# Covid-19 Data

Daily US Deaths from COVID−19

This is the daily death toll in the US from Covid-19 between March 14 and September 2, 2020. On average, there are 1083 deaths per day (blue line). Harmonic analysis is useful for examining variations in this data with respect to the mean value.

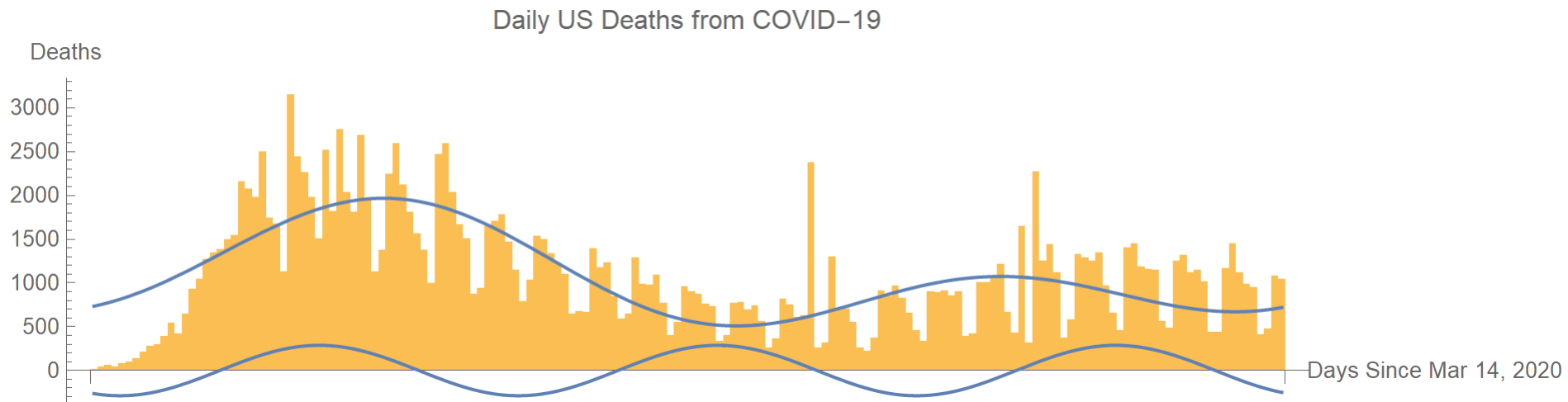This is a time series with units of days. The temporal frequency ν of the signal will have units of $days^{-1}$.
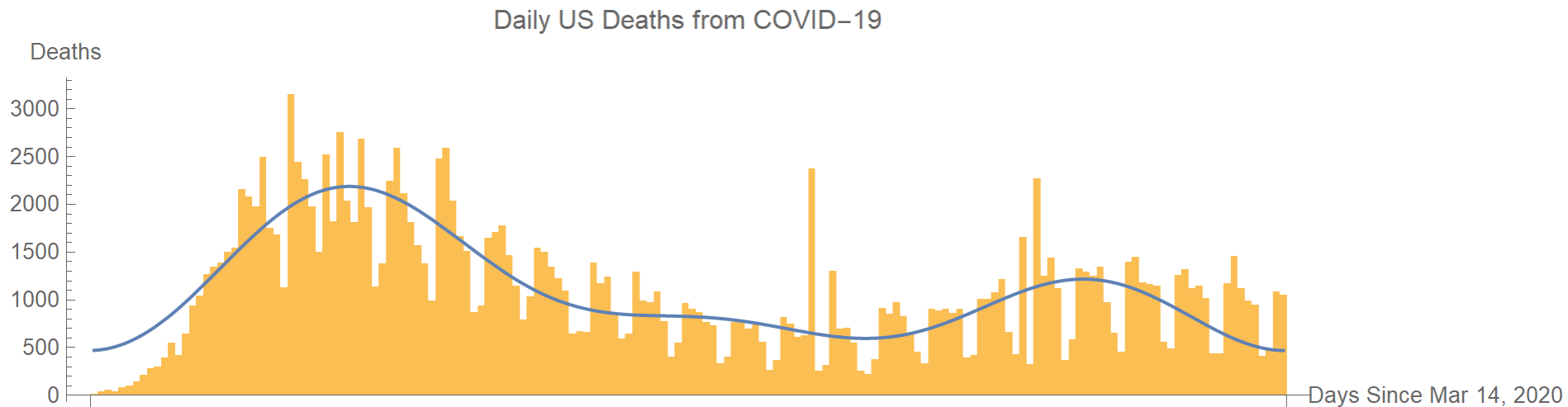
Largest Sinusoidal Component

Daily US Deaths from COVID-19

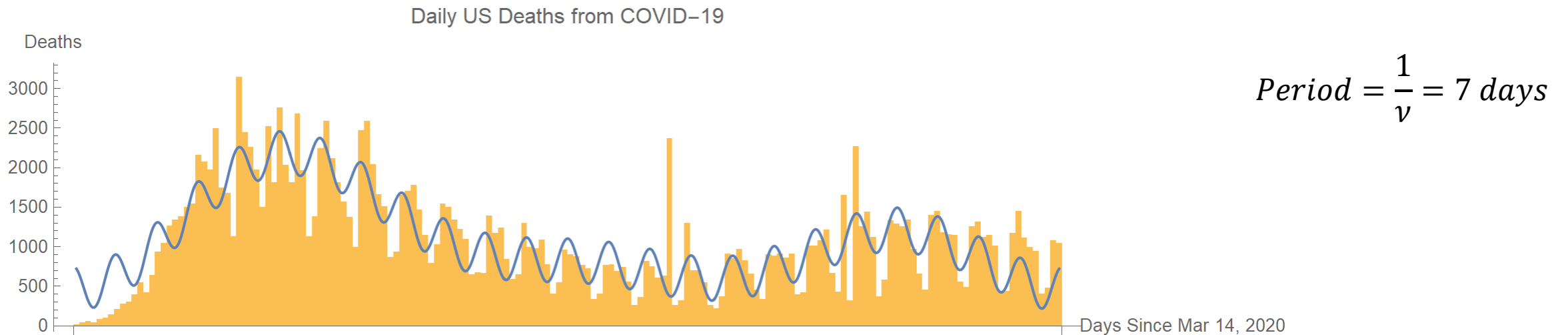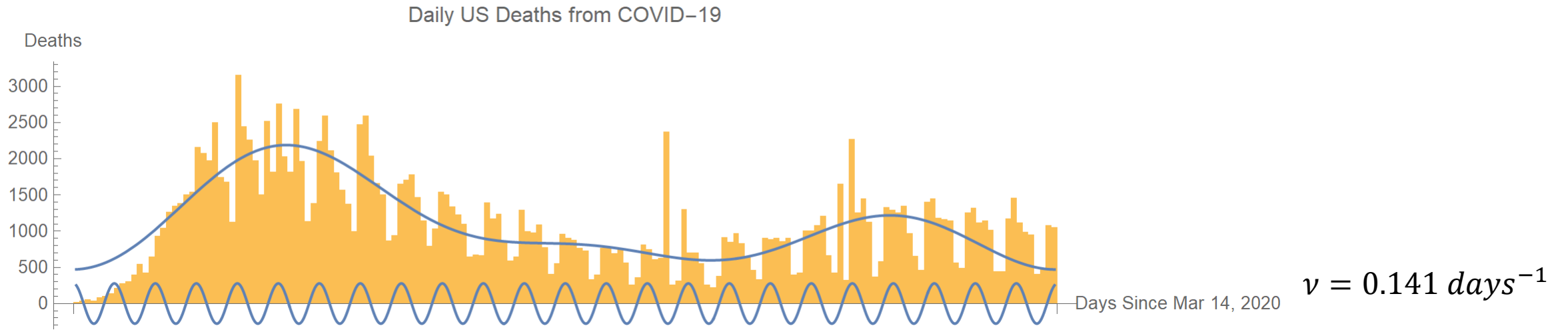$\nu = 0.00588 \ days^{-1}$
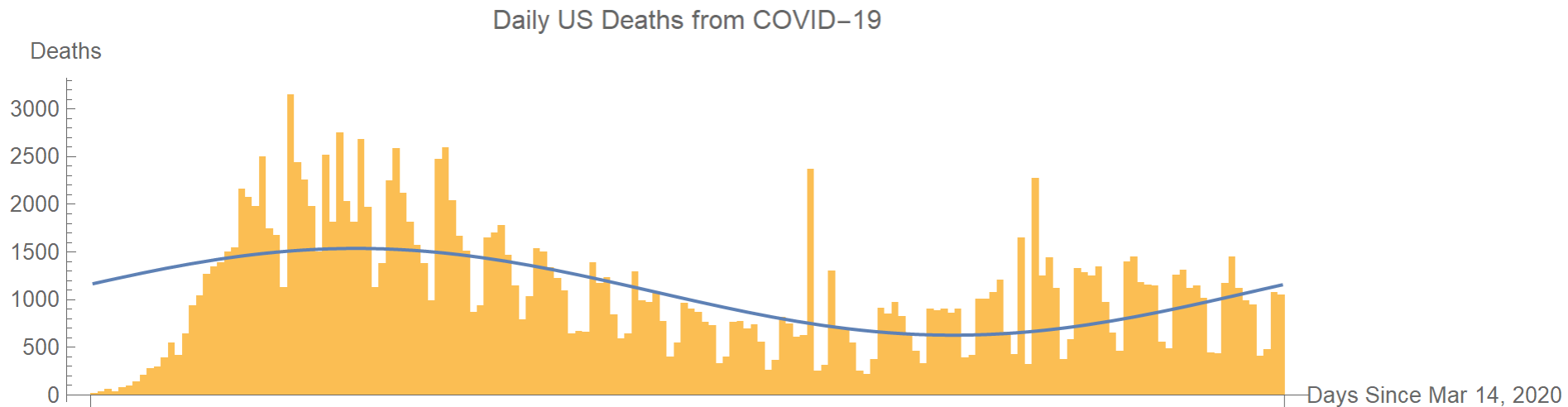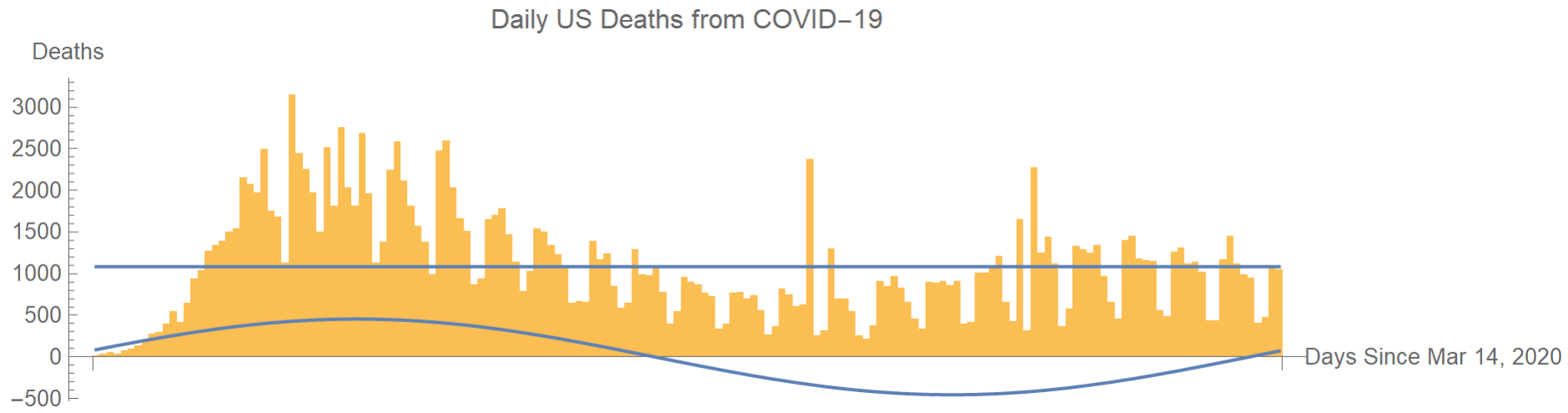
Largest 2 Sinusoidal Components

$$\nu = 0.0118 \; days^{-1}$$
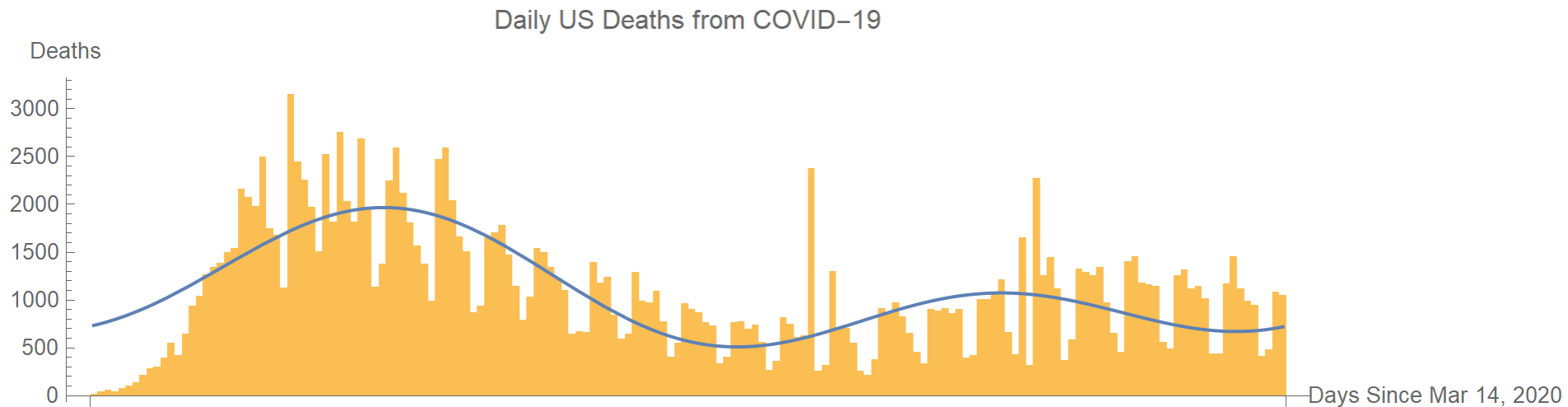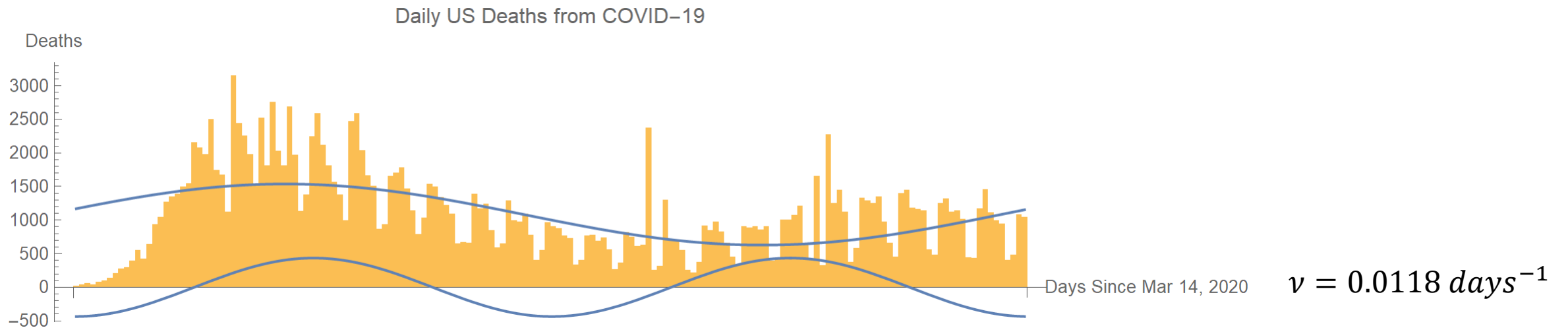
Largest 3 Sinusoidal Components

Daily US Deaths from COVID-19

$$\nu = 0.0176 \; days^{-1}$$

Largest 4 Sinusoidal Components

Daily US Deaths from COVID−19

$\nu = 0.141 \ days^{-1}$

$Period = \dfrac{1}{\nu} = 7 \ days$
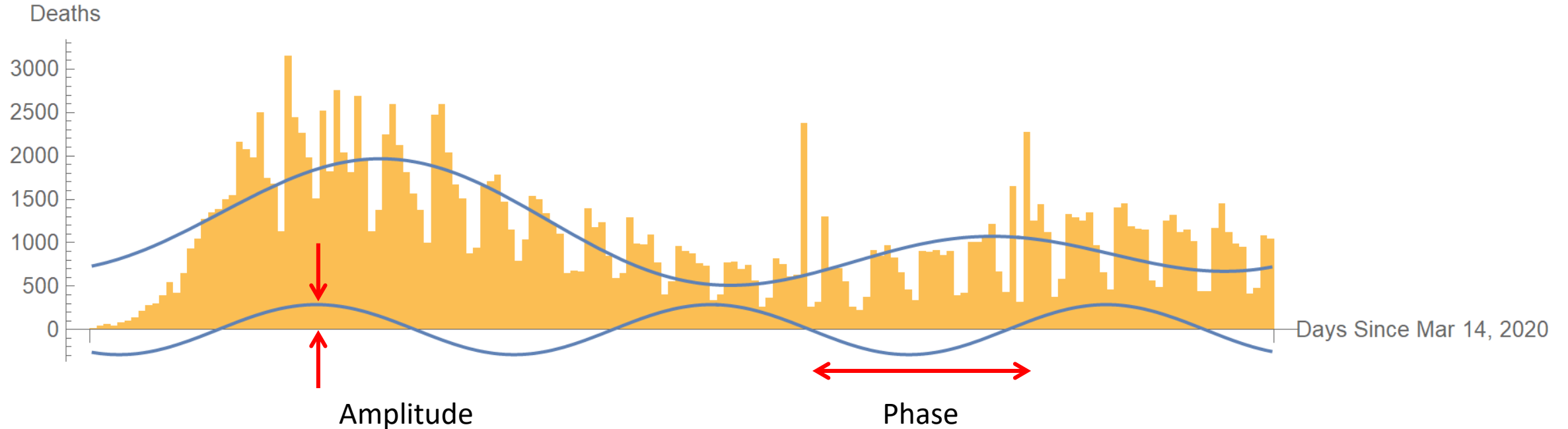
Harmonic Analysis 1D

Daily US Deaths from COVID-19

For each sinusoidal component we are adding to approximate the signal, we have control over two items: the amplitude and the phase. The amplitude tells us how high the peaks (and how low the valleys) are. The phase allows us to shift the pattern left or right.
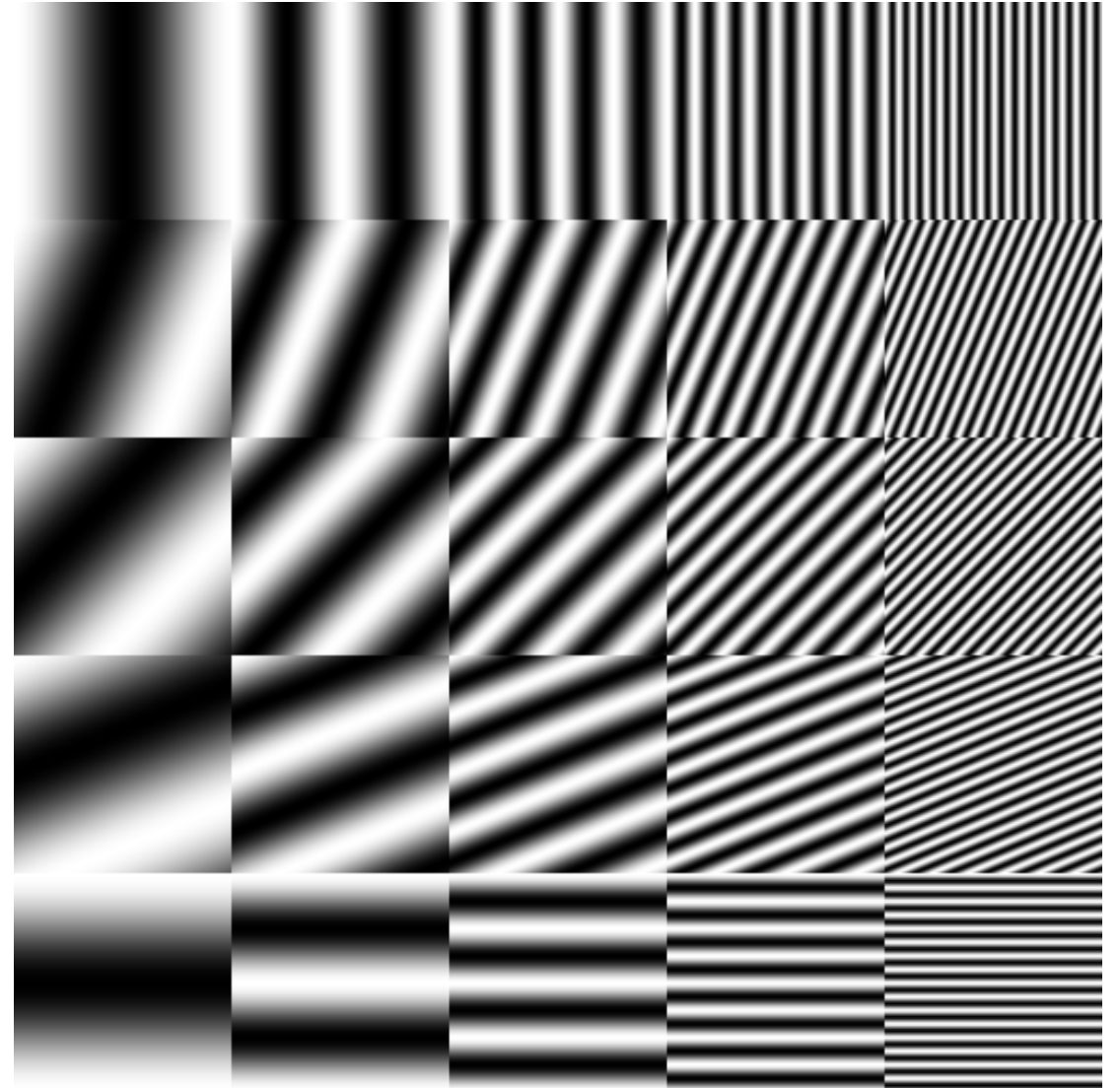
Harmonic Analysis 2D

In 2D, you want to represent some 2D pattern like the letter E here as a combination of sines and cosines.
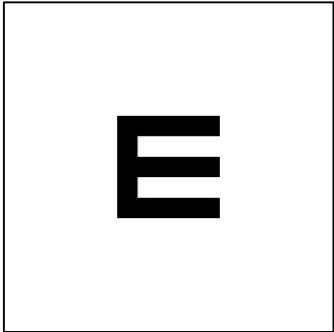
Now you have three things that can be varied:

- The amplitude, which controls how "white" the peaks are and how "black" the troughs are.
- The phase, which just shifts the pattern.
- The orientation, which is the angle the pattern makes with the x-axis.
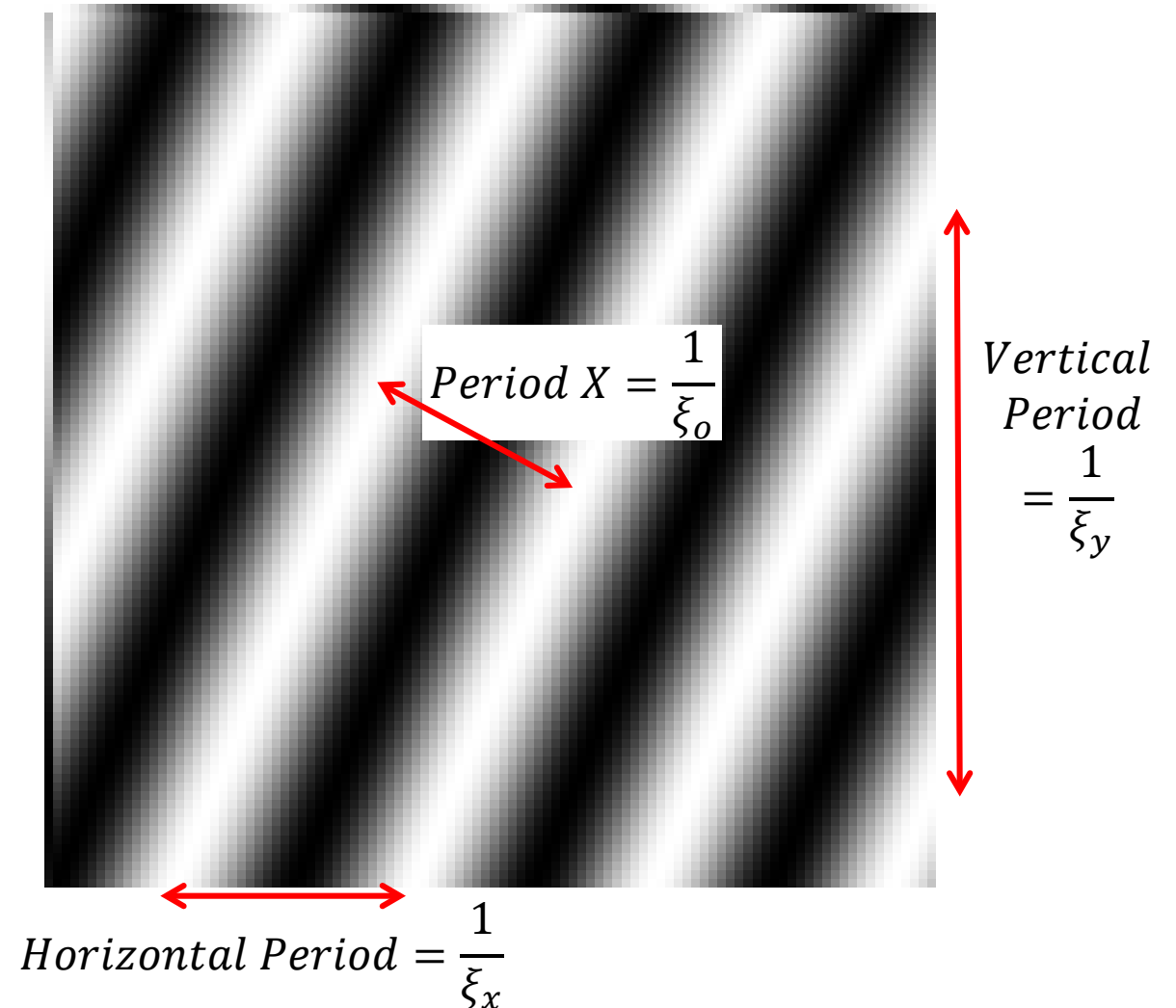
E

Period & Spatial Frequency

The *period X* is just the distance for one complete cycle of the sinusoid.

The spatial frequency ξ_o is just the reciprocal of this period $\xi_o = 1/X$.

Sometimes, we refer to the horizontal spatial frequency ξ_x and the vertical spatial frequency ξ_y, which are just the reciprocals of the periods along the x- and y-axis, respectively.

Use a little trig to convince yourself that
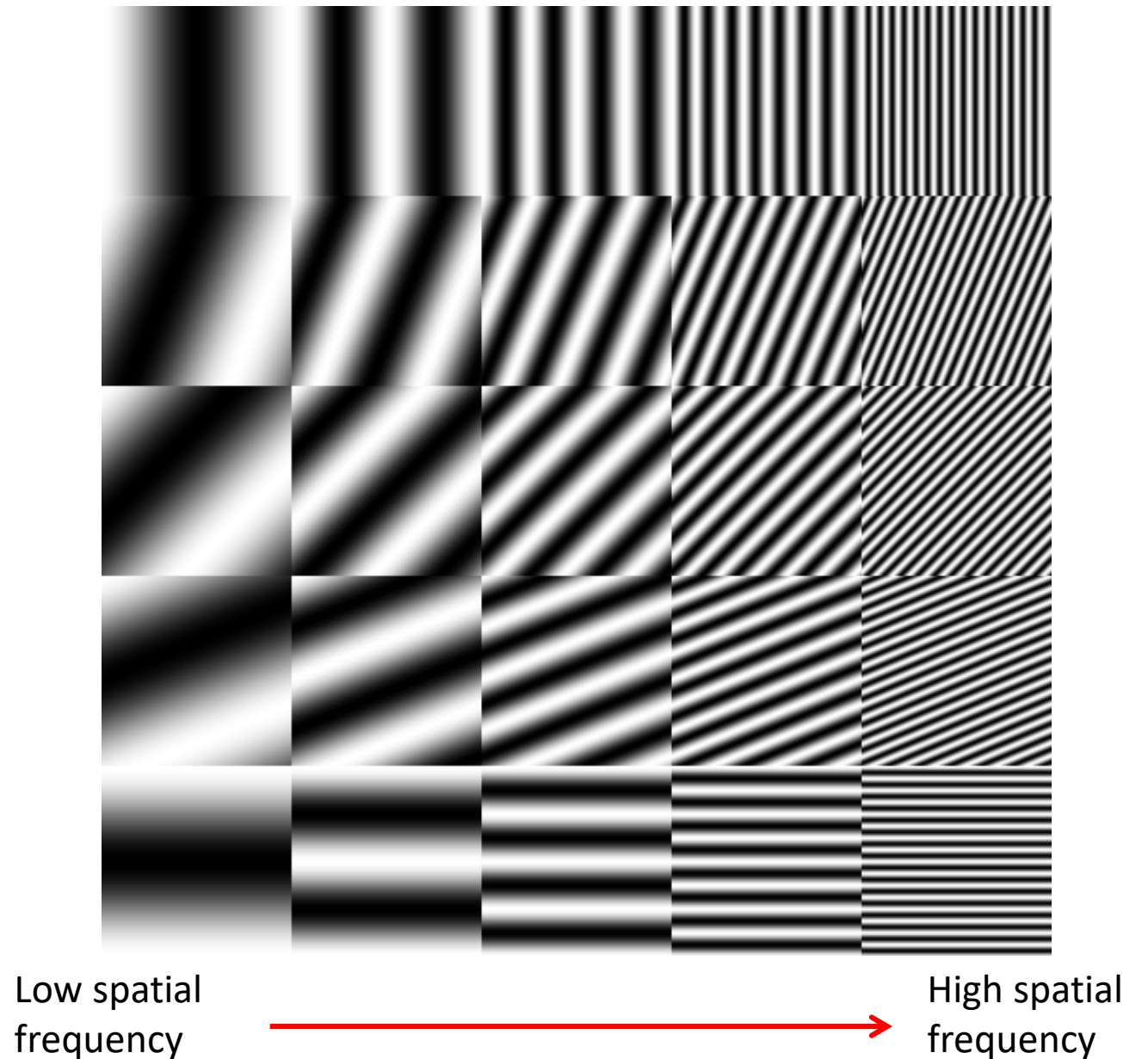
$$\xi_0 = \sqrt{\xi_x^2 + \xi_y^2}$$

$$Period\ X = \frac{1}{\xi_o}$$

$$Vertical\ Period = \frac{1}{\xi_y}$$

$$Horizontal\ Period = \frac{1}{\xi_x}$$

Spatial Frequency

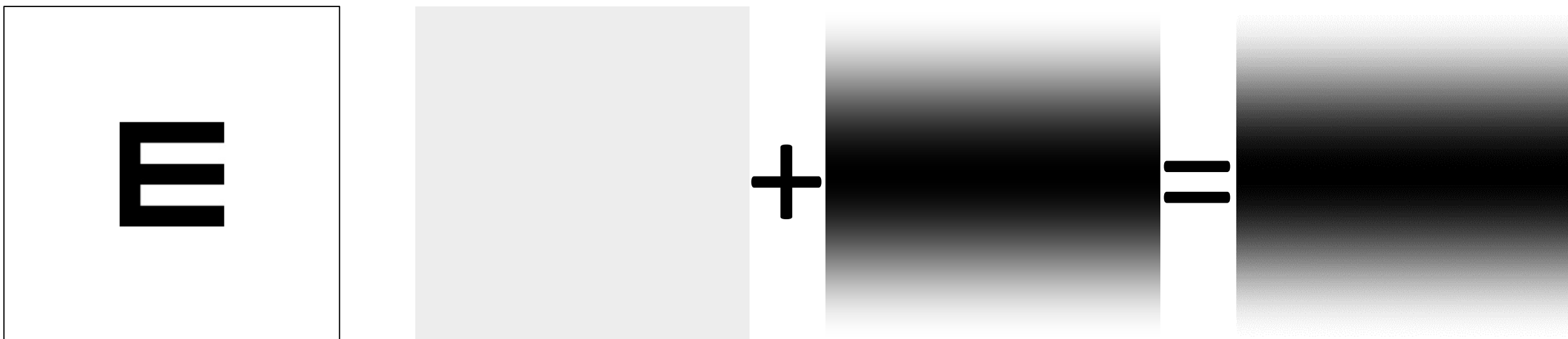Each column has the same spatial frequency ξ_o, but the orientation of the pattern rotates.

Each row has the same orientation, but increasing spatial frequency.
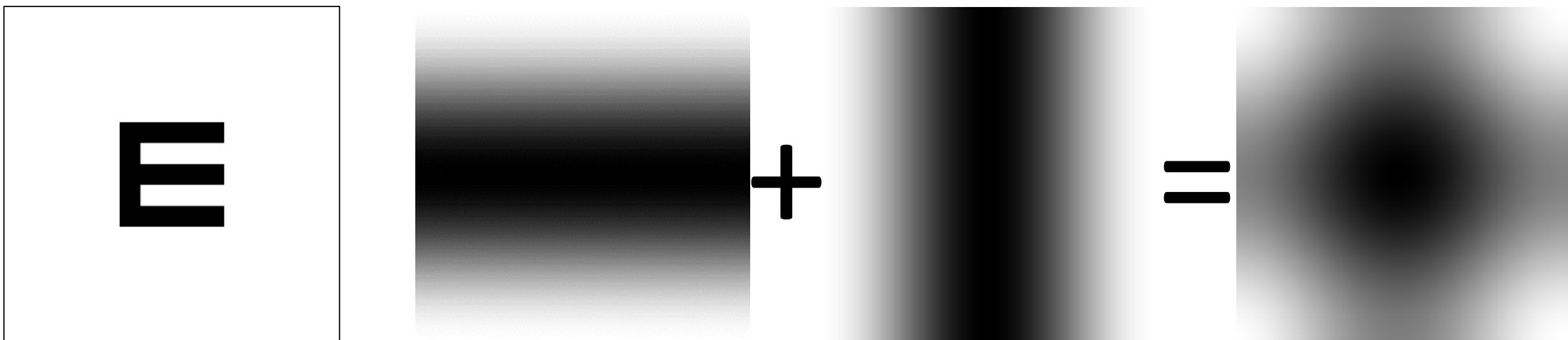
Low spatial frequency means a large period.

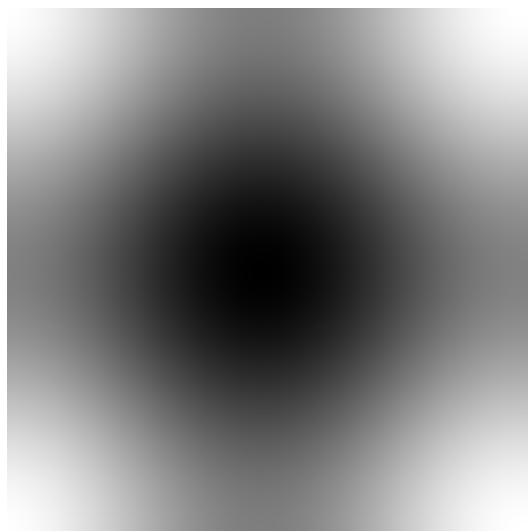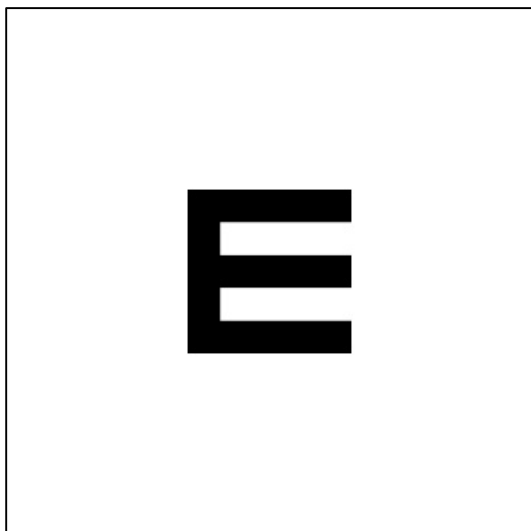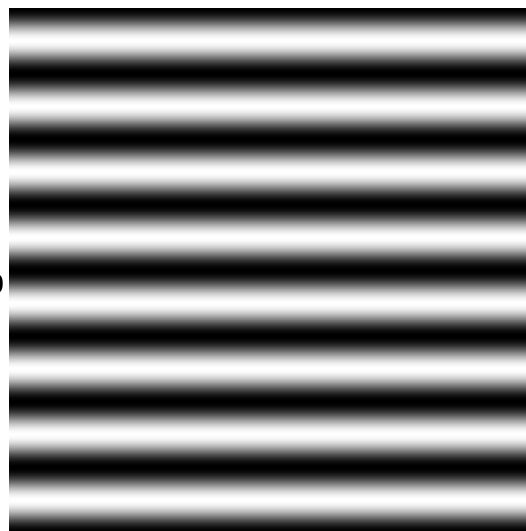High spatial frequency means a small period.

Low spatial frequency → High spatial frequency

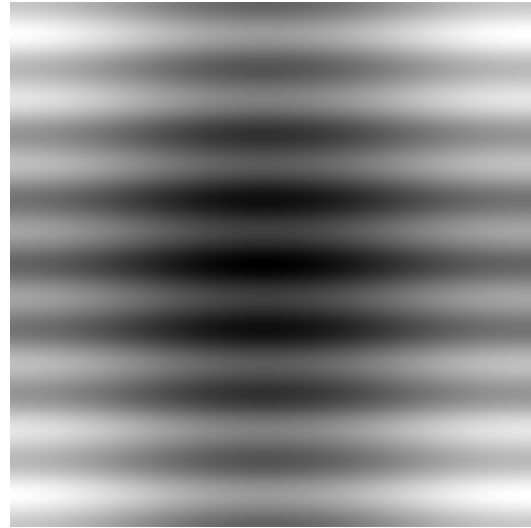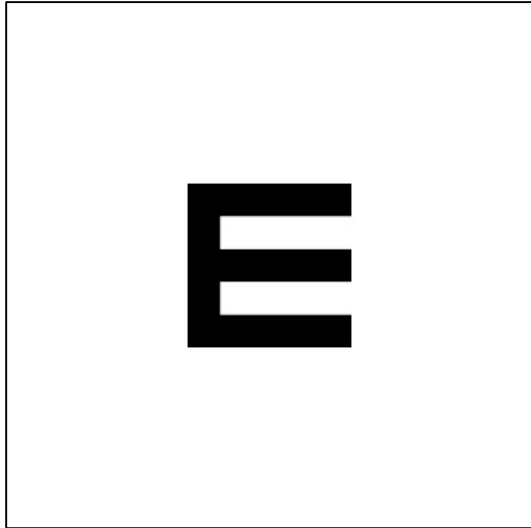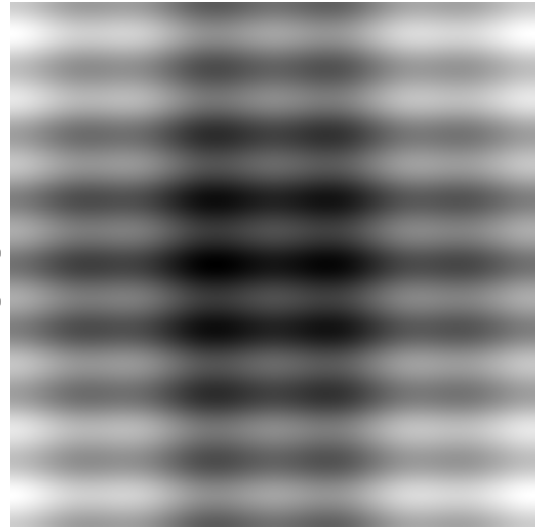# Harmonic Analysis 2D
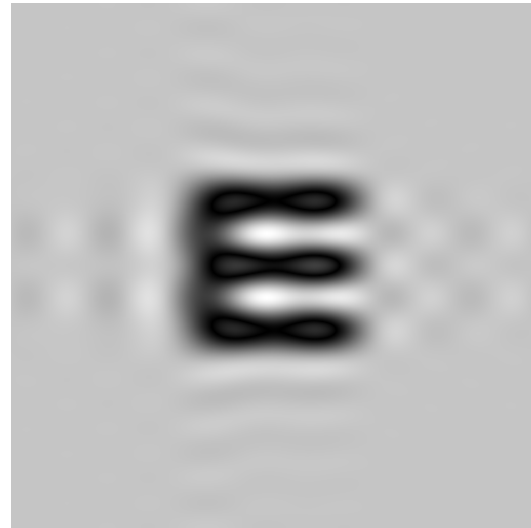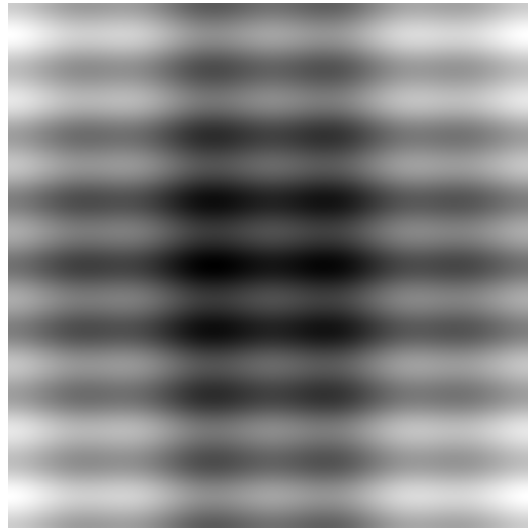
Harmonic Analysis 2D
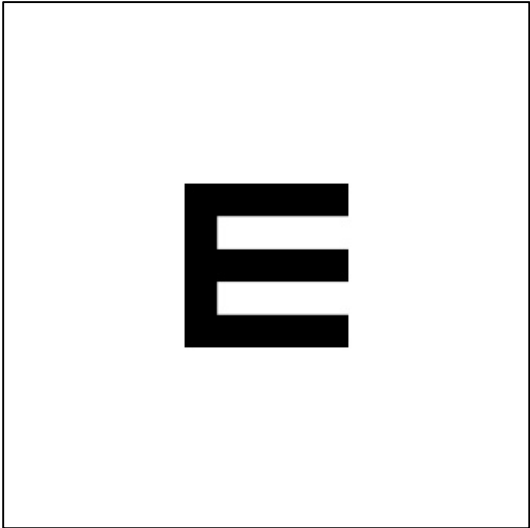
Harmonic Analysis 2D

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Continue adding additional terms.