Project 5: The neuron as coincidence detector vs. integrator

1) Implement a leaky integrate and fire neuron with input current that is linear in the input spikes, which are generated from a presynaptic population of excitatory and inhibitory neurons. Show what happens when you change the membrane time constant (the product of resistance and capacitance), and when you change the balance of excitation and inhibition. How does the regularity of spiking change? How important is spike timing? When does the neuron act as a coincidence detector, and when does it act as a random walk (see Shadlen & Newsome, 1994)?

2) Shadlen and Newsome claim that excitation and inhibition are approximately balanced, favoring a random walk regime. How does this claim hold up in light of more recent evidence (reviewed in Okun & Lampl, 2009)?

3) It has been suggested that some psychiatric conditions, such as autism, are associated with altered excitation-inhibition balance (Sohal & Rubenstein, 2019). Relate your simulations in part 1 to the observation of sensory hypersensitivity in autism.

References:

Okun, M., & Lampl, I. (2009). Balance of excitation and inhibition. *Scholarpedia, 4*, 7467.

Shadlen, M. N., & Newsome, W. T. (1994). Noise, neural codes and cortical organization. *Current Opinion in Neurobiology, 4*, 569-579.

Sohal, V. S., & Rubenstein, J. L. (2019). Excitation-inhibition balance as a framework for investigating mechanisms in neuropsychiatric disorders. *Molecular Psychiatry, 24*, 1248-1257.