Ph3 Mathematica Homework: Week 5

Eric D. Black

California Institute of Technology

v1.1

1 Exporting data

Earlier you learned how to import data from a text file. This week we are going to work on exporting. Just as you can import just about anything into Mathematica, you can export just about any format as well. You can write data to text files, but you can also generate graphics that you can use in papers or presentations. This is a huge subject, and we will only touch on its surface here.

We will practice importing data, processing it, and exporting the results. This is a process you would go through a lot in a research setting. The processing we are going to do is called *windowing*, and it is widely used in digital signal processing in both research and engineering. Again, this is a huge subject, and we are only going to touch on it here. Fortunately, the actual math of applying a window is relatively simple.

1.1 Windowing

The data you got from your oscilloscope is in a form known as a *time series*, a sequence of values (in this case voltages) that occur one right after another in time. Your data is actually only a sample of a larger time series. It is only as much as would fit on the oscilloscope's screen. It is, in a way, a view through a small *window* of a part of all of the data that was available when you ran your experiment. This *windowing* is essentially multiplying your data stream by a rectangular function who's value is one inside the 'scope's screen and zero everywhere else. This is called a *rectangular window*, and it

introduces anomalies to your signal that can be problematic in later signal processing, Fourier analysis, or reconstruction. These problematic effects are largely due to the sharp edges of the window and can be mitigated by changing the window's shape. Many different types of windows have been studied, and each has its own use. One of the simplest is the *Hann* window, named after its inventor.
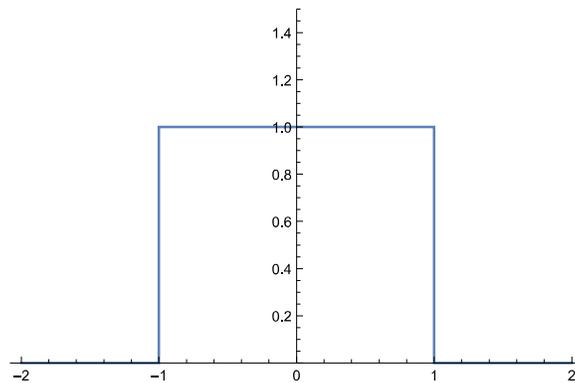

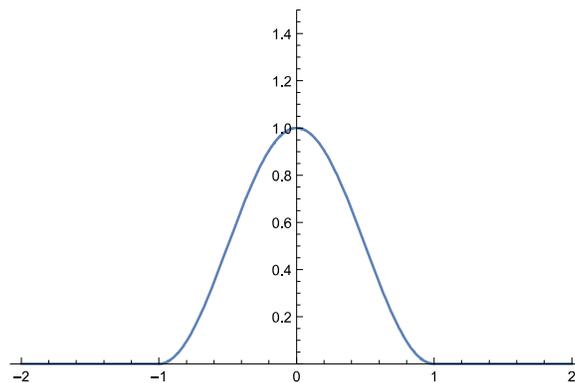Figure 1: A rectangular window function between -1 and 1.

Figure 2: A Hann window between -1 and 1.

A Hann window in the time interval $0 \leq t \leq T$ is described by the function

$$w(t) = \frac{1}{2}\left[1 - \cos\left(\frac{2\pi t}{T}\right)\right], 0 \leq t \leq T$$

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Because these windows are always applied to discrete data sets, it is sometimes useful to define them as a function of the index of the (one-dimensional) list of data points.

$$w(n) = 0.5 \left[1 - \cos\left(\frac{2\pi(n-1)}{N}\right) \right], 1 \leq n \leq N$$

Exercise 1: Load the data you downloaded from your oscilloscope in the first lab, and apply a Hann window to it by multiplying its y-values times the windowing function.

$$z_n = w(n)y_n, 1 \leq n \leq N$$

Exercise 2: Plot both the windowed and unwindowed data, and compare the two. Use the `Joined->True` option to make smoother plots than Mathematica's default option of plotting discrete points.

Exercise 3: Export the plot of the windowed data as a pdf. The `Export` command takes three arguments, the name of the file you want to create, the data that you are exporting (in this case a graph), and the format you want to export it as.

```
Export["~/Desktop/Hann.pdf", zplot, "PDF"]
```

Exercise 4: Export the windowed data to a text file. Open the file in a text editor, and print out the first page to confirm that the format is correct.