# CNS2025: Homework 2

Due: 2025-09-17 23:59

The objective of this homework is convert a frame-based spike train to firing rate versus time similar to Figure 1.4 of the textbook or what is shown on the slide 18 of the lecture, using a different set of data.

## Question 1

Load the data file `hw02-data.npz` using `numpy.load()`. Inspect the results and describe what data are available in the file.

The data `frames` is an array of spike counts for the frames of time steps during the experiment. The size of the time step is given by the data `delta_t`. Since each data with a given key must be an array in a `.npz` file, we need to extract the `delta_t` value (it's a zero-dimensional array in this case) using the expression `f['delta_t'][()]`:

```
with np.load('hw02-data.npz',allow_pickle=True) as f:
        frames = f['frames']
        delta_t = f['delta_t'][()]
```

There are about 10 seconds of data in the file. For all the exercises, show only the results between 0 and 5 s of time in your plots.

## Exercise 2

Similar to the subplot **A**, produce a plot of spikes using the `plt.vlines()` function from Matplotlib.

## Exercise 3

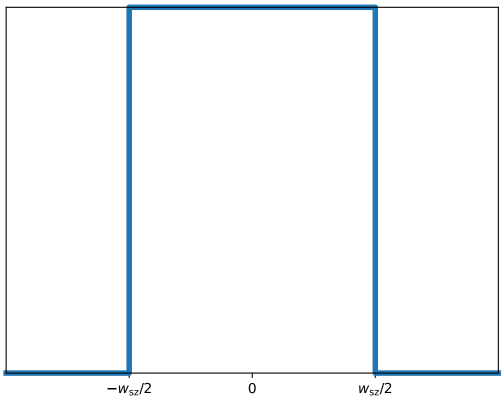
Obtain the discrete-time firing rate by binning spikes into fixed time bins of the size $\Delta t = 100\ \mathrm{ms} = 0.1\ \mathrm{s}$ similar to the subplot **B**.

For the following exercises, you may use the `numpy.convolve()` function, as discussed in the lecture, to produce the firing rates. Be careful about the alignment between the data array and the array of the kernel function. Also, make sure the range of your window function array is large enough to enclose the significant part of the window function.

## Exercise 4

Produce the subplot **C**: Approximate firing rate determined by sliding a rectangular window function along the spike train with window size $w_{\mathrm{sz}} = 100$ ms.

This can be done by convolution with the square window function:

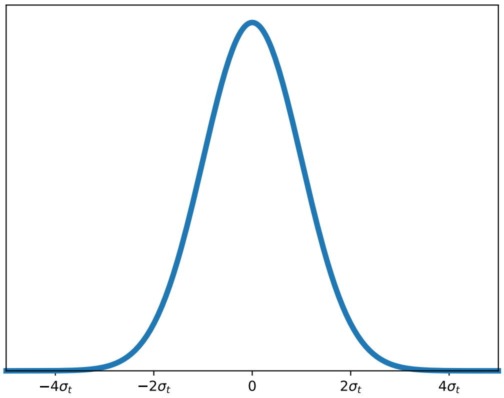



## Exercise 5

Produce the subplot **D**: Approximate firing rate computed using a Gaussian window function with $\sigma_t = 100$ ms.

$$W(t) = \frac{1}{\sqrt{2\pi}\sigma_t} \exp\left(-\frac{t^2}{2\sigma_t^2}\right)$$

This function is as visualized below.

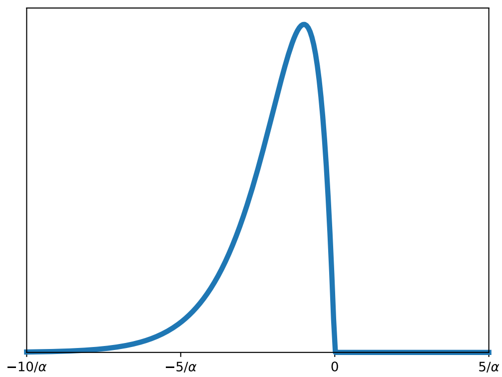



## Exercise 6

Produce the subplot **E**: Approximate firing rate using the causal window function with $\alpha = 10$ Hz.

$$W(t) = [-\alpha^2 t \exp(\alpha t)]_+$$

This function is as visualized below.

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