Preface

How are the Fourier Transform, Fourier Series, Discrete-Time Fourier Transform, and Discrete Fourier Transform related? Answering this question is a large part of what this book is about. The *Fourier Transform* (FT), *Fourier Series* (FS), *Discrete-Time Fourier Transform* (DTFT), and the *Discrete Fourier Transform* (DFT) are often considered as separate topics. When considering Fourier analysis, it is common to start with Fourier series (the historical development) and then generalize to the Fourier transform. In this book, we take a different approach. We will start with the Fourier transform, and derive the other three as special cases of the Fourier transform.

The main differences among the four have to do with the nature of their inputs and outputs. These are summarized in the following table.

Transform Comparison Chart

	Input $g(t)$	**Output $G(f)$**
Fourier Transform	Continuous, Aperiodic	Continuous, Aperiodic
Fourier Series	Continuous, Periodic	Discrete, Aperiodic
Discrete-Time Fourier Transform	Discrete, Aperiodic	Continuous, Periodic
Discrete Fourier Transform	Discrete, Periodic	Discrete, Periodic

The Fourier transform and its inverse are introduced in Chapter 1. Lots of examples of using the scaling and shifting theorems and given in Chapter 2, and the relationship between the Fourier transform and convolution and correlation operations are examined in Chapter 3. In Chapter 4, we show that taking the Fourier transform of a periodic signal results in the Fourier series. Taking the Fourier transform of a sampled signal leads to the discrete-time Fourier transform as illustrated in Chapter 5. We show in Chapter 6 that if a sampled signal is periodic, its Fourier transform leads to the discrete Fourier transform. In Chapter 7, we derive the fast Fourier transform (FFT) algorithm for computing the discrete Fourier transform. Ten MATLAB examples of using the fast Fourier transform are presented in Chapter 8, including examples of amplitude and frequency modulation as well as binary and quadrature phase shift keying of digital signals.

In Chapter 9, we introduce the discrete cosine transform (DCT) and show that it can be derived from the fast Fourier transform. The example of using the two-dimensional discrete cosine transform as part of the JPEG image compression algorithm is described in some detail.

Appendices derive the two-dimensional Fourier transforming property of a lens, and derive the Fourier transform of a triangle function and a Gaussian function.

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