FISA DISCIPLINEI
Syllabus

1. Information about the program

1.1. University	West University of Timisoara
1.2. Faculty	PHYSICS
1.3. Department	PHYSICS
1.4. Study direction	PHYSICS
1.5. Study cycle	MASTER
1.6. Study program / qualification	METODE AVANSATE DE CERCETARE IN FIZICA/ ADVANCED RESEARCH METHODS IN PHYSICS

2. Subject matter information

2.1. Subject matter			**Magnetic materials** ARMP 1104				
2.2. Subject teacher			Dr. Nicoleta Stefu, Associate Professor				
2.3. Subject applications teacher (seminar / laboratory)			Dr. Nicoleta Stefu, Associate Professor				
2.4. Study year	1	2.5. Semester	1	2.6. Assessment type	**E**	2.7. Subject type	DS, DOP

3. Study time distribution

3.1. Nr. of hours/week	4	In which: 3.2 course	2	3.3. seminar/laboratory	0/2
3.4. Total hours in educational plan	56	In which: 3.5 course	28	3.6. seminar/laboratory	28

Time distribution:	**hours**
Study after lecture notes, bibliography or notes	60
Additional documentation in the library, electronic specialty platforms/ field	20
Seminar / laboratory preparations, homework, portfolio and essays	30
Tutoring	0
Exams	10
Other activities...	-

3.7. **Total number of personal study hour**	120
3.8. **Total number of hours in semester**	176
3.9. **Number of credits**	7

4. Preconditions (where appropriate)

4.1. curriculum	• Mathematics - Analysis • Electricity and magnetism • Differential and integral calculus • Physics of the atom
4.2. Competences	• General competencies: the ability of analysis and synthesis;

	accumulation of basic general knowledge; proper use of terminology in physics and computer science in written and oral communication in English; Basic Skills PC operating; ability to work independently and in teams. • Professional Skills: identification and proper use of the main physical laws and principles in a given context; use of software packages for data analysis and processing.

5. Conditions (where appropiate)

5.3 for course	• Laptop + projector+ whiteboard
5.4 for seminar/lab	• Devices from the lab of Magnetic Materials • PC. • Each seminar activity will be done in small groups (3-4 students) on the topics described in the seminar section.

6. Objectives of the discipline - expected learning outcomes to the formation of which the completion and promotion of the discipline contribute

Knowledge	• to know the advanced notions in the field of Physics, which involves a critical understanding of theories and principles • to know the language specific to the field • to know physical phenomena and interpret them by formulating hypotheses and operationalizing key concepts and the appropriate use of laboratory equipment • to know the constructive and operating principles of the equipment for obtaining and characterizing materials and to explain how to use it
Skills	• to compare the theoretical results provided by the specialized literature with those of an experiment carried out within a professional project • To describe physical systems using specific theories and tools (experimental and theoretical models, algorithms, schemes, etc.) • to apply the principles and laws of physics in solving theoretical or practical problems, under conditions of qualified assistance • to characterize the specific properties of some materials taking into account the field in which they are used • to identify the most appropriate methods to develop new materials with well-defined properties
Responsibility and autonomy	• participate in some concrete physics experiments • to critically analyze a specialized report, scientific communication with a medium degree of difficulty in the field of physics • to be autonomous in the context of handling laboratory equipment, including

	in situations requiring an interdisciplinary approach • to autonomously use information sources and resources for communication and assisted professional training (Internet portals, specialized software applications, databases, online courses, etc.) both in Romanian and in a language of international circulation

7. Table of content

7.1 Course – 28 hours	Teaching methods	Observations
Lecture 1. (4 hours) Introductory lecture. Chapter 1. Magnetic materials. Angular momenta**;** Magnetic Moments	Lecture, introductory conversation, heuristic conversation, illustration, use of analogies and algorithms.	• The lecture will be interactive; learning is facilitated by engaging the students in conversation episodes, capture of attention, updating the knowledge previous acquired and systematization / fixing of new knowledge **Compulsory reading:** ***Lecture notes 1*** available on e-learning platform **Optional supplementary material:** [1] Pages 87-90 [4] pages 62-67 **Video** This lecture is part of 8.02 Physics II: Electricity and Magnetism, as taught in Spring 2002 by Dr. Walter Lewin at MIT. https://www.youtube.com/watch?v=TJGRatHJgEI
Lecture 2 (4 hours) **Magnetic Moment and its Energy in a Magnetic Field; Definitions of Magnetization and Magnetic Susceptibility; Classification of Magnetic Materials; Diamagnetism; Paramagnetism. The Langevin Function of Magnetization and the Curie Law**	Lecture, conversation, mathematical calculation, fixing and deepening knowledge Building a mind map	**Compulsory reading:** ***Lecture notes 2*** available on e-learning platform **Optional supplementary material:** [1] Pages 90-99 [4] pages 104-106
Lecture 3 (4 hours) **The Brillouin Function of Magnetization and the Curie Law; Magnetic Ordered State; Weiss molecular field theory (the classical theory); Generalization of Weiss molecular field theory; Magnetism and hysteresis**	Lecture, conversation, mathematical calculation, fixing and deepening knowledge	**Compulsory reading:** ***Lecture notes 3*** available on e-learning platform **Optional supplementary material:**

		[1] Pages 117-128 [2] pages 53-59 [4] pages 107-110
Lecture 4 (4 hours) **The quantum theory of ferromagnetism. The Heitler –London model. The Heisenberg-Dirac hamiltonian. The exchange interaction ; Magnetism and hysteresis.** **Chapter 2. Magnetic anisotropy. Anisotropy**	Lecture, conversation, mathematical calculation, fixing and deepening knowledge	**Compulsory reading:** ***Lecture notes 4*** available on e-learning platform **Optional supplementary material:** [1] Pages 197 [2] pages 63-65 [4] pages 168
Lecture 5 (4 hours) **Crystallographic anisotropy; Shape anisotropy; Induced anisotropy. Magnetostriction; Other ferromagnetic phenomena (magneto-caloric, magneto-resistance, magneto-optic)**	Lecture, conversation, mathematical calculation, fixing and deepening knowledge	**Compulsory reading:** ***Lecture notes 5*** available on e-learning platform **Optional supplementary material:** [1] Pages 198-204 [2] pages 63-65 [4] pages 169-187
Lecture 6 (4 hours) **Chapter 3. Magnetization dynamics** **Larmor precession. Electron paramagnetic resonance; Bloch equations. Magnetic resonance. Magnetic relaxation; Ferromagnetic resonance ; Antiferromagnetic resonance**	Lecture, conversation, mathematical calculation, fixing and deepening knowledge	**Compulsory reading:** ***Lecture notes 6*** available on e-learning platform **Optional supplementary material:** [1] Pages 428-435 [4] pages 305-325
Lecture 7 (4 hours) **Chapter 4. Magnetic nanoparticle systems and applications** **Characteristic length scales; Small particles ; Quantum dots and molecular clusters; Bulk nanostructures; Ferrofluids; Magneto-rheological and magneto-elastic systems; Smart materials**	Lecture, conversation, retaining and deepening knowledge conversation	**Compulsory reading:** ***Lecture notes 7*** available on e-learning platform **Optional supplementary material:** **[3] pages 177-189** [4] pages 264-268, 293-300

Bibliography

1. B. D. Cullity, C. D. Graham, **Introduction To Magnetic Materials**, IEEE Press, Wiley, 2009
2. Peter Mohn, **Magnetism In The Solid State,** An Introduction, Corrected Second Printing, 2006, Springer
3. Nicola Spaldin, **Magnetic Materials, Fundamentals And Applications,** Cambridge University Press, 2011
4. J.M.D. Coey, **Magnetism and magnetic materials**, Cambridge University Press, 2010.

7.2 Seminar / labs	**Teaching methods**	**Observations/Bibliography**
Seminar 1. (4 hours) **Methods for measuring the magnetic susceptibility**	Discussion on various methods for measuring the magnetic	Compulsory reading: ***Laboratory notes***

	susceptibility and magnetic permeability	available on the e-learning platform
Seminar 2. (4 Hours) **Determination of the saturation magnetisation and of the dimension of the particles of a ferofluid by means of magnetisation curve.**	Data processing and interpretation of the results. Students will work in small groups (3-4 students). Will read and discuss the article in bibliography, will be given a set of measurements and will follow the algorithm described in article and do the calculations presented there, using the appropriate software. In the end they will present their work and the results, discussing the differences between their results and the ones presented in the article.	**Compulsory bibliography:** I. Hrianca, I. Malaescu, C. N. Marin, **N. Stefu**, *Magnetic relaxation processes in radio-frequency field for dispersed monodomenic particles*, Analele Uiversitatii de Vest din Timisoara, Vol. XXXVI, Seria Stiinte Fizice (1997) 17
Seminar 3. (4 hours) **Determination of particle dimension by means of Neel and Brown relaxation times in suspensions of magnetic nanoparticles.**	Data processing and interpretation of the results. Students will work in small groups (3-4 students). Will read and discuss the article in bibliography, will be given a set of measurements and will follow the algorithm described in article and do the calculations presented there, using the appropriate software. In the end they will present their work and the results, discussing the differences between their results and the ones presented in the article.	**Compulsory bibliography:** I. Malaescu, L. Gabor, F. Claici, **N. Stefu**, *"Preparation of ferrofluids with magnetite and mixed ferrite particles and characterization in a radiofrequency field"*, Analele Uiversitatii de Vest din Timisoara, Vol. XXXVIII, Seria Stiinte Fizice (1998) 90
Seminar 4. (4 hours) **Determination of the magnetic properties of the ferrofluid from resonance measurements**	Data processing and interpretation of the results. Students will work in small groups (3-4 students). Will read and discuss the article in bibliography, will be given a set of measurements and will follow the algorithm described in article and do the calculations presented there, using the appropriate software. In the end they will present their work and the results, discussing the differences between their results and the ones presented in the article.	**Compulsory bibliography:** I. Hrianca, I. Malaescu, **N. Stefu,** F. Claici, *Behavior in Radiofrequency Field and Magnetic Resonance of Ferrofluids*, Analele Universitatii de Vest din Timisoara, Vol. XL, Seria Stiinte Fizice, (1999)

Seminar 5. (4 hours) **Determination of anisotropy constant by means of magnetic resonance**	Data processing and interpretation of the results. Students will work in small groups (3-4 students). Will read and discuss the article in bibliography, will be given a set of measurements and will follow the algorithm described in article and do the calculations presented there, using the appropriate software. In the end they will present their work and the results, discussing the differences between their results and the ones presented in the article.	**Compulsory bibliography:** P.C.Fannin, C.N.Marin, I. Malaescu, **N.Stefu,** *"An investigation of the microscopic and macroscopic properties of magnetic fluids",* **Physica B: Condensed Matter**, Volume 388, Issues 1-2, Pages 1-440 (15 January 2007) *Pages 87-92*
Seminar 6 (4 hours) **Study of the anisotropy constant and Lande factor by means of static and dynamic measurements in ferrofluids with mixed ferrite particles**	Data processing and interpretation of the results. Students will work in small groups (3-4 students). Will read and discuss the article in bibliography, will be given a set of measurements and will follow the algorithm described in article and do the calculations presented there, using the appropriate software. In the end they will present their work and the results, discussing the differences between their results and the ones presented in the article.	**Compulsory bibliography:** I. Malaescu, **N. Stefu**, L. Gabor, *Relaxation Process and Ferromagnetic Resonance Investigation of Ferrofluids with Mn – Zn and Mn – Fe Mixed Ferrite Particles,* **J. Magn. Magn. Mater** , 234 (2001) 299-305
Seminar 7. (4 hours) **Determination of the microwave specific loss power of magnetic fluids subjected to a static magnetic field**	Data processing and interpretation of the results. Students will work in small groups (3-4 students). Will read and discuss the article in bibliography, will be given a set of measurements and will follow the algorithm described in article and do the calculations presented there, using the appropriate software. In the end they will present their work and the results, discussing the differences between their results and the ones presented in the article.	**Compulsory bibliography:** P.C.Fannin, I. Malaescu, C.N.Marin, **N.Stefu,** *Microwave specific loss power of magnetic fluids subjected to static magnetic field,* Eur. Phys. J. E., 27, 145-148 (2008)
Bibliography		

1. I. Hrianca, I. Malaescu, C. N. Marin, **N. Stefu**, *Magnetic relaxation processes in radio-frequency field for dispersed monodomenic particles*, Analele Uiversitatii de Vest din Timisoara, Vol. XXXVI, Seria Stiinte Fizice (1997) 17
2. I. Malaescu, L. Gabor, F. Claici, **N. Stefu**, *"Preparation of ferrofluids with magnetite and mixed ferrite particles and characterization in a radiofrequency field"*, Analele Uiversitatii de Vest din Timisoara, Vol. XXXVIII, Seria Stiinte Fizice (1998) 90
3. I. Hrianca, I. Malaescu, **N. Stefu,** F. Claici, *Behavior in Radiofrequency Field and Magnetic Resonance of Ferrofluids*, Analele Universitatii de Vest din Timisoara, Vol. XL, Seria Stiinte Fizice, (1999)
4. P.C.Fannin, C.N.Marin, I. Malaescu, **N.Stefu,** *"An investigation of the microscopic and macroscopic properties of magnetic fluids"*, **Physica B: Condensed Matter**, Volume 388, Issues 1-2, Pages 1-440 (15 January 2007) *Pages 87-92*
5. I. Malaescu, **N. Stefu**, L. Gabor, *Relaxation Process and Ferromagnetic Resonance Investigation of Ferrofluids with Mn – Zn and Mn – Fe Mixed Ferrite Particles*, **J. Magn. Magn. Mater** , 234 (2001) 299-305

P.C.Fannin, I. Malaescu, C.N.Marin, **N.Stefu,** *Microwave specific loss power of magnetic fluids subjected to static magnetic field*, Eur. Phys. J. E., 27, 145-148 (2008)

8. Relation between subject content and the expectations of employers

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9. Assesment

Activity type	9.1 Assesment criteria	9.2 Assesment method	9.3 Percent in final mark
9.4 Course	- the clarity, logic and scientific level of the presentation will be evaluated; - correctness of the answers to the questions will be evaluated - The ability of explaining the studied magnetic phenomena will be evaluated	*Summative assessment* - Oral examination based on an essay on a topic discussed in class, presented in English	**70%**
9.5. Seminar/labs	- After each seminar activity, each student will present a report in English and will be evaluated as follows: -his/her work in the group will be assessed - the correctness of results obtained after processing the data will be discussed and evaluated - the problems that occurred and the way they were solved during the activity will be evaluated - the discussion on the correlation with the results presented in the article will be evaluated.	*Formative assessment:* - continuous	**30%**
9.6 Minimum performance standards			

Mark 5 corresponds to the minimum accumulated knowledge, i.e. for the student capacity to:

- Correctly answer 3 questions from the theoretical part (in final evaluation), mark 5 in seminar.

Completion date:15.09.2024

Subject teacher's signature:
Associate Professor Dr. Nicoleta STEFU,

Subject applications teacher's signature:
Associate Professor Dr. Nicoleta STEFU,

Department Director' Signature:
Associate Professor Dr. Nicoleta STEFU,