L.EEC025 - Fundamentals of Signal Processing (FunSP)
2025/2026 – 1st semester

Lectures (T): **2 × 1 h/week (1 class of ± 210 students)**
Lab classes (PL): **2 h/week (9 classes of ± 22 students each)**

Week-by-week Lectures/PL planning (13 weeks)

Week 1, Sept 15-19, 2025

Lectures/videos:

- Curricular Unit presentation.
- Characterization and representation of discrete-time signals and systems.
- Linear and shift-invariant systems (LSI).
- Deterministic and discrete-time random signals.
- Special forms of the discrete-time convolution: the auto-correlation and the cross-correlation.
  - illustrative exercise solving

PL:

- Intro to Matlab, review of the discrete-time convolution.

Week 2, Sept 22-26, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (discrete-time signals/systems)
→ DSP Lab

Lectures/videos:

- Introduction to the frequency-domain representation of discrete-time signals and systems.
- The discrete-time Fourier transform (DTFT). DTFT properties. DTFT transform pairs.
- The DTFT of the auto-correlation and of the cross-correlation.
  - illustrative exercise solving

PL:

- Organization of groups of 4 students for AD purposes (throughout the semester).
- Getting started with the STM32F7 Discovery kit (to be used in all FunSP Lab classes).

Week 3, Sept 29 – Oct 03, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (DTFT, AC/CC)
→ DSP Lab

Lectures/videos:

- Sampling and reconstruction of signals.
- Frequency-domain interpretation of sampling.
- The sampling theorem and aliasing.
- Discrete-time processing of continuous-time signals.
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab**: Generation on the STM32F7 kit of deterministic signals (LUT-based) and random signals. Viewing program output.

Week 4, Oct 06-10, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (sampling/reconstruction signals)
→ DSP Lab

Lectures/videos:

- The direct Z-Transform. Causality and stability conditions.
- Information associated with the distribution of poles and zeros in the Z-plane.
- Z-Transform pairs.
- Characterization in the Z domain of FIR and IIR discrete-time systems (time permitting)
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab**: Understanding sampling and reconstruction with the STM32F7 kit.

Week 5, Oct 13-17, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (Z-Transform)
→ DSP Lab

Lectures/videos:

- The inverse Z-Transform. Z-Transform properties.
- The Z-Transform of the auto/cross-correlation functions.
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab**: Measuring the frequency response of a moving average filter running in real-time on the STM32F7 kit.

Week 6, Oct 20-24, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (Z-Transform)
→ DSP Lab

Lectures/videos:

- Characterization of LSI systems in the frequency-domain.
- Frequency-domain selectivity.
- Phase response, phase distortion and group delay.
- Inverse systems. All-pass systems.
- Minimum-phase systems, linear-phase and maximum-phase systems.
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab** on “comparison between DMA-based and interrupt-based transfer of individual samples”

FEUP week (Oct 27– 31)

Week 7, Nov 03-07, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (LSI systems in frequency-domain)
→ DSP Lab

Lectures/videos:

- FIR linear-phase systems.
- Structures for the realization of IIR filters.
- Structures for the realization of FIR filters.
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab**: "FIR and IIR comb filters".

Week 8, Nov 10-14, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (LSI systems in frequency-domain)
→ DSP Lab

Lectures/videos:

- Design of IIR filters using the impulse invariance and bilinear transformation methods.
- Design of FIR filters using the window method and the MinMax optimization methods.
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab** on "test of 2^{nd}-order IIR filters: an All-Pole and an All-Pass filter".

Week 9, Nov 17-21, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (IIR/FIR filter realiz. structures)
→ DSP Lab

Lectures/videos:

- The Discrete Fourier Transform (DFT). Analysis and synthesis equations.
- The DFT as a frequency-domain sampling of the DTFT.
- The circular/periodic properties of the DFT.
- Relationship between the circular convolution and the linear convolution.
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab:** on "design, realization and test of FIR filters".

Week 10, Nov 24-28, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (IIR/FIR filter design)
→ DSP Lab

Lecture/videos:

- The computation of the DFT using the Fast Fourier Transform (FFT).
- The DFT-DIT and DFT-DIF algorithms.
- Programming of the FFT.
- Efficient FFT computation of real-valued signals.
- Fast FIR filtering in the frequency domain using the FFT (time permitting)
- The overlap-add and overlap-save methods (time permitting)
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab**: on "design and implementation of a discrete-time differentiator and Hilbert Transformer".

Week 11, Dec 02-05, 2025

Distributed Assessment
→ Short quiz in Lecture

Lecture/videos:

- The computation of the auto/cross-correlation using the DFT/FFT.
- Introduction to spectrum estimation using the DFT/FFT.
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab** on "6th-order IIR band-stop filter".

Week 12, Dec 09-12, 2025

Distributed Assessment
→ Short quiz in Lecture

Lecture/videos:

- The periodogram, average spectrum, and spectrogram.
- Introduction to adaptive filtering.
  - illustrative exercise solving

PL:

- Exercise solving.
- **DSP Lab**: on "FFT and power spectrum".

Week 13, Dec 15-19, 2025

Distributed Assessment
→ Short quiz in Lectures
→ VQ in Lab (DFT filterbank, spectrogram)
→ DSP Lab

Lectures/videos:

- Applications of signal processing
- Course wrap-up and feedback

PL:

- Exercise solving.
- **DSP Lab** on “system identification with adaptive filtering”.