ECE 260: Optional Textbook

1 Introduction

If you would like extra reference material beyond that contained in the required references for the course, you might wish to obtain a copy of the following **optional** textbook:

A. V. Oppenheim and A. S. Willsky with S. H. Nawab, Signals & Systems, 2nd edition, Prentice Hall, 1997 (ISBN 0-13-814757-4).

This is one of the best introductory textbooks on signals and systems, covering both the continuous-time and discrete-time cases. Although, in this course, we focus almost exclusively on the continuous-time case, the discrete-time material will still be useful for reference purposes in later courses. For example, the discrete-time case will be covered in detail in ECE 310 (Digital Signal Processing I). This textbook will also be a useful reference for courses such as ECE 350 (Communications Theory and Systems I) and ECE 360 (Control Theory and Systems I) amongst others.

2 Relationship Between Optional Textbook and Major Course Topics

The correspondence between chapters in the optional textbook and major course topics should be self-evident in most cases, as the correspondence is almost one to one. Perhaps, the only comment that needs to made in this regard is that Chapters 6 and 8 in the optional textbook are essentially Fourier transform material, and thus correspond to the Fourier transform topic in the course.

3 Material Covered

In what follows, the material covered in the course is identified, broken down by chapter in the optional textbook.

Chapter 1: Signals and Systems

This chapter contains material on both continuous-time and discrete-time signals/systems. We do not cover the discrete-time material in this course, except for a few very basic concepts (as noted below). We do cover the following material:

- Section 1.0: Introduction (p. 1)
- Section 1.1: Continuous-Time and Discrete-Time Signals (pp. 1–7)
  - both continuous-time and discrete-time
  - skip signal power
- Section 1.2: Transformations of the Independent Variable (pp. 7–14)
  - skip discrete-time material, except definitions of even and odd discrete-time signal
- Section 1.3: Exponential and Sinusoidal Signals (pp. 14–30)
  - skip sections 1.3.2, 1.3.3
- Section 1.4: The Unit Impulse and Unit Step Functions (pp. 30–38)
  - continuous-time case only
- Section 1.5: Continuous-Time and Discrete-Time Systems (pp. 38–43)
  - continuous-time case only
- Section 1.6: Basic System Properties (pp. 44–56)
  - continuous-time case only
- Mathematical Review (p. 71)

Chapter 2: Linear Time-Invariant Systems

This chapter contains material on both continuous-time and discrete-time signals/systems. We do not cover any of the discrete-time material from this chapter. We do cover the following:

- Section 2.0: Introduction (pp. 74–75)
- Section 2.2: Continuous-Time LTI Systems: The Convolution Integral (pp. 90–102)
- Section 2.3: Properties of Linear Time-Invariant Systems (pp. 103–116)
  - continuous-time case only

Chapter 3: Fourier Series Representation of Periodic Signals

This chapter considers the Fourier series representation of both continuous-time and discrete-time signals. We only cover the continuous-time case in this course. In particular, we cover the following material from this chapter:

- Section 3.0: Introduction (pp. 177–178)
- Section 3.1: A Historical Perspective (pp. 178–182)
  - for interest only
- Section 3.2: The Response of LTI Systems to Complex Exponentials (pp. 182–186)
  - continuous-time case only
- Section 3.3: Fourier Series Representation of Continuous-Time Periodic Signals (pp. 186–195)
- Section 3.4: Convergence of the Fourier Series (pp. 195–201)
- Section 3.5: Properties of Continuous-Time Fourier Series (pp. 202–211)
  - linearity, time shifting, time reversal only
- Section 3.8: Fourier Series and LTI Systems (pp. 226–231)
  - continuous-time case only
- Section 3.9: Filtering (pp. 231–239)
  - continuous-time case only

Chapter 4: The Continuous-Time Fourier Transform

We cover all of the material in this chapter, namely:

- Section 4.0: Introduction (pp. 284–285)
- Section 4.1: Representation of Aperiodic Signals: The Continuous-Time Fourier Transform (pp. 285–296)
- Section 4.2: The Fourier Transform for Periodic Signals (pp. 296–300)
- Section 4.3: Properties of the Continuous-Time Fourier Transform (pp. 300–314)
- Section 4.4: The Convolution Property (pp. 314–322)
- Section 4.5: The Multiplication Property (pp. 322–327)
- Section 4.6: Tables of Fourier Transform Properties and of Basic Fourier Transform Pairs (pp. 328–330)
- Section 4.7: Systems Characterized by Linear Constant-Coefficient Differential Equations (pp. 330–333)

Chapter 6: Time and Frequency Characterization of Signals and Systems

This chapter examines how the Fourier transform can be used to analyze LTI systems. We cover the following small subset of material from this chapter:

- Section 6.0: Introduction (p. 423)
- Section 6.1: The Magnitude-Phase Representation of the Fourier Transform (pp. 423–427)
  - continuous-time only
- Section 6.2: The Magnitude-Phase Representation of the Frequency Response of LTI Systems (pp. 427–439)
  - skip sections 6.2.1, 6.2.2, 6.2.3
- Section 6.3: Time-Domain Properties of Ideal Frequency-Selective Filters (pp. 439–444)
  - continuous-time only

Chapter 7: Sampling

This chapter looks at the Fourier transform in the context of sampling and interpolation. We cover (time permitting) the following subset of material from this chapter:

- Section 7.0: Introduction (pp. 514–515)

- Section 7.1: Representation of a Continuous-Time Signal By Its Samples: The Sampling Theorem (pp. 515–522)
- Section 7.2: Reconstruction of a Signal From Its Sample Using Interpolation (pp. 522–527)
- Section 7.3: The Effect of Undersampling: Aliasing (pp. 527–534)

Chapter 8: Communication Systems

This chapter looks at the Fourier transform in the context of communication systems. We cover (time permitting) the following small subset of material from this chapter:

- Section 8.0: Introduction (pp. 582–583)
- Section 8.1: Complex Exponential and Sinusoidal Amplitude Modulation (pp. 583–587)
- Section 8.2: Demodulation for Sinusoidal AM (pp. 587–594)
  - synchronous demodulation only, skip section 8.2.2
- Section 8.4: Single-Sideband Sinusoidal Amplitude Modulation (pp. 597–601)
  - do not cover in detail (this material is mostly for interest)

Chapter 9: The Laplace Transform

We cover most of the material in this chapter, including the following:

- Section 9.0: Introduction (p. 654)
- Section 9.1: The Laplace Transform (pp. 655–662)
- Section 9.2: The Region of Convergence for Laplace Transforms (pp. 662–670)
- Section 9.3: The Inverse Laplace Transform (pp. 670–673)
- Section 9.5: Properties of the Laplace Transform (pp. 682–692)
- Section 9.6: Some Laplace Transform Pairs (pp. 692–693)
- Section 9.7: Analysis and Characterization of LTI Systems Using the Laplace Transform (pp. 693–706)
  - skip Butterworth filters
- Section 9.8: Some Function Algebra and Block Diagram Representations (pp. 706–713)
- Section 9.9: The Unilateral Laplace Transform (pp. 714–720)

Appendix A: Partial-Fraction Expansion

We cover most of the material in this appendix, namely:

- Section A.1: Introduction (pp. 909–910)
- Section A.2: Partial-Fraction Expansion and Continuous-Time Signals and Systems (pp. 910–916)

4 Additional Practice Problems

Some students may want additional practice problems beyond those contained in the required references for the course. The optional textbook provides a vast wealth of such problems. Since not all of the material in the optional textbook is covered in the course, the problems that a student should have the necessary background to complete are identified below. In the list below, the problems marked with an asterisk (i.e., "$*$") are particularly good problems to try. In particular, these problems might be helpful in preparing for the final exam and/or midterm exams.

Chapter 1: Signals and Systems

1.1, 1.2*, 1.5*, 1.6 a, 1.7 bd, 1.8, 1.9 ab, 1.10*, 1.17*, 1.19 a*, 1.20 ab, 1.21* bcd, 1.23 a, 1.25, 1.27* abcdefg, 1.30* abdhjl, 1.31* ab, 1.32, 1.38 a, 1.40, 1.42 ab, 1.43 a (continuous-time case only), 1.44 abc
complex numbers: 1.48, 1.49*, 1.50, 1.51, 1.52*, 1.53*

Chapter 2: Linear Time-Invariant Systems

2.8*, 2.9, 2.10, 2.11, 2.14*, 2.16 c, 2.20 b, 2.22* abcde, 2.23, 2.27, 2.29*, 2.40*, 2.42, 2.44 ad, 2.45 abcd, 2.46, 2.47, 2.48 abefg, 2.50

Chapter 3: Fourier Series Representations of Periodic Signals

3.1, 3.3*, 3.4*, 3.5, 3.6*, 3.8, 3.13, 3.15*, 3.17, 3.19, 3.20, 3.21, 3.22* abc, 3.23, 3.24, 3.25, 3.26*, 3.34, 3.35*, 3.40, 3.41, 3.42, 3.43, 3.44, 3.45, 3.46, 3.47*, 3.61, 3.62, 3.63, 3.64

Chapter 4: The Continuous-Time Fourier Transform

any questions from the list: 4.1–4.47
4.21*, 4.22* abd, 4.32* abcd, 4.33* abc, 4.34* abc, 4.36* abc, 4.44* ab

Chapter 6: Time and Frequency Characterization of Signals and Systems

6.1, 6.3 a, 6.5, 6.21* abcd, 6.22* ab, 6.23, 6.26* abc, 6.33 ab

Chapter 7: Sampling

7.1*, 7.2, 7.3*, 7.4, 7.5, 7.6*, 7.7, 7.8*, 7.9, 7.10, 7.21*, 7.22*, 7.26, 7.27

Chapter 8: Communication Systems

8.1, 8.2, 8.3, 8.4*, 8.6, 8.8, 8.22*

Chapter 9: The Laplace Transform

9.1, 9.2, 9.3, 9.4, 9.6, 9.7*, 9.8*, 9.9*, 9.12, 9.13, 9.14, 9.15*, 9.16* ab, 9.17, 9.18 ac, 9.21*, 9.22*, 9.23, 9.26*, 9.27, 9.28* ab, 9.29, 9.30, 9.31*, 9.32, 9.33*, 9.34, 9.35, 9.41*, 9.42, 9.43*, 9.45*, 9.46, 9.47, 9.48, 9.49, 9.50, 9.51, 9.54, 9.56, 9.57, 9.58
unilateral Laplace transform and/or solving differential equations: 9.19, 9.20 c, 9.39, 9.40* c, 9.59