SYLLABUS

1. Information about the study programme

1.1 Institution of higher education	West University of Timișoara
1.2 Faculty	Physics
1.3 Department of	Physics
1.4 Field of study	Physics
1.5 Study cycle	Master degree
1.6 Study programme / Qualification	**ADVANCED RESEARCH METHODS IN PHYSICS**

2. Information about the subject/discipline

2.1 Name			**Microwaves and applications in materials science ARPM1208**				
2.2 Course coordinator			Prof. Dr. habil. Cătălin Nicolae MARIN				
2.3 Seminar coordinator			Prof. Dr. habil. Cătălin Nicolae MARIN				
2.4 Year of study	1	**2.5 Semester**	2	**2.6 Type of assessment**	Exam	**2.7 Type of discipline**	Compulsory

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

3.1 Number of hours per week	**4**	**3.2 course**	**2**	**3.3 seminars/labs**	**2**
3.4 Total hours in the curriculum	**56**	**3.5 course**	**28**	**3.6 seminars/labs**	**28**
Distribution of time:					**hours**
Study based on Instructions, course materials, bibliography and notes					**28**
Additional documentation library, specialized electronic platforms / field					**10**
Training seminars / laboratories, homework, essays, portfolios and essays					**21**
Tutoring					**5**
Examinations					**5**
Other activities					

3.7 Total hours of individual study	**69**
3.8 Total hours per semester	**125**
3.9 Number of credits	**5**

4. Prerequisites (where applicable)

4.1 of curriculum	Knowledge of electricity, magnetism and classical electrodynamics, elementary notions of mathematical analysis and algebra, as well as knowledge of using a computer to process experimental data.
4.2 of skills	Ability of abstraction and analyse physical phenomena. Minimum technical skills for carrying out electromagnetism and electromagnetic wave experiments.

5. Conditions (where applicable)

5.1 for the course	The courses are interactive (students are encouraged to ask questions and formulate discussion topics from the course theme). To consolidate knowledge, students receive homework projects or can take tests, and the results throughout the semester are quantified for the final grade.
5.2 for the seminar / laboratory	The course material is discussed, then practical activities are carried out in working groups, under the supervision and guidance of the teaching staff.

6. Discipline objectives – learning outcomes

Knowledge	• Knowledge and acquisition of the laws of physics for the description of the basic phenomena in electromagnetism, the physical quantities that intervene as well as the laws that govern the presented phenomena. • Knowing and learning the electrical and magnetic properties of materials and their manifestation in the microwave electromagnetic field. • Knowledge in the description of microwave propagation phenomena on guiding structures and in material environments. • Knowledge and acquisition of some practical applications of microwaves.
Skills	• Skills training for performing laboratory measurements, making circuits, real-time measurements, acquisitions and computer data processing. • Identification and appropriate use of the main laws of electromagnetism related to microwaves in a given context. • Use of software packages for data analysis and processing. • Solving physics problems under imposed conditions, using numerical methods. • Application of knowledge in the field of microwaves both in concrete situations from related fields and in experiments, using standard laboratory equipment. • Communication and analysis of didactic, scientific and popularizing information in the field of physics.
Responsibility and autonomy	• Developing the capacity for initiative and choice. • Encouraging the exploration of physical phenomena. • Promoting student responsibility in dealing with learning subjects through the effective use of information sources and communication resources. • Cultivating fairness and responsibility in the activity carried out.

7. Contents

7.1 Course	**Teaching methods**	**Comments**
1. Microwave frequencies and uses. Microwave circuit elements analysis. Maxwell's equations	Exposure. Conversations.	**2 hours**
2. Electromagnetic characterization of the propagation medium. Study of plane wave propagation. Propagation	Exposure. Conversations.	**2 hours**

parameters for the plane wave. The study of the reflection and transmission of the electromagnetic wave at the separation surface between two propagation media		
3. Wave equation and membrane equation. Propagation modes	Exposure. Conversations.	**2 hours**
4. Transmission lines – definitions. Equations of transmission lines in permanent harmonic regime. Propagation constant. General solutions of transmission line equations	Exposure. Conversations.	**2 hours**
5. Characteristic impedance. The solutions of the transmission line equations terminated on a given load. Input impedance	Exposure. Conversations.	**2 hours**
6. The equivalent quadrupole of the transmission line. Wave propagation through finite transmission line. Smith chart for transmission lines. Impedance matching with reactive elements	Exposure. Conversations.	**2 hours**
7. Uniform waveguides - definitions, classification. Rectangular waveguide. Propagation parameters in the rectangular waveguide. Circular waveguides	Exposure. Conversations.	**2 hours**
8. Elementary notions of the theory of linear microwave circuits. Impedance description of waveguides elements and circuits. Foster's reactance theorem. Even and odd properties of input impedance. N-ports circuits.	Exposure. Conversations.	**2 hours**
9. Scattering matrix formulation – properties and determination. Scattering matrix of two-port junction. Transmission matrix representation	Exposure. Conversations.	**2 hours**
10. Excitation of waveguides. Waveguide coupling and apertures. Transmission-line resonant circuits. Electromagnetic resonators.	Exposure. Conversations.	**2 hours**
11. Resonant cavity - definition and characterization. The study of the H10 wave in the parallelepiped resonant	Exposure. Conversations.	**2 hours**

cavity by the reflection method. The fundamental parameters of the resonant cavity. Resonance curve of the cavity. Application of the perturbation method to the resonant cavity. Application - determination of dielectric parameters using the perturbation method		
12. Microstrip technology of transmission lines in microwave integrated circuits. Couplers and power dividers made in microstrip technology. Filters built in microstrip technology. Microstrip antennas	Exposure. Conversations.	**2 hours**
13. Heating of materials in microwave field. Microwave absorbers and shielding	Exposure. Conversations.	**2 hours**
14. Microwaves in telecommunications. Radiotelescopes. Microwave security and control equipment. Continuous flow microwave pasteurization. Medical applications of microwaves	Exposure. Conversations.	**2 hours**

Bibliography:

- I. Mălăescu, Microunde și tehnologii cu microunde, Editura Universității de Vest, Timișoara, 2008
- J. D. Jackson, Electrodinamica clasică – vol.1 și vol.2, Editura tehnică, București, 1991
- G. Rulea, Bazele teoretice și experimentale ale tehnicii microundelor, Editura Științifică și Enciclopedică, București, 1989
- R. E. Collin, Foundations for Microwave Engineering, Mc-Graw-Hill, London, 1966

7.2. Seminar / laboratory	**Teaching methods**	**Comments**
1. Study of the electromagnetic spectrum in the 1 MHz – 1 GHz range and electromagnetic jamming	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
2. Study of the propagation of electromagnetic waves on the bifilar transmission line	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
3. Study of coaxial line input impedance (effect of frequency and line length)	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**

4. The effect of the static magnetic field on the input impedance of a coaxial line	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
5. Measurement of the frequency dependence of the magnetic permeability of materials by the short-circuited coaxial line method	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
6. Measurement of the frequency dependence of the complex dielectric permittivity by the hollow coaxial line method	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
7. Measuring the electromagnetic shielding effectiveness of materials according to ASTM D4935_10	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
8. Frequency dependence of electromagnetic wave propagation parameters	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
9. Determination of the Neel relaxation time in nanostructured materials	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
10. Study of ferromagnetic resonance in composite materials	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
11. Study of microwave propagation on the rectangular waveguide	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
12. Determination of the anisotropy field and the effective anisotropy constant of materials from ferromagnetic resonance measurements	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
13. Determination of the processional decay time of the magnetization of magnetic nanoparticle systems	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**
14. Laboratory colloquium and recoveries	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**2 hours**

Bibliography:

- C. N. Marin, Măsurarea parametrilor electrici și magnetici ai materialelor cu linii de transmisie - Notițe pentru laborator, Editura Eurobit, Timișoara, 2014, ISBN 978-973-132-183-7.
- C. N. Marin, Proprietăți magnetice ale materialelor - notițe pentru laborator, Editura Eurobit, Timişoara, 2016, ISBN 978-973-132-326-8
- C. N. Marin, Thermal and particle size distribution effects on the ferromagnetic resonance in magnetic fluids, J.Magn.Magn.Mater., 300 (2006) 397 - 406.
- P.C.Fannin, C.N. Marin, C. Couper, Precessional decay time of nanoparticles in magnetic fluids, J.Magn.Magn.Mater.322 (9-12) (2010) 1682-1685
- P.C.Fannin, I.M?l?escu, C.N.Marin, The effective anisotropy constant of particles within magnetic fluids as measured by magnetic resonance, J.Magn.Magn.Mater. 289 (2005) 162-164.
- P. C. Fannin, O. M. Bunoiu, I. Malaescu, C. N. Marin, D. Ursu, Magnetically tuning microwave propagation parameters in ferrofluids, The European Physical Journal E, 44, Issue 6 (2021) Article number 83
- P.C. Fannin, C. MacOireachtaigh, C. Couper, An improved technique for the measurement of the complex susceptibility of magnetic colloids in the microwave region. J. Magn. Magn. Mater. 322 (2010) 2428–2833

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

The content of the subject is similar to that of the same subject taught at different physics faculties in the country and abroad and aims to know and acquire the specific notions for describing the basic phenomena related to microwaves and their applications.

9. Evaluation

Type of activity	9.1 Evaluation criteria	9.2 Evaluation methods	9.3 Percentage of the final mark
9.4 Course	Proving the learning of the lecture material.	Oral exam	80 %
9.5 Seminar / laboratory	Assessment of problem-solving skills and practical laboratory work	Practical evaluation during the semester	20 %
9.6 Minimum performance standards			
Knowing the laws for describing microwave propagation phenomena and formulating examples of applications.			

Date of submission:
10.01.2024

Course coordinator: Prof. Dr. Habil. C. N. Marin
Signature:

Date of approval in department:

Seminary / laboratory: Prof. Dr. Habil. C. N. Marin
Signature:

HEAD OF THE DEPARTMENT: Assoc. Prof. Dr. Nicoleta Ștefu
Signature: