COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Electronic Devices, Circuits and Architectures**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Microelectronics, Optoelectronics and Nanotechnologies

2. Date despre disciplină

2.1 Course name (ro) (en)				Prelucrarea digitală a semnalelor Digital Signal Processing			
2.2 Course Lecturer				Prof. dr. ing. Dragoș BURILEANU			
2.3 Instructor for practical activities				Ș.L. dr. ing. Șerban MIHALACHE			
2.4 Year of studies	3	2.5 Semester	2	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		D	2.9 Course code	04.D.06.O.410		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	4	Out of which: 3.2 course	2	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	56	Out of which: 3.5 course	28	3.6 seminary/laboratory	28

Distribution of time:	hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.	40
Tutoring	0
Examinations	4
Other activities (if any):	0

3.7 Total hours of individual study	44.00
3.8 Total hours per semester	100
3.9 Number of ECTS credit points	4

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Finishing the following courses: – Signals and Systems; – Computer Programming.
4.2 Results of learning	General knowledge of: – analog signal processing; – basic concepts of computer programming.

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	– The lectures will take place in a room equipped with a video projector and a computer.
5.2 Seminary/ Laboratory/Project	– The laboratory will take place in a room with specific equipment, which must include: computers, video projector, specialized software (the MATLAB software suite). – Mandatory attendance of laboratory sessions (in accordance with the NUSTPB undergraduate studies regulations).

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

This course is studied within the "Electronic Engineering, Telecommunications, and Information Technologies" domain / "Microelectronics, Optoelectronics and Nanotechnologies" specialization, and aims to familiarize students with the fundamental aspects of digital signal processing: specific algorithms, processing techniques, and practical implementation considerations. The primary goal is to understand the phenomena associated with the main DSP techniques, from the perspective of the system designer. Numerous examples and detailed explanations in the lectures help to clarify more difficult theoretical aspects, as well as to solve practical applications and problems, with relevance to stimulating the students' learning process. Additionally, the laboratory applications aim to provide practical mastery of the main concepts in the DSP field. The implemented applications include various software simulations using the MATLAB development environment.
The course covers the following basic concepts and specific topics: time and frequency domain representation and analysis of discrete signals and systems, the Discrete Fourier Transform and the concept of frequency resolution, Fast Fourier Transform algorithms, synthesis and analysis of digital filters. All of these contribute to providing students with an overview of the methodological and procedural benchmarks of the DSP field.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	– Demonstrates a basic understanding of analog signal acquisition and digital processing methods, characterization of discrete-time signals in the time and frequency domains, as well as digital filter analysis and design. – Applies the acquired theoretical knowledge practically and uses simulation environments for digital signal analysis and processing. – Applies standardized methods and tools specific to the DSP field to carry out the evaluation process of a situation, depending on the problems to be solved, and identify solutions. – Justifies and analyzes coherently and correctly the context of applying the basic knowledge of the DSP field, using key concepts of the course and the specific methodology. – Oral and written communication in Romanian: uses the specific scientific vocabulary of the DSP field to communicate effectively and accurately, both in writing and orally. – Oral and written communication in a foreign language (English): demonstrates understanding and correct application of the vocabulary related to signal processing in a foreign language.
Transversal (General) Competences	– Communicates effectively, especially during practical sessions, coordinating efforts with others to solve medium-complexity problems. – Autonomy and critical thinking: the ability to think scientifically, to independently search for and analyze data, to identify solutions, and to draw and present conclusions. – Analytical and synthetic ability: presents acquired knowledge in a synthetic manner as a result of a systematic analysis process. – Adheres to academic ethics: accurately cites bibliographic sources used in research activities. – Practical application of emotional intelligence: demonstrates appropriate socio-emotional management of academic situations, showing self-control and objectivity in decision-making or stressful situations.

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* – Defines correctly the basic concepts of digital signal processing: sampling and quantization, convolution, causality and stability, digital filter, impulse response, transfer function, frequency response, window function, frequency resolution, etc. – Describes appropriately the fundamental concepts and specific measures for time and frequency domain representations of discrete signals and systems. – Highlights the methods of characterizing digital filters using the z-transform. – Understands and applies Fourier analysis (especially the discrete Fourier transform) for the frequency characterization of discrete, periodic, and aperiodic signals. – Defines and uses the concept of a fast algorithm for the discrete Fourier transform. – Understands the concept of a digital filter and the main synthesis techniques for FIR and IIR digital filters. – Is able to correctly analyze various types of digital filters in the time and frequency domains. – Is able to design various particular digital filter types, especially intended for use in audio applications.
Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* – Selects and groups relevant information in a given context, thus being able to adequately describe various theoretical or practical aspects of DSP. – Uses DSP concepts justifiably to address problems correctly. – Experimentally verifies the identified solutions for the practical resolution of a DSP application. – Formulates correct conclusions about the results of the experiments performed. – Justifies the methods and the solutions used to solve problems.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* – Selects appropriate bibliographic sources and analyzes them. – Respects academic ethics by correctly citing the bibliographic sources used. – Demonstrates receptiveness to new learning contexts. – Collaborates with peers and faculty in conducting educational activities. – Demonstrates autonomy in organizing the learning context and problems to be solved. – Recognizes the value of their contribution to the engineering field in identifying viable solutions to address social and economic problems. – Analyzes business opportunities or entrepreneurial development based on the knowledge acquired in the field of DSP. – Demonstrates time management skills and other real-life situation management abilities.

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

– The coursework is approached in an interactive manner, encouraging active student participation. Both classical teaching methods are used (lecture and exposition), using PowerPoint presentations through multimedia means, as well as interactive ones, based on question-and-answer sessions and student feedback, constantly adapting the pedagogical approach to the students' assimilation and learning possibilities (through additional review of certain notions and concepts, if this proves necessary).

Each meeting begins with a brief recap of the previous chapters, with an emphasis on the concepts covered in the last meeting. The presentations use numerous images and diagrams, so that the information presented is as easy to understand and assimilate as possible. A number of exercises or problems are worked with the students and the homework related to the course chapters is discussed with them.
Complete course materials are available in electronic form on the faculty's Moodle platform.
– Teaching in laboratory sessions is based on oral communication and detailed explanation of the methods used and the results obtained, in a constantly interactive manner. Students independently implement and evaluate the same problems using the computer and software environment. The developed applications help students in developing optimal communication relationships in a climate conducive to learning through discovery.
All laboratory materials are available in electronic form on the faculty's Moodle platform.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	"Introduction" – Generalities. Examples; comparison with analog solutions. Performance and limitations in digital signal processing	2
2	"Time-domain representation of discrete signals and systems" – Discrete-time signals: definition, examples, notation conventions; properties, fundamental operations. Discrete-time systems: linearity and time invariance, convolution; causality and stability; digital filters	3
3	"Frequency-domain representation of discrete signals and systems" – Basic concepts of Fourier analysis. Frequency response of a discrete system; the Fourier transform for discrete-time, aperiodic signals. Sampling and reconstruction of analog signals. Time – frequency duality in digital signal processing	4
4	"Analysis of discrete systems using the z-transform" – The z-transform for discrete-time signals. The inverse z-transform. Characterization of digital filters: transfer function, stability, frequency response; examples	4
5	"The discrete Fourier transform (DFT)" – Fourier representation of finite-duration sequences. The connection between the discrete Fourier transform and the z-transform; "frequency sampling". The discrete Fourier transform for unlimited duration signals. Window functions. Frequency resolution. DFT properties	6
6	"The fast Fourier transform (FFT)" – Discrete Fourier transform computation complexity. Basics of the fast Fourier transform; efficient computation of the DFT. The Cooley-Tukey (decimation-in-time) algorithm. Practical aspects of FFT implementation and optimization techniques	3
7	"Digital filter design" – Basic concepts, classification, frequency domain specifications; from the requirements of an application to the development and testing of a digital filter. Infinite impulse response (IIR) digital filter design. Finite impulse response (FIR) digital filter design. Digital filter structures and representation. Computation complexity of digital filters	6
	Total:	28

Bibliography:
1. D. Burileanu, *Prelucrarea digitală a semnalelor*, lecture notes available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. D. Burileanu, Ș. Mihalache, *Prelucrarea digitală a semnalelor: concepte fundamentale, tehnici avansate, aplicații*, MATRIX ROM, București, 2022, ISBN: 978-606-25-0767-1.
3. A.V. Oppenheim, R.W. Schafer, *Discrete-Time Signal Processing*, 3rd Ed., Pearson, 2010.
4. J.G. Proakis, D.G. Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications*, 5th Ed., Pearson, 2021.
5. S.K. Mitra, *Digital Signal Processing: A Computer-Based Approach*, 4th Ed., McGraw-Hill, 2010.
6. V.K. Madisetti, D.B. Williams (Eds.), *The Digital Signal Processing Handbook*, CRC Press, 1999.

LABORATORY

Crt. no.	**Content**	**No. hours**
1	Introduction to the MATLAB development environment. Generation and time-domain representation of discrete sequences	4
2	Time-domain representation of discrete systems: convolutions, impulse response, stability. Simple digital filters: time-domain response, transfer function, pole-zero diagrams, frequency response	4
3	Frequency-domain representation of discrete-time signals: the Discrete Fourier Transform (DFT), spectral analysis fundamentals, Fast Fourier Transform (FFT)	4
4	Digital filters: synthesis, analysis, implementation	4
5	Various applications of digital signal processing. Digital filters for audio applications	4
6	Additional problems for digital signal processing applications	4
7	Final colloquium	4
	Total:	28

Bibliography:
1. Ș. Mihalache, D. Burileanu, *Prelucrarea digitală a semnalelor – Platforme de laborator*, lab tutorials available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. Ș. Mihalache, D. Burileanu, *Prelucrarea digitală a semnalelor: aplicații fundamentale și avansate folosind MATLAB*, MATRIX ROM, București, 2024, ISBN: 978-606-25-0933-0.
3. D. Burileanu, Ș. Mihalache, *Prelucrarea digitală a semnalelor: concepte fundamentale, tehnici avansate, aplicații*, MATRIX ROM, București, 2022, ISBN: 978-606-25-0767-1.

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Knowledge of fundamental theory and concepts relating to DSP. Understanding how to apply theoretical knowledge to solve domain-specific problems.	Exam during the exam session (written evaluation)	50%
	Knowledge of fundamental theory and concepts relating to DSP. Understanding how to apply theoretical knowledge to solve domain-specific problems.	Test during the semester (written evaluation)	10%

11.5 Seminary/laboratory/project	Understanding fundamental DSP algorithms and techniques. Understanding how to simulate and implement (software) the studied methods using an advanced development environment (MATLAB).	Continuous evaluation (practical and oral evaluation) Final laboratory colloquium (practical and written evaluation)	40%
11.6 Passing conditions			
– Obtaining a grade of at least 50%. – Meeting the general laboratory activity requirements (attending the lab sessions and attempting the final colloquium).			

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

Over the last two decades, the field of digital signal processing (DSP) has undergone a spectacular development, both theoretically and technologically. The ever-increasing market demands for products using DSP techniques can be explained by the fundamental advantage of using the power of numerical computation for the mathematical manipulation of signals, and by the fact that digital integrated circuit manufacturers today offer cheap and highly performant circuits that can efficiently implement complex processing functions. Seen as a cutting-edge field of the beginning of the century and millennium, DSP constantly demands engineers with solid theoretical and practical knowledge.

This course directly responds to the current development and evolution needs of the European economy in the field of Electronic Engineering, providing a fundamental knowledge base in digital signal processing for this area. In the context of the current progress of information technology and electronic devices, the target areas of activity are extremely numerous: communications, medical engineering, instrumentation equipment, geophysics, multimedia technologies, robotics and intelligent interfaces, consumer electronics, etc.

Thus, students are provided with competencies that are adequate to the needs of current qualifications and a modern, quality, and competitive scientific and technical training, which allows them to be quickly employed after graduation. The course is perfectly integrated into the policy of the National University of Science and Technology POLITEHNICA Bucharest, both in terms of content and structure, and in terms of the skills and international openness offered to students. Potential employers target both the academic environment (teaching and research profile) and the research and development environment in state and private institutions that use digital signal processing methods and techniques.

The content of the course is largely similar to that of others with the same objectives taught in universities in the European Union and is continuously updated and adapted following consultations with representatives of the business environment.

Date	Course lecturer	Instructor(s) for practical activities
26.09.2025	Prof. dr. ing. Dragoș BURILEANU	Ș.L. dr. ing. Șerban MIHALACHE

Date of department approval	Head of department
22.10.2025	Prof. Dr. Claudius Dan
Date of approval in the Faculty Council	Dean
	Prof. dr. ing. Radu Mihnea UDREA