SYLLABUS

1. Program information

1.1 Higher education institution	Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Electronics, Telecommunications and Information Technology
1.3 Department	Communications
1.4 Field of study	Electronic engineering, telecommunications and information technologies
1.5 Cycle of study	Bachelor of Science
1.6 Study program / Qualification	Telecommunications technologies and systems / Engineer
1.7 Form of education	IF – full-time education

2. Course information

2.1 Course title	Digital signal processing			Course code	45.00
2.2 Course coordinator	Assoc.Prof. Lăcrimioara-Romana GRAMA, Ph.D. – Lacrimioara.Grama@bel.utcluj.ro				
2.3 Seminar/ laboratory/ project/ practical activity coordinator	Eng. Carla-Mihaela BULZESCU – Carla.Bulzescu@bel.utcluj.ro				
2.4 Year of study	IV	2.5 Semester	1	2.6 Type of assessment	E
2.7 Course status	Formative category				DF
	Optionality				DOB

3. Estimated total time

3.1 Hours per week	4	of which:	3.2 Lecture	2	3.3 Seminar	0	3.3 Laboratory	2	3.3 Project	0	3.3 Practical training	0
3.4 Hours per semester	56	of which:	3.5 Lecture	28	3.6 Seminar	0	3.6 Laboratory	28	3.6 Project	0	3.3 Practical training	0

3.7 Time distribution (hours per semester) for individual study and assessment:	
(a) Assessment	3
(b) Study using textbook, course materials, bibliography, and notes	20
(c) Additional documentation in the library, on specialized electronic platforms, and in the field	6
(d) Preparation for seminars/laboratories, assignments, reports, portfolios and essays	12
(e) Tutoring	3
(f) Other activities	0

3.8 Total hours of individual study and assessment (sum of (3.7(a)...3.7(f))	44
3.9 Total hours per semester (3.4+3.8)	100
3.10 Number of credits	4.0

4. Prerequisites (where applicable)

4.1 curriculum	Mathematical Analysis, Linear Algebra, Applied Informatics, Special Mathematics, Differential Equations, Electronic Devices, Computer-Aided Graphics, Signals and Systems, Digital Integrated Circuits, Circuit Analysis and Synthesis, Digital Integrated Circuit Systems, Software Engineering
4.2 competencies	Basic knowledge of signals and systems, complex numbers, mathematical series and transforms; matrix computation and programming skills; basic use of the MATLAB environment

5. Requirements (where applicable)

5.1. for the development of the lecture	Lecture room equipped with blackboards, computer and video projector, with Internet access. Electronic devices may be used for educational purposes.
5.2. for the development of the seminar/ laboratory/ project	Laboratory equipped with computers, a blackboard and a video projector/interactive whiteboard; Internet access; access to MATLAB Online; a MathWorks account and access to MATLAB Drive and Microsoft Teams. The laboratory material must be studied in advance, and the assigned tasks must be completed during the laboratory session.

6. Specific competencies acquired

Professional competencies	C2. Applying the basic methods for the acquisition and processing of signals C2.1 Temporal, spectral and statistical characterization of signals C2.2 Explaining and interpreting the methods of signal acquisition and processing C2.3 Use of simulation media for signal analysis and processing C2.4 Use of specific methods and tools for signal analysis C2.5 Design of basic functional blocks for digital signal processing with hardware and software implementation C3. Application of the basic knowledge, concepts and methods regarding the architecture of computer systems, microprocessors, microcontrollers, languages and programming techniques C3.1 Description of the functioning of a computing system, of the basic principles of the architecture of general-purpose microprocessors and microcontrollers, of the general principles of structured programming C3.2 Use of general-purpose and specific programming languages to microprocessor and microcontroller applications; explaining the functioning of automatic control systems that use these architectures and interpreting experimental results C3.3 Solving concrete practical problems including elements of data structures and algorithms, programming and use of microprocessors or microcontrollers C3.4 Elaboration of programs in a general and/or specific programming language, starting from the specification of the requirements to the execution, debugging and interpretation of the results in correlation with the processor used C3.5 Development of projects involving hardware components (processors) and software components (programming)

Transversal competencie	

7. Expected learning outcomes

Knowledge	- The student/graduate identifies and describes basic concepts, principles and methods in mathematics, physics, chemistry, technical drawing, economics and computer science.
Skills	- The student/graduate operates with basic concepts, principles and methods in mathematics, physics, chemistry, technical drawing, economics and computer science. - The student/graduate performs engineering and economic calculations of medium complexity and associates them with graphical/alphanumeric representations or with representations specific to computer-aided design. - The student/graduate describes physico-chemical and economic phenomena and processes.
Responsibility and autonomy	- The student/graduate applies the values of ethics and professional deontology specific to the engineering profession. - The student/graduate applies logical reasoning, evaluation and self-assessment in decision-making. - The student/graduate communicates effectively about engineering activities with a wide range of audiences. - The student/graduate is engaged in lifelong learning in order to acquire and implement knowledge, as needed, using appropriate learning strategies. - The student/graduate promotes dialogue, cooperation, respect for others and interculturality. - The student/graduate works effectively as a team member or as a team leader. - The student/graduate fluently uses at least one international language in technical communication.

8. Course objectives (based on the grid of specific competencies acquired)

8.1 General objective of the course	To develop students' ability to characterize, analyze, design, and implement digital signal processing algorithms and systems using time-domain, *z*-domain, and frequency-domain representations, as well as specialized software tools.
8.2 Specific objectives	- to represent, classify, and process discrete-time signals and to characterize discrete-time systems, particularly LTI systems; - to determine the response of LTI systems using convolution, constant-coefficient difference equations, and the *z*-transform, and to assess their causality and stability; - to use the Fourier series, Fourier transform, DFT, and FFT for the spectral analysis and interpretation of signals;

	- to relate pole-zero locations and the frequency response to the properties and behavior of digital systems; - to design FIR and IIR digital filters based on given specifications; - to select and compare appropriate implementation structures for FIR and IIR systems; - to implement and verify signal analysis and processing algorithms in MATLAB and to critically interpret the results obtained.

9. Contents

9.1 Lecture	No. of hours	Teaching methods	Remarks
Introduction to digital signal processing. The concept of frequency for continuous-time and discrete-time signals; normalized frequency; sampling and aliasing.	2	Interactive lecture and heuristic discussion; explanation and demonstration; problem-based learning and guided deduction; problem solving and analysis of alternative strategies; numerical examples and case studies; MATLAB demonstrations; formative questions and quizzes with immediate feedback.	Course materials, problems and supplementary resources are available on the course webpage and in Microsoft Teams. MATLAB demonstrations and formative activities are used for selected topics. Students are encouraged to study the materials and solve the proposed problems throughout the semester.
Discrete-time signals and systems. Elementary signals, classifications and operations. LTI systems and the convolution sum.	2		
Analysis of discrete-time LTI systems. Causality and stability; signal correlation; FIR and IIR systems; free and forced responses.	2		
Direct forms for discrete-time systems. LTI systems described by constant-coefficient difference equations; impulse response and stability.	2		
Bilateral and unilateral *z*-transforms. Region of convergence, poles and zeros, transfer function and inverse *z*-transform.	2		
Analysis of LTI systems in the *z*-domain. Transient and steady-state responses; causality and stability; Fourier series for periodic discrete-time signals.	2		
Fourier transform for aperiodic discrete-time signals. Properties and frequency-domain characteristics of LTI systems.	2		
Discrete Fourier transform. Properties; circular and linear convolution; zero-padding, frequency resolution. and spectral leakage.	2		
Fast Fourier transform. Radix-2 decimation-in-time and decimation-in-frequency FFT algorithms; split-radix algorithms.	2		
Discrete-time LTI systems viewed as frequency-selective filters. Pole-zero placement; linear-phase FIR filters.	2		
Digital filter design. Specifications and approximation; FIR filter design using the window method and the	2		

9.1 Lecture	**No. of hours**	**Teaching methods**	**Remarks**
frequency-sampling method; indirect IIR filter design methods.			
Direct methods for IIR filter design. Padé approximation. Implementation of FIR systems in direct, cascade, and lattice forms.	2		
Implementation of IIR systems. Direct forms, cascade and parallel structures, lattice and lattice-ladder structures; comparison of realization structures.	2		
Integrated review of the course topics and solving comprehensive problems in preparation for the final assessment.	2		

Bibliography

[1] *Course webpage* (lecture slides, solved problems, proposed problems): https://sp.utcluj.ro/Teaching_4TTS.html
[2] *Microsoft Teams* (materials, anouncements și and formative activities).
[3] J. G. Proakis, D. G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 5th ed., Pearson, 2022.

Additional references:

[4] C. Rusu, L. Grama, *Lecture notes in digital signal processing*, Ed. Risoprint, 2009.
[5] C. Rusu, *Prelucrarea numerică a semnalelor*, Ed. Risoprint, 2002.
[6] C. Rusu, *Prelucrări digitale de semnale*, Ed. Risoprint, 2000.
[7] D. Sundararajan, Digital Signal Processing: An Introduction, 2nd ed., Springer, 2024.
[8] P. P. Vaidyanathan, Signals, Systems, and Signal Processing, Cambridge University Press, 2024.
[9] T. Holton, *Digital Signal Processing: Principles and Applications,* Cambridge University Press, 2021.
[10] R. Allred, *Digital Filters for Everyone*, Creative Arts & Sciences House, 3rd ed, 2015.
[11] S. Smith, *Digital Signal Processing: A Practical Guide for Engineers and Scientists*, Newnes, 1st ed, 2013.
[12] A. V. Oppenheim, R. W. Schafer, *Discrete-Time Signal Processing*, Pearson, 3rd ed, 2009.

9.2 Seminar /laboratory /project /practical training	**No. of hours**	**Teaching methods**	**Remarks**
Brief introduction to MATLAB for digital signal processing.	2	Introductory explanation and demonstration; learning by doing; guided individual work; modelling and simulation in MATLAB; numerical and symbolic computation; verification, graphical representation and interpretation of results; ongoing feedback.	Materials are studied before the activity. Tasks are completed individually in MATLAB Online and are finalized, validated and discussed during the laboratory session. The laboratory material and exercises are available in MATLAB Drive.
The most commonly used discrete-time signals in digital signal processing.	2		
Sampling and reconstruction of analog signals. Correlation of discrete-time signals.	2		
Discrete-time linear time-invariant systems.	2		
The *z*-transform. Analysis of discrete-time LTI systems in the *z*-domain.	2		
Practical assessment 1 – Week 6.	2	Individual practical assessment in MATLAB, based on two application-oriented tasks; verification of the code,	A 30-minute practical test. The remaining time is used for feedback and for completing or

9.2 Seminar /laboratory /project /practical training	No. of hours	Teaching methods	Remarks
		results and their interpretation.	discussing the laboratory activities.
Fourier transform and discrete Fourier transform.	2	Explanation and demonstration; guided exercises; modelling, design, simulation and comparative analysis in MATLAB; verification and interpretation of results; ongoing feedback.	Materials are studied before the activity. Tasks are completed individually in MATLAB Online and are finalized, validated and discussed during the laboratory session. The laboratory material and exercises are available in MATLAB Drive.
Linear convolution and circular convolution.	2		
Design of finite impulse response filters.	2		
Discrete-time LTI systems viewed as frequency-selective filters.	2		
Design of infinite impulse response filters.	2		
Practical assessment 2 – Week 12.	2	Individual practical assessment in MATLAB, based on two application-oriented tasks; verification of the code, results and their interpretation.	A 30-minute practical test. The remaining time is used for feedback and for completing or discussing the laboratory activities.
Seminar: solving review problems and addressing students' questions — Weeks 13–14.	4	Guided and independent problem solving; heuristic discussion; feedback and clarification.	Integrated review and discussion of students' questions; no new content is introduced.

Bibliography

[1] Laboratory materials available in MATLAB Drive and on the course webpage: https://sp.utcluj.ro/Teaching_4TTS.html
[2] MathWorks, MATLAB and Signal Processing Toolbox Documentation, continuously updated online resource.
Additional references:
[3] L. Grama, *digital Signal Processing – laboratory guide*, Ed. UTPRESS, 2014.
[4] O. Alkin, *Discrete-Time Signals and Systems: A MATLAB Integrated Approach*, 2nd ed., CRC Press, 2025.
[5] P. P. Vaidyanathan, Signals, Systems, and Signal Processing, Cambridge University Press, 2024.
[6] D. Sundararajan, Digital Signal Processing: An Introduction, 2nd ed., Springer, 2024.
[7] S. L. Marple Jr., *Digital Spectral Analysis MATLAB® Software User Guide*, Dover Publications, 2019.
[8] L. Chaparro, *Signals and systems using MATLAB*, Academic Press, 2nd ed, 2014.
[9] M. X. Cohen, *Fundamentals of time-Frequency analyses in Matlab/Octave*, sinc(x) Press, 1st ed, 2014.
[10] S. K. Mitra, *Digital signal processing – a computer-based approach*, McGraw-Hill, 4th ed., 2010.
[11] L. Grama, C. Rusu, *Prelucrarea numerică a semnalelor – aplicaţii şi probleme*, Ed. UTPRESS, 2008.
[12] L. Grama, A. Grama, C. Rusu, *Filtre numerice – aplicaţii şi probleme*, Ed. UTPRESS, 2008.

10. Alignment of the course contents with the expectations of the epistemic community, professional associations, and representative employers in the field related to the program

The course content and the teaching-learning-assessment methods are aligned with the current requirements of the Electronics, Telecommunications, and Information Technology Engineering field, considering the expectations of the academic and professional community, representative employers, as well as the national quality assurance standards in higher education. The course helps prepare students in line with employer expectations and the quality requirements set for engineering study programs.

11. Assessment

Activity type	**11.1 Assessment criteria**	**11.2 Assessment methods** (and type of assessment: continuous/ summative)	**11.3 Weight in final grade**
11.4 Lecture	- correct understanding and use of fundamental concepts and relationships; - modelling and analysis of signals and systems in the time, z and frequency domains; - selection of the appropriate method, accuracy of calculations and justification of the solution steps; - stability analysis, filter design and engineering interpretation of the results.	Written examination, summative assessment: three problems, duration: two hours. The assessment covers signal and system analysis, the use of transforms, and the design or implementation of filters. Quizzes and class participation may earn bonus points, up to a maximum final grade of 10, without changing the assessment weights.	**75%**
11.5 Seminar/ Laboratory/ Project /Practical activity	- correct and clear implementation of the required algorithms in MATLAB; - appropriate use of functions and graphical representations; - validation of the results against the theoretical model or by using alternative methods; - interpretation of the results and identification of computational or programming errors.	Two individual practical assessments in MATLAB, as continuous assessment, each lasting 30 minutes and held in Weeks 6 and 12; each assessment consists of two application-oriented tasks. The practical assessment grade, PA, is the average of the two assessments. Laboratory activity may earn bonus points, up to a maximum final grade of 10, without replacing the practical assessments.	**25%**
11.6 Minimum performance standard **Weighted average: WA = 0.75 · WE + 0.25 · PA**, where **WE** is the written examination grade and **PA** is the average grade of the practical assessments. **Requirements for passing: WE ≥ 4** and **WA ≥ 4.5**, so that the final grade awarded is at least 5. Bonus points cannot compensate for failure to meet the requirement **WE ≥ 4**. **Minimum theoretical standard:** correct selection and application of the fundamental methods for signal and system analysis, or design method, and interpretation of the result. **Minimum practical standard:** completion of the basic tasks in MATLAB, obtaining valid results, and providing an essential interpretation of those results.			

Completion date:	Course coordinators	teaching rank, title First name LAST NAME	Signature
23.06.2026	Lecture	Assoc.Prof. Lăcrimioara-Romana GRAMA, Ph.D.	
	Applications	Eng. Carla-Mihaela BULZESCU	

Approval of the Head of the Department coordinating the course, only if this differs from the department organizing the study program	Head of the Bases of Electronics Department Prof. Sorin HINTEA, Ph.D.

Date of approval by the Council of the Department of Communications 26.06.2026	Head of the Communications Department Prof. Virgil DOBROTĂ, Ph.D.
Date of approval by the Council of the Faculty of Electronics, Telecommunications and Information Technology 30.06.2026	Dean, Prof. Ovidiu-Aurel POP, Ph.D.