

# **ECE 310 Spring 2026**

## **Course Learning Objectives**

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### **About this document**

This document provides a summary of the learning objectives from this course to help students prepare for the final exam. We split up the course into seven major units and aggregate the learning objectives from the lecture notes relevant to each topic. Note that this document is not necessarily an exhaustive list of concepts to study for the final, but a good summary to determine how comfortable you are with the main areas and topics of the course. Lecture numbers for each set of topics are with respect to the lecture notes for Section E (3pm section). Any lectures not listed below will not be covered on the final, e.g. Lectures 12 and 24.

## **1 LTI discrete-time systems, impulse response, convolution**

**(Lectures 1–5)**

### **Learning objectives**

1. Describe what defines a signal and explain the difference analog vs. digital signals and systems.
2. Explain what defines a complex number, be able to identify the magnitude and phase of a complex number, and visualize them on the complex plane.
3. Convert between rectangular and polar forms of complex numbers and state Euler's identities for complex numbers.
4. Interpret and visualize common discrete-time signals including Kronecker delta and unit step.
5. State the conditions for a systems to be linear, time-invariant, and causal.
6. State the definition of a system being bounded-input bounded-output (BIBO) stable.
7. Prove whether a given discrete-time system is linear, time-invariant, causal, or stable.
8. Define the impulse response of a discrete-time system.
9. Define and compute the convolution between two discrete-time signals.
10. Apply key properties of convolution including the if-and-only-if relationship between (1) system being LTI, (2) system response described by convolution, and (3) system response being fully described by its impulse response (refer to Lecture 4, Figure 1).
11. Interpret LTI systems defined by a Linear Constant-Coefficient Difference Equation (LCCDE).

## 2 $z$ -transform

(Lectures 6–11)

### Learning objectives

1. Define the  $z$ -transform of a discrete-time signal and explain the significance of the region of convergence (ROC) for a  $z$ -transform.
2. Identify the poles and zeros of a  $z$ -transform and interpret the corresponding pole-zero plot.
3. Compute the  $z$ -transform by inspection using a table of transform pairs and applying key properties of the  $z$ -transform.
4. Write the common forms for the  $z$ -transform of finite-length and infinite-length signals.
5. Compute the inverse  $z$ -transform of a given rational expression in the  $z$ -domain using partial fraction expansion and inspection.
6. Compute the response of an LTI system to an input signal using the  $z$ -transform.
7. Write the transfer function of an LTI system described by an LCCDE.
8. Identify FIR and IIR systems based on characteristics of an LCCDE or transfer function.
9. Use  $z$ -transform properties and system algebra to compute the response of a larger LTI system composed of multiple LTI systems.
10. Explain the conditions for an LTI system to be BIBO stable using: the definition of BIBO stability, impulse response, or  $z$ -transform.
11. Define what makes causal and non-causal LTI systems in the  $z$ -domain.
12. Identify bounded inputs that cause unstable systems to yield unbounded outputs.

## 3 Discrete-time Fourier transform

(Lectures 13–16)

### Learning objectives

1. Explain what defines a periodic function, including continuous-time and discrete-time complex exponential signals.
2. Explain what the continuous-time Fourier transform and discrete-time Fourier transform represent for a given analog or digital signal, respectively
3. Compute the discrete-time Fourier transform of a discrete-time signal or show that it does not exist.
4. Explain the relationship between the  $z$ -transform and the DTFT.
5. Apply key properties of the DTFT to compute transform pairs and analyze signals in both the time-domain and frequency-domain.
6. Compute the response of LTI systems to periodic complex exponential and sinusoidal input signals.
7. Describe and evaluate the response of LTI systems to aperiodic input signals using the DTFT.
8. Compute and plot the magnitude response of an LTI system.
9. Compute and plot the phase response of an LTI system.

## 4 Sampling, A/D conversion, D/A conversion

(Lectures 17–19, 32)

### Learning objectives

1. State and sketch the resulting DTFT of a discrete-time signal obtained via ideal sampling of a continuous-time signal.
2. Demonstrate how changes to the sampling rate will affect the resulting DTFT of the obtained discrete-time signal.
3. Explain Nyquist criterion for sampling bandlimited continuous-time signals.
4. Identify the Nyquist rate of a continuous-time signal.
5. Explain ideal digital-to-analog conversion using sinc interpolation.
6. Describe ideal digital-to-analog conversion in the frequency domain via ideal low-pass filtering.
7. Define and identify the aliasing effect when sampling bandlimited continuous-time signals using Nyquist criterion.
8. Demonstrate how sampling below the Nyquist rate aliases sinusoidal signals in the time-domain and frequency-domain.
9. Explain the practical issues with ideal digital-to-analog conversion.
10. Demonstrate how a zero-order hold analog-to-digital conversion scheme provides a practical solution for reconstructing analog signals, including the use of upsampling prior to D/A conversion.
11. Determine the available transition bandwidth for the analog reconstruction filter in an upsampled ZOH digital-to-analog conversion scheme.

## 5 Discrete Fourier Transform

(Lectures 20–23, 25, 26)

### Learning objectives

1. Explain why the DTFT is intractable to compute and store in practice and why this motivates using the DFT.
2. Explain the relationship between the DTFT and the DFT, and describe how the two transforms are different.
3. Explain and apply DFT properties for analyzing signals in both the time-domain and DFT-domain.
4. Understand the circular convolution property of the DFT and perform circular convolution of finite-length sequences.
5. State the DTFT spectrum of a finite-length sinusoidal signal and how the length of the signal affects the corresponding DFT.
6. Explain what zero-padding is and how it helps better visualize the DFT of a discrete-time signal.
7. Identify the key challenges in performing spectral analysis including the varying amplitudes and distances between sinusoidal components.
8. Describe how the choice of window function can affect spectral analysis.

9. Explain the trade-offs between common window functions, e.g. rectangular and Hamming windows.
10. Explain the computational complexity of directly computing the DFT according to the summation or matrix formulation vs. the complexity of the fast Fourier transform.
11. Apply the merging equations of the decimation-in-time fast Fourier transform to compute the DFT a short sequence.
12. Draw decimation-in-time butterfly diagrams for short sequences.
13. Explain the computational complexity of performing convolution in the time-domain.
14. Understand how we may compute linear convolution by using the circular convolution and the DFT.

## 6 Digital filter design

(Lectures 27–29)

### Learning objectives

1. Explain what defines common ideal digital filter types including low-pass, band-pass, and high-pass filters.
2. Discuss the practical limitations of implementing ideal digital filters.
3. Define and explain the significance of group delay using the phase response.
4. Describe the key features of a practical LTI filter's magnitude response including passband, stopband, and transition band.
5. Understand the key design tradeoffs and desirable features in practical filter design.
6. Draw the direct form I and direct form II block diagrams of a filter described by an LCCDE.
7. Explain what defines linear-phase FIR filters using group delay.
8. Identify the four types of linear-phase filters.
9. Describe the difference between linear-phase and generalized linear-phase FIR filters.
10. Apply the window method of FIR filter design and understand the tradeoffs of different window choices for low-pass filter design.
11. Create high-pass, band-pass, and band-stop filters by modifying an appropriately designed low-pass filter.

## 7 Multirate signal processing

(Lectures 30–31)

### Learning objectives

1. State how downsampling by a given integer factor changes a signal in the time-domain and frequency-domain.
2. Explain the importance of an anti-aliasing filter in a downsampling system.
3. Understand why downsampling and digital rate conversion in general is an important application of digital signal processing.

4. Describe how upsampling affects a signal in the time-domain and frequency-domain.
5. Explain the structure and reasoning for using an interpolation filter in an upsampling system.
6. Implement a non-integer rate conversion scheme using interpolator and decimator systems.