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. Specific skills gained

Professional competences	C1. Learning of a coherent and functional fundamental knowledge system in material science; C2. Capacity to characterize specific materials properties in relation with their applications; C3. Use of methods for investigation of the structure of materials; C4. Comparison of experimental results with theoretical models.
Transversal competences	T1. Ability to obtain and analyse information through ICT T2. Team work T3. Capacity for communication T4. Reflective thinking
Key competences	K1. Literacy competences K2. Mathematical competences K3. Digital competences K4. Efficient use of informational and communication resources in English language. K5. Learning competences

7. Course Objectives

7.1 Main Objective	• OG: To gain knowledge of physical phenomena in magnetic materials in magnetic field.

7.2 Specific objectives	O1: To understand the origin of magnetism and the magnetic phenomena. O2: To put into practice the knowledge gained in characterizing magnetic materials O3: To develop the capacity for organization and investigation. O4: To use mathematic calculation and specific software in order to process data.

8. Table of content

8.1 Course – 28 hours	Teaching methods	Observations
Lecture 1. (4 hours) Introductory lecture. Chapter 1. Magnetic materials. Angular momenta**;** Magnetic Moments • Contributes to OG and O1 • contributes to the formation of professional competences C1 and C2 • contributes to the formation of Key Competences competences K2 and K4	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** • OG and O1 • contributes to the formation of professional	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

competences C1 and C2 • contributes to the formation of Key Competences competences K2 and K4		
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** • OG and O1 • contributes to the formation of professional competences C1 and C2 • contributes to the formation of Key Competences competences K2 and K4	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** • OG and O1 • contributes to the formation of professional competences C1 and C2 • contributes to the formation of Key Competences competences K2 and K4	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)** • OG and O1 • contributes to the formation of professional competences C1 and C2 • contributes to the formation of Key Competences competences K2 and K4	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;**	Lecture, conversation, mathematical calculation, fixing and deepening knowledge	**Compulsory reading:** ***Lecture notes 6*** available on e-learning platform **Optional supplementary material:**

Ferromagnetic resonance ; Antiferromagnetic resonance • OG and O1 • contributes to the formation of professional competences C1 and C2 • contributes to the formation of Key Competences competences K2 and K4		[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** • OG and O1 • contributes to the formation of professional competences C1 and C2 • contributes to the formation of Key Competences competences K2 and K4	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.		

8.2 Seminar / labs	**Teaching methods**	**Observations/Bibliography**
Seminar 1. (4 hours) **Methods for measuring the magnetic susceptibility** • contributes to the formation of professional competences C3 • contributes to the formation of Key Competences competences K1	Discussion on various methods for measuring the magnetic susceptibility and magnetic permeability	Compulsory reading: ***Laboratory notes*** 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.** • contributes to the formation of professional competences C2, C3, C4	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	**Compulsory bibliography:** I. Hrianca, I. Malaescu, C. N. Marin, **N. Stefu**, *Magnetic relaxation processes in radio-frequency field for*

• contributes to the formation of Key Competences competences K1, K2, K3, K4 Students will: • put into practice the knowledge gained in characterizing magnetic materials (O2). • develop the capacity for organization and investigation. (O3) • use mathematic calculation and specific software in order to process data (O4). Students will develop the following transversal competences T1, T2, T3 and T4	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.	*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.** • contributes to the formation of professional competences C2, C3, C4 • contributes to the formation of Key Competences competences K1, K2, K3, K4 Students will: • put into practice the knowledge gained in characterizing magnetic materials (O2). • develop the capacity for organization and investigation. (O3) • use mathematic calculation and specific software in order to process data (O4). Students will develop the following transversal competences T1, T2, T3 and T4	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** • contributes to the formation of professional competences C2, C3, C4 • contributes to the formation of Key Competences competences K1, K2, K3, K4 Students will: • put into practice the knowledge gained in	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	**Compulsory bibliography:** I. Hrianca, I. Malaescu, **N. Stefu,** F. Claici, *Behavior in Radiofrequency Field and Magnetic Resonance of Ferrofluids,* Analele Universitatii de Vest din

characterizing magnetic materials (O2). • develop the capacity for organization and investigation. (O3) • use mathematic calculation and specific software in order to process data (O4). Students will develop the following transversal competences T1, T2, T3 and T4	results, discussing the differences between their results and the ones presented in the article.	Timisoara, Vol. XL, Seria Stiinte Fizice, (1999)
Seminar 5. (4 hours) **Determination of anisotropy constant by means of magnetic resonance** • contributes to the formation of professional competences C2, C3, C4 • contributes to the formation of Key Competences competences K1, K2, K3, K4 Students will: • put into practice the knowledge gained in characterizing magnetic materials (O2). • develop the capacity for organization and investigation. (O3) • use mathematic calculation and specific software in order to process data (O4). Students will develop the following transversal competences T1, T2, T3 and T4	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** • contributes to the formation of professional competences C2, C3, C4 • contributes to the formation of Key Competences competences K1, K2, K3, K4 Students will: • put into practice the knowledge gained in characterizing magnetic materials (O2). • develop the capacity for organization and investigation. (O3)	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

• use mathematic calculation and specific software in order to process data (O4). Students will develop the following transversal competences T1, T2, T3 and T4		
Seminar 7. (4 hours) **Determination of the microwave specific loss power of magnetic fluids subjected to a static magnetic field** • contributes to the formation of professional competences C2, C3, C4 • contributes to the formation of Key Competences competences K1, K2, K3, K4 Students will: • put into practice the knowledge gained in characterizing magnetic materials (O2). • develop the capacity for organization and investigation. (O3) • use mathematic calculation and specific software in order to process data (O4). Students will develop the following transversal competences T1, T2, T3 and T4	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)

9. Relation between subject content and the expectations of employers

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10. Assesment

Activity type	10.1 Assesment criteria	10.2 Assesment method	10.3 Percent in final mark
10.4 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%**
10.5. 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%**
10.6 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: 09.09.2023

Subject teacher's signature:
Associate Professor Dr. Nicoleta ȘTEFU [redacted]

Subject applications teacher's signature:
Associate Professor Dr. Nicoleta ȘTEFU [redacted]

Department Director' Signature:
Associate Professor Dr. Cătălin Nicolaie Marin [redacted]