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** • **Code COR - 211101 physicist.** • **Code COR - 211103 research assistant in physics.** • **Code COR - 211105 research assistant in physics-chemistry.** • **Code COR - 211107 research assistant in technological physics.**

2. Information about the subject/discipline

2.1 Name			**Microwaves and applications ARMP1208**				
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**	E	**2.7 Type of discipline**	Compulsory

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

3.1 Number of hours per week	**3**	**3.2 course**	**2**	**3.3 seminars/labs**	**1**
3.4 Total hours in the curriculum	**42**	**3.5 course**	**28**	**3.6 seminars/labs**	**14**
Distribution of time:					**hours**
Study based on Instructions, course materials, bibliography and notes					**42**
Additional documentation library, specialized electronic platforms / field					**30**
Training seminars / laboratories, homework, essays, portfolios and essays					**26**
Tutoring					**5**
Examinations					**5**
Other activities					

3.7 Total hours of individual study	**108**
3.8 Total hours per semester	**150**
3.9 Number of credits	**6**

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	• to know the advanced notions in the field of Physics (with emphasis on microwaves), which involves a critical understanding of theories and principles; • to know the working formulas for calculations with physical quantities using properly the principles and laws of physics; • 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 in the area of microwaves; • to know the constructive and operating principles of the equipment for obtaining and characterizing materials in microwave field 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 deduce the working formulas for calculations with physical quantities, using appropriately the principles and laws of physics; • 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 use the computer and calculation programs for the numerical simulation of the physical processes (use of software packages for data analysis and processing); • to perform laboratory measurements, real-time measurements, acquisitions and computer data processing.

Responsibility and autonomy	• to assume responsibility for managing professional development; • to participate in some specific physics experiments; • to present scientific seminars and to popularize some notions of physics; • to critically analyse a specialized report, scientific communication with a medium degree of difficulty in the field of microwaves; • 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; • to carry out research internships in various production/research units in order to become familiar with and operate modern equipment, obtain interesting results and prepare reports on 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 parameters for the plane wave. The study of the reflection and transmission of the electromagnetic wave at the separation surface between two propagation media	Exposure. Conversations.	**2 hours**
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	Exposure. Conversations.	**2 hours**

chart for transmission lines. Impedance matching with reactive elements		
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 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	Exposure. Conversations.	**2 hours**
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	Exposure. Conversations.	**2 hours**

flow microwave pasteurization. Medical applications of microwaves		

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.	**1 hour**
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.	**1 hour**
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.	**1 hour**
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.	**1 hour**
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.	**1 hour**
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.	**1 hour**
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.	**1 hour**
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.	**1 hour**

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.	**1 hour**
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.	**1 hour**
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.	**1 hour**
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.	**1 hour**
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.	**1 hour**
14. Laboratory colloquium and recoveries	Presentation of the practical work. Performing the experiment, processing the experimental data, interpreting the results and reporting them.	**1 hour**

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:
21.01.2025

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: