FFT) to evaluate the magnetic field interactions distribution in a regular lattice.	Lecture, exemplification	2h [9]

Bibliografie

Referinţe principale:
1. J. E. Gentle, *Random Number Generation and Monte Carlo Methods*, 2nd Edition (Springer, 2003).
2. Morten Hjorth-Jensen, *Computational Physics* (University of Oslo, Fall 2009).
3. D. Depla, S. Mahieu (eds.), *Reactive Sputter Deposition*, Springer Series in Materials Science, vol. 109 (Springer, Berlin, 2008), chapter 3.
4. C. K. Birdsall and A. B. Langdon, *Plasma Physics via Computer Simulations* (IOP Publishing, New York, 1991).
5. G.S.Fishman, *Monte Carlo: Concepts, Algorithms, and Applications* (Springer Verlag, New York, 1995). "*Monte Carlo Methods in Statistical Physics*", ed. K. Binder (Springer-Verlag, 1979).
6. K. Binder and D.W. Heermann, *Monte Carlo Simulation in Statistical Physics. An Introduction*, 4th Edition (Springer, 2002).
7. N. Metropolis and S. Ulam, "The Monte Carlo method", *Journal of the American Statistical Association* 44:335-341, 1949.
8. Anastasis C. Polycarpou, *Introduction to the finite element method in electromagnetics*, Synthesis lectures on computational electromagnetics (Morgan & Claypool Publishers, 2006).
9. C. Sidney Burrus, *Fast Fourier Transforms* (Open Textbook Library, 2012).

Referinţe suplimentare:
10. http://stoner.phys.uaic.ro/moodle/
11. W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, *Numerical Recipes in C, The Art of Scientific Computing*, 2nd Edition (Cambridge University Press, New York, 2002).

8.2	Seminar / Laborator	Metode de predare	Observaţii (ore şi referinţe bibliografice)
1.	Comparison of different random numbers generators.	Numerical applications, guided discovery process	2h [1,2]
2.	Generation of random numbers with specific distributions using the Acceptance-rejection method.	Numerical applications, guided discovery process	2h [1,2]
3.	Generation of random numbers with specific distributions using the ICDF method.	Numerical applications, guided discovery process	2h [1,2]

4.	Code development for collision treatment using the Monte Carlo Collision method.	Numerical applications, guided discovery process	2h [3]
5.	Code development for collision treatment using the null-collision method.	Numerical applications, guided discovery process	2h [3]
6.	Code development for the study of diffusion *via* random walks.	Numerical applications, guided discovery process	2h [2]
7.	Code development for the study of the radioactive decay.	Numerical applications, guided discovery process	2h [2]
8.	One-dimensional Ising model: numerical implementation and validation against analytical solution.	Conversation, explanation	2h [4-6]
9.	Two-dimensional Ising model: Metropolis dynamics.	Conversation, explanation	2h [4-6]
10.	Two-dimensional Ising model: Glauber dynamics.	Conversation, explanation	2h [4-6]
11.	Cellular automaton: Game of life.	Conversation, explanation	2h [4-6]
12.	Cellular automaton: critical phenomena, self-organization.	Conversation, explanation	2h [4-6]
13.	Open source Finite Element Method (FEM) solving packages: FEniCSx.	Conversation, explanation	2h [7]
14.	Fast Fourier Transform numerical algorithm.	Conversation, explanation	2h [8]

Bibliografie

Referinţe principale:
1. J. E. Gentle, *Random Number Generation and Monte Carlo Methods*, 2nd Edition (Springer, 2003).
2. Morten Hjorth-Jensen, *Computational Physics* (University of Oslo, Fall 2009).
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6. N. Metropolis and S. Ulam, "The MonteCarlo method", *Journal of the American Statistical Association* 44:335-341, 1949.
7. Anders Logg, Kent-Andre Mardal, Garth Wells, *Automated Solution of Differential Equations by the Finite Element Method. The FEniCS Book* (Springer, 2012).
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10. W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, *Numerical Recipes in C, The Art of Scientific Computing*, 2nd Edition (Cambridge University Press, New York, 2002).

9. Coroborarea conţinutului disciplinei cu aşteptările reprezentanţilor comunităţii, asociaţiilor profesionale şi angajatorilor reprezentativi din domeniul aferent programului

Algorithm analysis and design are compulsory components of computer programming education, required by both scientific and industrial research.

10. Evaluare

Tip activitate	**10.1 Criterii de evaluare**	**10.2 Metode de evaluare**	**10.3 Pondere în nota finală (%)**
10.4 Curs	- completeness and correctness of the acquired knowledge; - capacity of operating with the acquired knowledge; - capacity of analysis, personal interpretation, originality, creativity.	Formative assessment (during the semester) - written tests.	50%
10.5 Seminar/ Laborator	- active participation to practical works; - the capacity of using in practice the acquired knowledge.	Formative assessment (during the semester) - problem solving and homeworks.	50%
10.6 Standard minim de performanţă			
Minimum grade (course and laboratory): 5. Explain the specific steps required to develop algorithms for solving problems of medium difficulty. Independent solving of a medium complexity problem using numerical algorithms.			

Data completării	Titular de curs	Titular de seminar
26.09.2022	Assoc. Prof. PhD. Claudiu COSTIN Lect. PhD. Radu TANASĂ	Assoc. Prof. PhD. Claudiu COSTIN Lect. PhD. Radu TANASĂ

Data avizării în departament

Director de departament

Assoc. Prof. PhD. Iordana AȘTEFĂNOAEI