# Everything Is a Wave An Introduction to Fourier Approximations

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2023

#### Everything Is a Wave

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- ▶ John-Baptiste Joseph Fourier the father of Fourier Analysis (1768 1830)
- ► Fourier Series is a way to approximate any periodic function, signal, curve, etc. using sinusoids
- ▶ The general formula for a Fourier Series approximation:

$$F(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos\left(\frac{2\pi nt}{P}\right) + \sum_{n=1}^{\infty} b_n \sin\left(\frac{2\pi nt}{P}\right)$$

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- $F(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos\left(\frac{2\pi nt}{P}\right) + \sum_{n=1}^{\infty} b_n \sin\left(\frac{2\pi nt}{P}\right)$
- $\triangleright$  F(t) is the function we are approximating
- P is the period
- $\triangleright$   $a_0$ ,  $a_n$ , and  $b_n$  are coefficients we will need to calculate

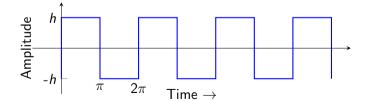
Coefficient Formulas

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#### Coefficient Formulas

$$ightharpoonup a_0 = \frac{1}{P} \int_0^P [F(t)] dt$$

#### Square wave



1. 
$$a_0 = \int_0^{2\pi} F(t)dt = 0$$

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1. 
$$a_0 = \int_0^{2\pi} F(t)dt = 0$$

2. 
$$a_1 = \frac{2}{2\pi} \int_0^{2\pi} \left[ F(t) \cdot \cos\left(\frac{2\pi \cdot 1 \cdot t}{2\pi}\right) \right]$$

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3. From 0 to 
$$\pi$$
,  $F(t) = h$  and from  $\pi$  to  $2\pi$   $F(t) = -h$ 

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$$a_1 = \frac{h}{\pi} \int_0^{\pi} [\cos(t)] dt - \frac{h}{\pi} \int_{\pi}^{2\pi} [\cos(t)] dt = 0$$

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5. All  $a_n = 0$  in our square wave example

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6. 
$$b_1 = \frac{2}{2\pi} \int_0^{2\pi} \left[ F(t) \cdot \sin\left(\frac{2\pi \cdot 1 \cdot t}{2\pi}\right) \right] dt$$

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7. 
$$b_1 = \frac{h}{\pi} \int_0^{\pi} [\sin(t)] dt - \frac{h}{\pi} \int_{\pi}^{2\pi} [\sin(t)] dt = \frac{4h}{\pi}$$

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- 3. From 0 to  $\pi$ , F(t) = h and from  $\pi$  to  $2\pi$  F(t) = -h
- 4.  $a_1 = \frac{h}{\pi} \int_0^{\pi} [\cos(t)] dt \frac{h}{\pi} \int_0^{2\pi} [\cos(t)] dt = 0$
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7. 
$$b_1 = \frac{h}{\pi} \int_0^{\pi} [\sin(t)] dt - \frac{h}{\pi} \int_{\pi}^{2\pi} [\sin(t)] dt = \frac{4h}{\pi}$$

8. If we continue to work out  $b_n$  we find a pattern:

$$b_n = \begin{cases} \frac{4h}{n\pi} & \text{when } n \text{ is odd} \\ 0 & \text{when } n \text{ is even} \end{cases}$$

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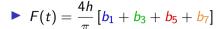
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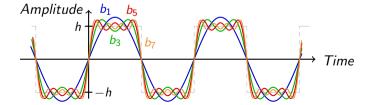


$$\blacktriangleright$$
  $b_1 = \sin(t)$ 

$$b_3 = \frac{\sin(3t)}{3}$$

$$b_5 = \frac{\sin(5t)}{5}$$

$$b_7 = \frac{\sin(7t)}{7}$$



1.  $i = \sqrt{-1}$ 

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2. Standard complex number  $z_s = x + iy$ 

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- 1.  $i = \sqrt{-1}$
- 2. Standard complex number  $z_s = x + iy$
- 3. Conjugate  $z_s^* = x iy$

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- 1.  $i = \sqrt{-1}$
- 2. Standard complex number  $z_s = x + iy$
- 3. Conjugate  $z_s^* = x iy$
- 4. Magnitude  $||z_s|| = \sqrt{z_s z_s^*} = \sqrt{(x+iy)(x-iy)} = \sqrt{x^2+y^2}$

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- 5.  $\theta = \begin{cases} \arctan\left(\frac{y}{x}\right), & x \ge 0\\ \arctan\left(\frac{y}{x}\right) + 180^{\circ}, & x < 0 \end{cases}$

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6. Polar form  $z_p = ||z_s||e^{i\theta}$ 

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- 1.  $i = \sqrt{-1}$
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- 6. Polar form  $z_p = ||z_s||e^{i\theta}$
- 7. Converting back to standard:  $\begin{cases} x = ||z_s|| \cos(\theta) \\ y = ||z_s|| \sin(\theta) \end{cases}$

#### 1. Why use complex numbers? It makes the calculations simpler!

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1. Why use complex numbers? It makes the calculations simpler!

2. The complex representation of the Fourier Series can be written as:

$$F(t) = \sum_{n=-\infty}^{\infty} c_n e^{i\frac{2\pi nt}{P}}$$

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2. The complex representation of the Fourier Series can be written as:

$$F(t) = \sum_{n=-\infty}^{\infty} c_n e^{i\frac{2\pi nt}{P}}$$

3. Euler's formula relates this back to our sinusoidal representation:

$$e^{it} = \cos(t) + i\sin(t)$$

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Complex Fourier Series

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$$F(t) = \sum_{n=-\infty}^{\infty} c_n e^{i\frac{2\pi nt}{P}}$$

3. Euler's formula relates this back to our sinusoidal representation:

$$e^{it} = \cos(t) + i\sin(t)$$

4. We can prove the complex representation is equal to the general equation using some trig identities:

$$\begin{cases} \cos(t) = \frac{e^{it} + e^{-it}}{2} \\ \sin(t) = \frac{e^{it} - e^{-it}}{2i} \end{cases}$$

1. 
$$c_n = \frac{1}{P} \int_0^P \left[ F(t) \cdot e^{-i\frac{2\pi nt}{P}} \right] dt$$

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2. 
$$c_0 = \frac{1}{2\pi} \int_0^{2\pi} \left[ F(t) \cdot e^{-i\frac{2\pi \cdot 0 \cdot t}{2\pi}} \right] dt$$

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3. 
$$c_0 = \frac{h}{2\pi} \left[ \int_0^{\pi} [1] dt - \int_{\pi}^{2\pi} [1] dt \right] = 0$$

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1. 
$$c_n = \frac{1}{P} \int_0^P \left[ F(t) \cdot e^{-i\frac{2\pi nt}{P}} \right] dt$$

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5. 
$$c_1 = \frac{h}{2\pi} \left[ \int_0^{\pi} \left[ e^{-it} \right] dt - \int_{\pi}^{2\pi} \left[ e^{-it} \right] dt \right] = \frac{4h}{i2\pi} = \frac{2h}{i\pi}$$

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$$1 \quad c = \frac{1}{T} \int_{-T}^{T} \left[ F(t) \cdot e^{-i\frac{2\pi nt}{T}} \right] dt$$

1. 
$$c_n = \frac{1}{P} \int_0^P \left[ F(t) \cdot e^{-i\frac{2\pi nt}{P}} \right] dt$$

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6. We find a familiar pattern if we continue to work  $c_n$  out  $c_n = \begin{cases} \frac{2h}{in\pi}, & \pm n = \text{odd} \\ 0, & \pm n = \text{even} \end{cases}$ 

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1. 
$$c_n = \frac{1}{P} \int_0^P \left[ F(t) \cdot e^{-i\frac{2\pi nt}{P}} \right] dt$$

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7. As long as  $c_n^* = c_{-n}$  the resulting F(t) will be real numbers

1. Fourier approximations are used in many fields including:

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- 1. Fourier approximations are used in many fields including:
  - Signal processing

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- 1. Fourier approximations are used in many fields including:
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- 2. It can be taken further to solve more complex problems:

Applications

- 1. Fourier approximations are used in many fields including:
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  - And more!
- 2. It can be taken further to solve more complex problems:
  - Fourier Transforms are used to approximate non-periodic functions

Applications

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  - A1
  - Graphical Programming
  - Computer Vision
  - And more!
- 2. It can be taken further to solve more complex problems:
  - Fourier Transforms are used to approximate non-periodic functions
  - ► Fourier Interpolation can approximate a path between points

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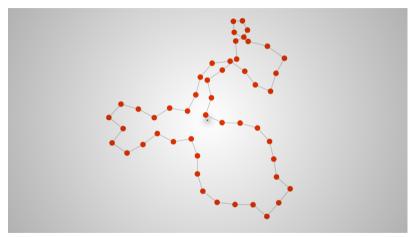
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- 1. Fourier approximations are used in many fields including:
  - Signal processing
  - Audio
  - Electrical Engineering
  - ► AI
  - Graphical Programming
  - Computer Vision
  - ► And more!
- 2. It can be taken further to solve more complex problems:
  - ► Fourier Transforms are used to approximate non-periodic functions
  - ► Fourier Interpolation can approximate a path between points
  - ► Fast Fourier Transform is a computational method that takes less steps to solve

#### Example 1: Fourier Interpolation



Video (external viewer)

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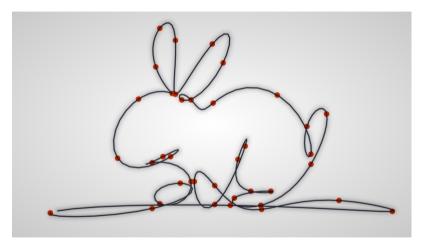
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## Example 2: Fourier Transform



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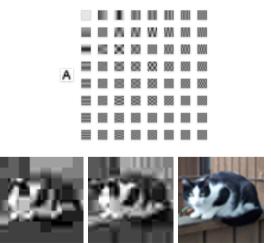
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## Example 3: Image Files

 Our waves can be represented as color data, which is used for image synthesis and JPG compression



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- ▶ Inigo Quilez: Fourier Series https://iquilezles.org/articles/fourier/
- ▶ Inigo Quilez: Visual for Example 1 & 2
- ▶ Better Explained: An Interactive Guide to the Fourier Transform https://betterexplained.com/articles/an-interactive-guide-to-the-fourier-transform/
- Better Explained: Intuitive Understanding of Euler's Formula https://betterexplained.com/articles/intuitive-understanding-of-eulersformula/
- ► Jez Swanson: An Interactive Introduction to Fourier Transforms https://www.jezzamon.com/fourier/
- Jez Swanson: Visuals for Example 3

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Complex Fourier

Revisiting the

Applications

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Works Cited

Questions

► Joao Neto: Fourier Transform A R Tutorial http://www.di.fc.ul.pt/~jpn/r/fourier/fourier.html

▶ Diego Unzueta: Fourier Transforms Animated Visualization https://towardsdatascience.com/fourier-transforms-animated-visualization-5bdb43b4b3d2

Math is Fun: Fourier Series https://www.mathsisfun.com/calculus/fourier-series.html

Darryl Morrell: Fourier Series Example https://www.youtube.com/watch?v=ci1gnhE8Kv8

thefouriertransform.com: https://www.thefouriertransform.com/series/fourier.php

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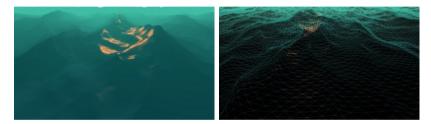
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amples

Works Cited

- Izaak Neutelings: Code for visual on "Visualization" slide https://tikz.net/fourier\_series/
- ➤ Torbjorn T: Code for visual on "Square Wave" slide https://tex.stackexchange.com/a/113050
- ► Keith Lantz: FFT Rendering of an ocean, visuals on Questions slide https://www.keithlantz.net/2011/11/ocean-simulation-part-two-using-the-fast-fourier-transform/

# Questions?



Waves rendered with Fast Fourier Transform!

Everything Is a Wave

Jai Veilleux

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Breaking it Dowr

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