

Lecture 1: Motivation to Signal Analysis

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$Y = \text{fft}(X)$
 $Y = \text{fft}(X, n)$
 $Y = \text{fft}(X, n, \text{dim})$

Continue building your math skill set ...

- **Arithmetic:** Addition, subtraction, multiplication, division, exponents, roots.
- **Algebra:** Mathematical symbols, solving equations, polynomials, logarithms, complex numbers.
- **Geometry:** Points, lines, planes, angles, circles, surfaces, curves.
- **Trigonometry:** Angles of triangles, trigonometric functions (sine, cosine, tangent, etc).
- **Calculus:** Functions, limits, **differentiation** and **integration**, slopes, areas, sequences and series.

Yet to learn (for engineers and scientists) ...

- Ordinary differential equations (ODE).
- Partial differential equation (PDE).
- Statistics, random variables, stochastic processes.
- Matrices, eigenvalues, eigenvectors, systems of equations.
- Transforms: Laplace transform and Fourier transform.
- Fourier series.
- Convolution and correlation.
- Queueing theory and graph theory.
- Optimization techniques.

Engineers use these math skills to **design** and build **useful devices**: hardware and software.

Electrical Engineering:

Modulation of signals and filtering allows us to design and build various communication devices: cell phones, Wi-Fi, ADSL modems, fiber modems, satellite systems, TV, etc.

Designers of power electronics can manipulate the grid signal (converting DC to AC and AC to DC) to power your devices using electricity. Modern inverters allow highly-efficient air conditioning/ fridges/etc. DC chargers allows use of batteries for energy storage.

Digital signal processing provides techniques to encode and compress audio signals (human voice) to send over the Internet with minimal bandwidth requirements (Zoom, Teams, Spotify, etc).

Computer Engineering:

Video compression uses discrete cosine transform (DCT) and/or discrete sine transform (DST), which are similar to discrete Fourier transform (DFT). This allows sending video over the Internet with minimal bandwidth requirements (YouTube, Netflix, Zoom, etc).

Image processing and recognition (for self-driving cars) can calculate a convolution between an image and a filter kernel.

Artificial Intelligence: Fourier Transforms allows filtering (or convolution) in Convolutional Neural Networks.

Fast Fourier Transform (FFT) is used in finite math involved in cryptography and cryptanalysis.

And many more:

For mechanical systems and robotics, FFTs can be used in vibration analysis to reduce wear and dampen oscillations.

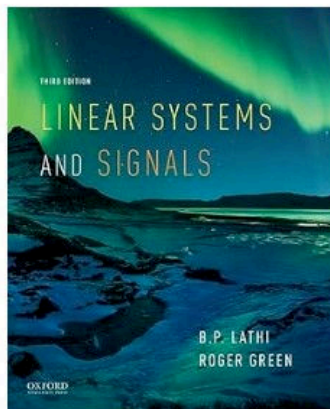
Application of Fourier transform and proteochemometrics principles to protein engineering.

Comparative analysis of DNA Sequences by Ramanujan-Fourier Transform.

Fourier series is used to solve various ordinary differential equations (ODEs) and partial differential equations (PDEs).

... and many more applications

- ***Linear Systems and Signals* by B.P. Lathi and Roger Green, Oxford University Press, 3rd Edition, 2017.**
- ***Schaum's Outline of Signals and Systems* by Hwei P Hsu, McGraw-Hill Education, 4th Edition, 2019.**
- *Signals and Systems: A Primer with MATLAB* by Matthew N. O. Sadiku, Warsame Hassan Ali and Sarhan M. Musa, CRC Press, 2nd Edition, 2024.
- *Signals and Systems* by Alan V. Oppenheim, Alan S. Willsky and S. Hamid, Pearson. 2nd Edition, 1996.
- *Signals and Systems for Dummies* by Mark Wickert, For Dummies, 1st edition, 2013.
- *Signals, Systems & Transforms* by Charles L. Phillips, John Parr and Eve Riskin, Pearson, 5th Edition, 2013.
- *Signals and Systems: A MATLAB Integrated Approach* by Oktay Alkin, CRC Press, 1st Edition, 2017.
- *Continuous and Discrete Signals and Systems* by Samir S. Soliman and Mandyam D. Srinath, Pearson, 2nd Edition, 1998.



Linear Systems and Signals (The Oxford Series in Electrical and Computer Engineering)

3rd Edition

by B.P. Lathi (Author), Roger Green (Author)

4.4 ★★★★★ (41)

Linear Systems and Signals, Third Edition, has been refined and streamlined to deliver unparalleled coverage and clarity. It emphasizes a physical appreciation of concepts through heuristic reasoning and the use of metaphors, analogies, and creative explanations. The text uses mathematics not only to prove axiomatic theory but also to enhance physical and intuitive understanding. Hundreds of fully worked examples provide a hands-on, practical grounding of concepts and theory. Its thorough content, practical approach, and structural adaptability make *Linear Systems and Signals*, Third Edition, the ideal text for undergraduates.

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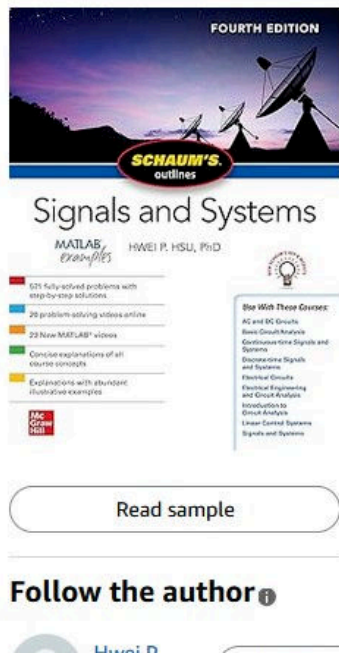
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Edition

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Schaum's Outline of Signals and Systems, Fourth Edition 4th Edition

by Hwei P. Hsu (Author)

4.6 ★★★★★ (92)

3.8 on Goodreads 85 ratings

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Be careful about symbols:

Quantity	My symbols	Others' symbols
Time	t	t
Frequency	f (Hz) or ω (rad/s)	f, ω or Ω
Signal	$x(t), y(t), z(t), m(t)$ or $v(t), i(t)$	$f(t), g(t)$ or $s(t)$
Power spectral density (PSD)	$S_x(\omega)$	
Imaginary unit	j	i

* Please avoid using $f(x)$ from Calculus, rather use $x(t)$.

Quantity	My symbol	Others' symbol
Complex exponential Fourier series coefficients	a_n	c_n, a_k
Compact Fourier series coefficients	c_n	b_n or d_n
Trigonometric Fourier series	a_n and b_n	$b_n \& c_n$ or $c_n \& d_n$
sinc() function	$\text{sinc}(t) = \frac{\sin(\pi t)}{\pi t}$	$\text{sinc}(t) = \frac{\sin(t)}{t}$