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Fourier Transform and Its Applications Using Microsoft EXCEL® (Second Edition)

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Fourier Transform and Its Applications Using Microsoft EXCEL® (Second Edition)

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To my family, Mari, Felix, and Michael

Contents

Preface

Preface to the first edition

The Fourier transform (FT) is one of the most useful mathematics tools and it has been applied to various physics and engineering applications. There are many textbooks on FT focusing on its mathematical theory. However, in order to acquire the knowledge and skill to conduct FT analysis, students of science and engineering need to practice realistic examples through which they can confirm and understand FT theories.

This book demonstrates FT examples selected from physics to illustrate the practical computational issues on FT and to develop a know-how for obtaining fine spectral analysis. Rather than presenting rigorous mathematics, this book offers examples for readers to try and to use Fourier transform for themselves.

With the recent remarkable advancement of computers, it is possible to study this subject with a single personal computer even at home. Microsoft EXCEL® has the fast FT routine in its built-in analysis tool pack and requires virtually no additional programming. This is a great advantage in acquiring the essence of FT step-by-step while also applying it to physics phenomena. This book uses only EXCEL for all analyses and graphs so that readers can acquire the spectra on their PC screens by themselves. Equations and parameters for EXCEL—based an acoustic FT analysis—are also included for reference purposes.

This book also discusses a method for computing power spectral density that is an alternative to the FT. It estimates spectral density from time-series data without FT. Both methods are compared using the same data set to learn more than could be investigated with one method alone.

Originally, the acoustic spectral analysis described in this book was created for the first STEM project at La Roche College, and extended to cover more FT-related subjects. The author hopes readers will gain the knowledge and skill of Fourier transform through this book, and step into more advanced subjects.

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Preface to the second edition

In this second edition, I have updated some inaccurate descriptions from the first edition, and added more applications of FT.

The second edition consists of two parts. The first part consists of chapters 1 to 3. Chapters 1 and 2 provides a foundation of FT, which can be applied to chapter 3 to conduct an acoustic spectral analysis. In chapter 2, the algorithms of and one- and two-dimensional fast Fourier transform (FFT) are added. Their VBA codes are given in the appendix. The second part contains chapters 4 to 6, where more

advanced topics are described including linear response theory, Fourier optics and stochastic process, spectral methods for solving diffusion equations, Green's functions, and quantum Fourier transform for Shor's algorithm and quantum walks. They are concise introductions to these advanced subjects. The appendix contains notes for EXCEL and the VBA codes along with detail mathematical calculations so that readers are able to confirm their calculations.

Late Summer 2023.

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Author biography

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Shinil Cho attended Rikkyo University in Tokyo, Japan for his BS degree; Seoul National University in Seoul Korea for his MS; and the Ohio State University in Ohio, USA for his PhD. He held post-doctoral fellowships at the Ohio State University and University of Florida, and he was also a visiting professor at University of South Carolina. He has been at La Roche University since 1995. Currently he is a Professor of the Department of Physics at La Roche in Pittsburgh, Pennsylvania.

He has conducted research in cryogenic magnetic resonance spectroscopy below 1 K and biometric fingerprint authentication. His current research interest includes quantum computation, biometrics, and physics education. Other than physics topics, he has many publications and has done many presentations in London, Tokyo, Hongkong, Singapore, and several cities in the United States.