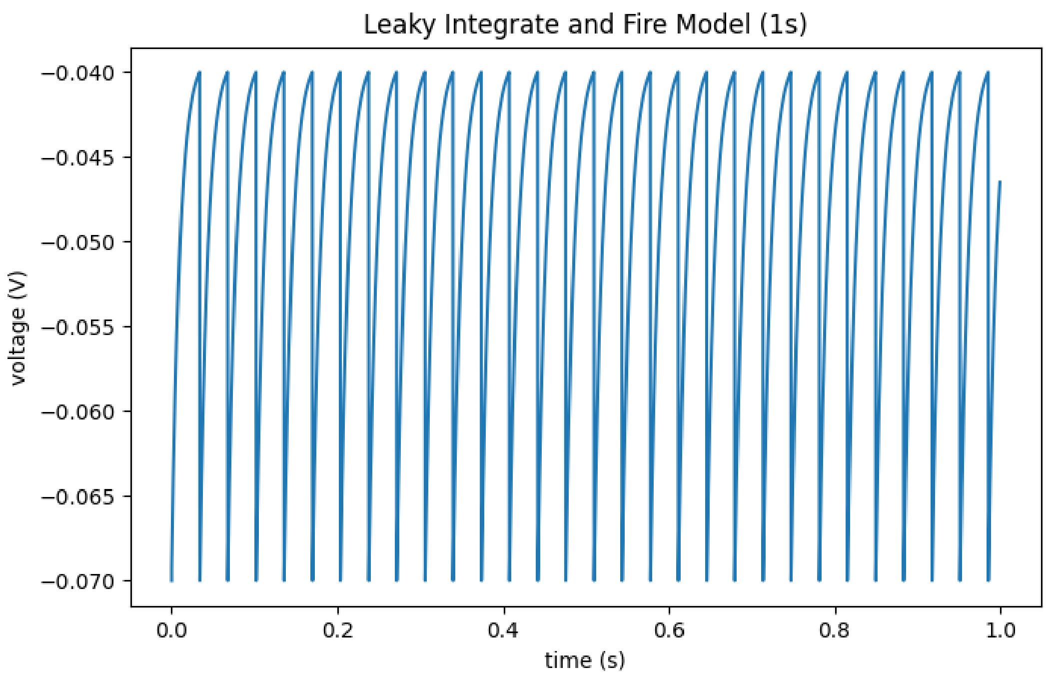
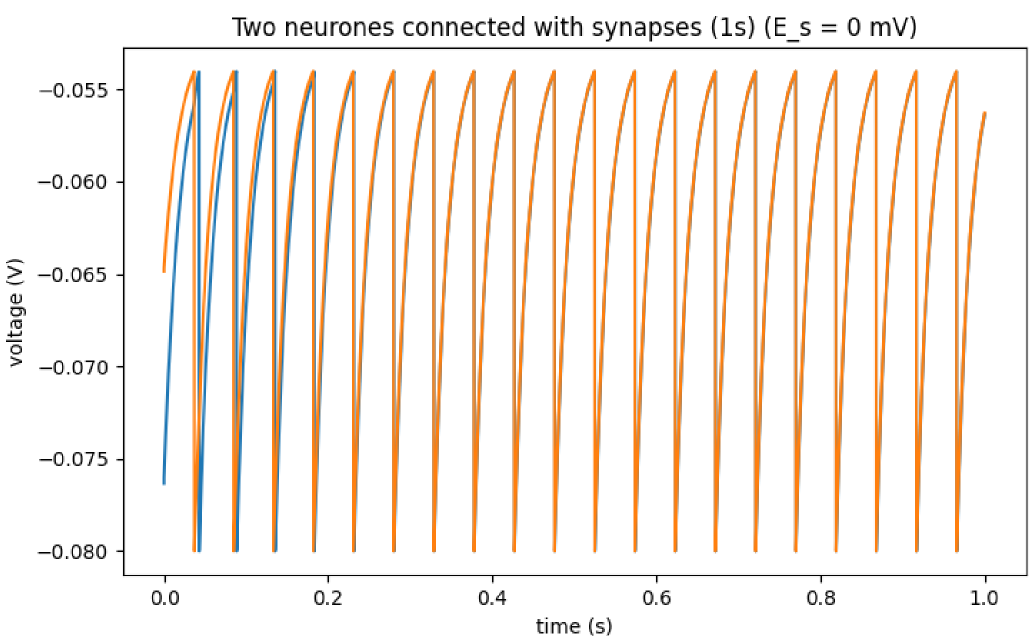
Part A

Question 1

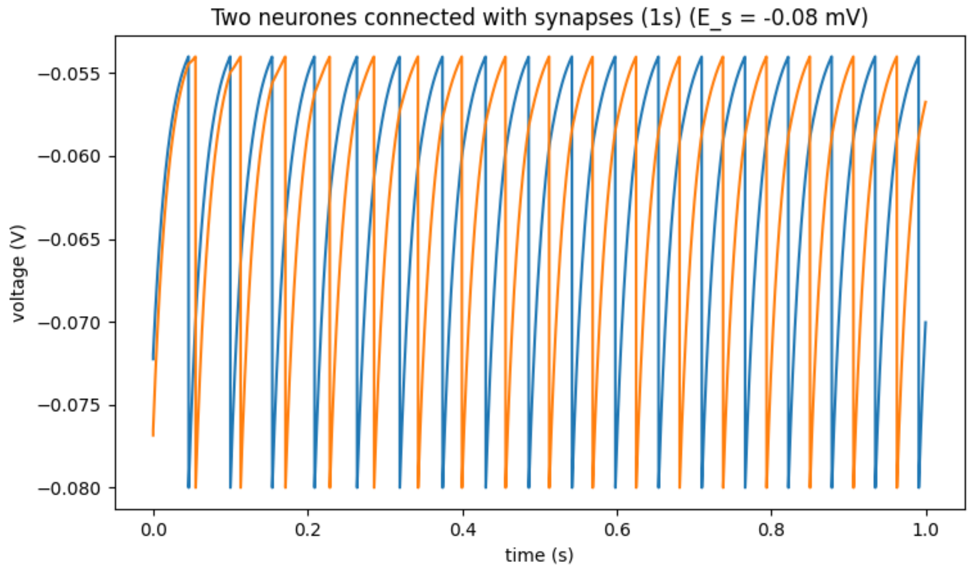


Question 2

Part A (excitatory):



Part B (inhibitory):

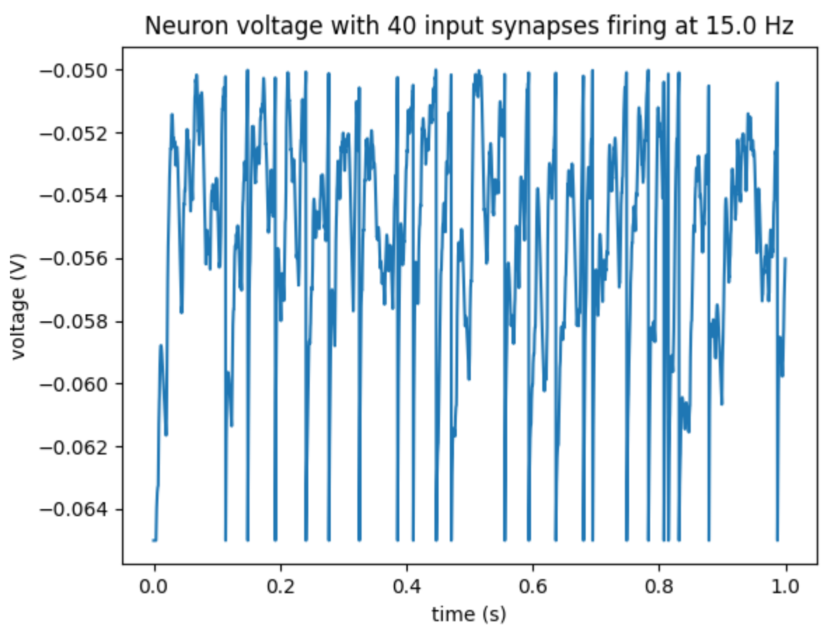


In the excitatory case (Es = 0 mV), the firing of one neuron increases the chances of the second neuron firing. This feeds back to the first and so on. So the end situation is both neurons fire together in sync.

In the inhibitory case (Es = Vrest), the firing of one neuron drives the potential of the other away from its threshold, so if one has recently fired then the next is less likely to fire. And so the end result is them firing out of phase.

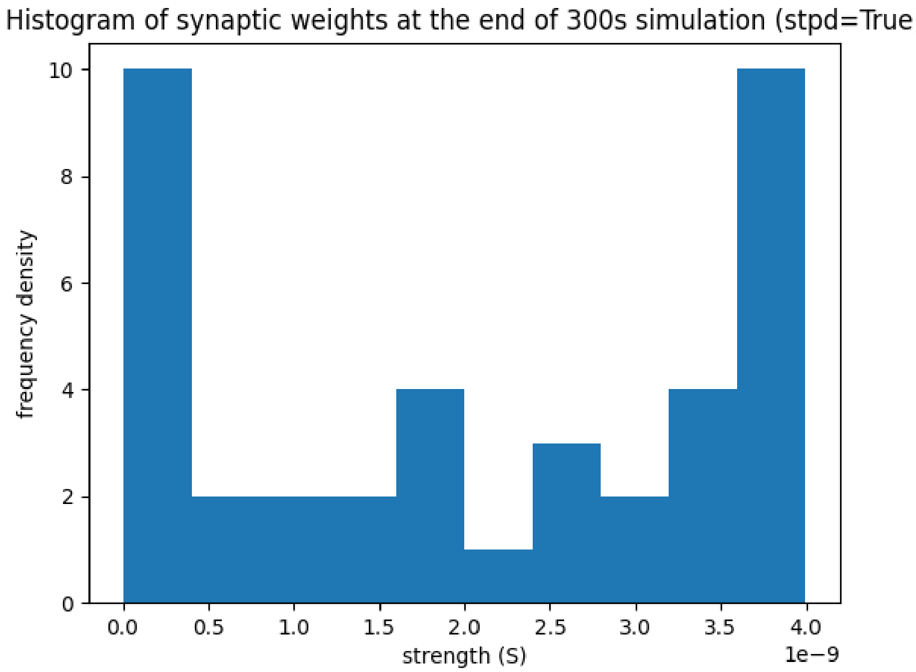
Part B

Question 1

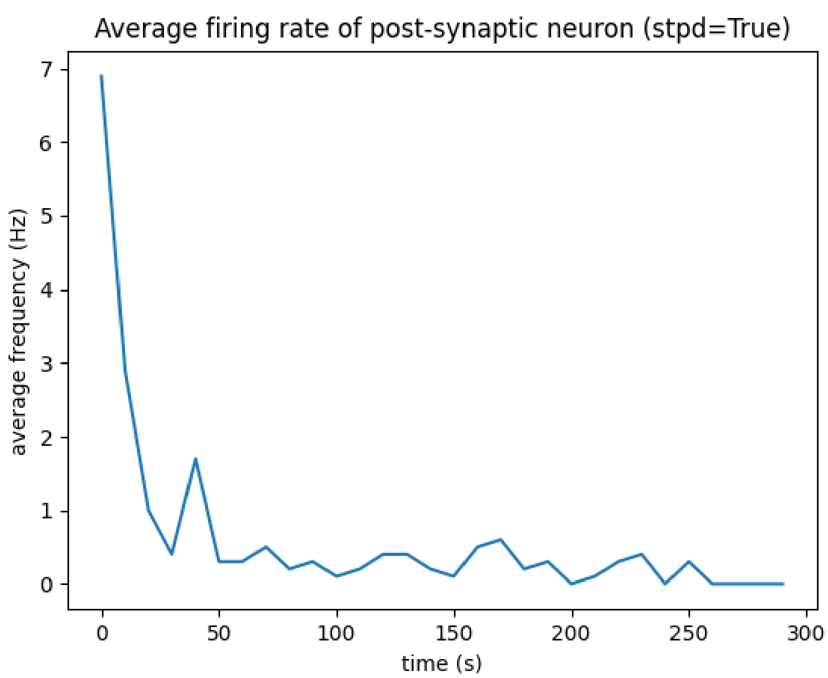


Question 2

The mean strength is around 2 nS:



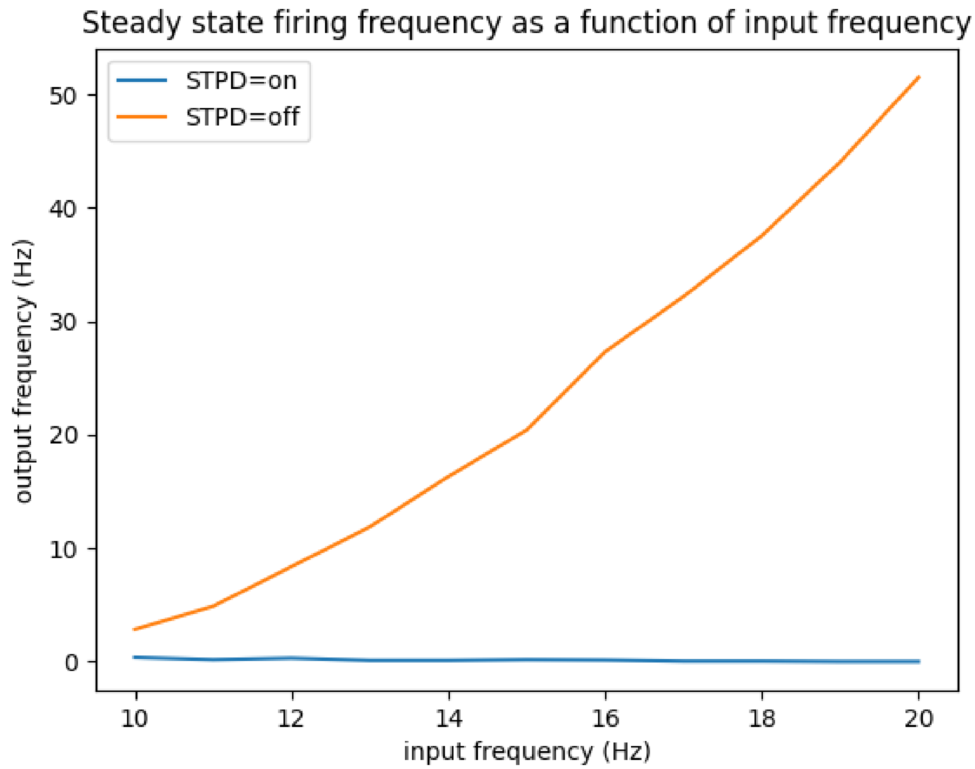
^ This looks like a quadratic polynomial curve. Something like y = (x-2)(x-2).



Average firing rate in last 30s (stpd = on, g_ = 4 nS, r = 15 Hz): **0.1 Hz**

Average firing rate in last 30s (stpd = off, g_ = 2 nS, r = 15 Hz): **0.0 Hz**

Question 3



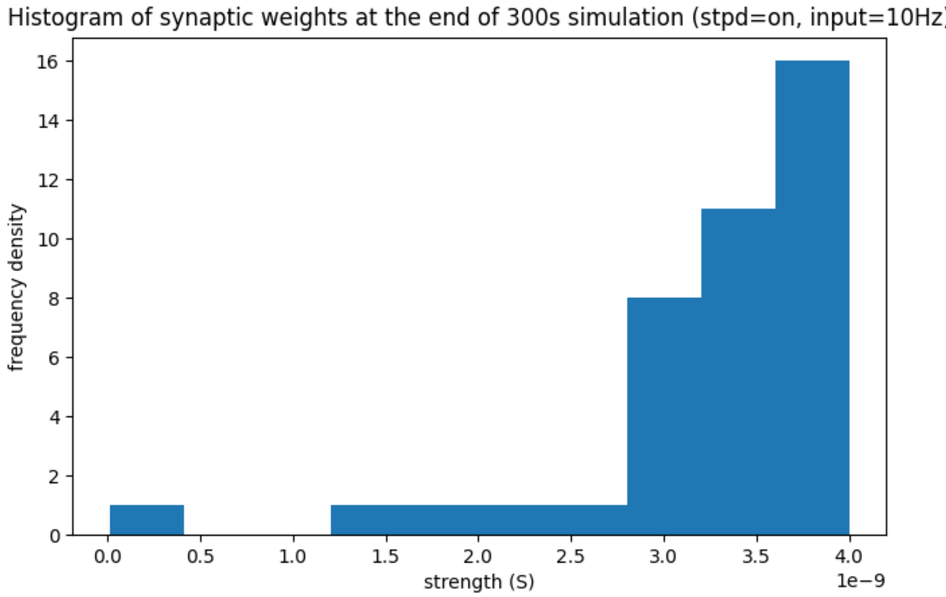
With stpd off, the output frequency has a linear relationship with the input frequency. With stpd on, there is no relationship and the output frequency is constant.

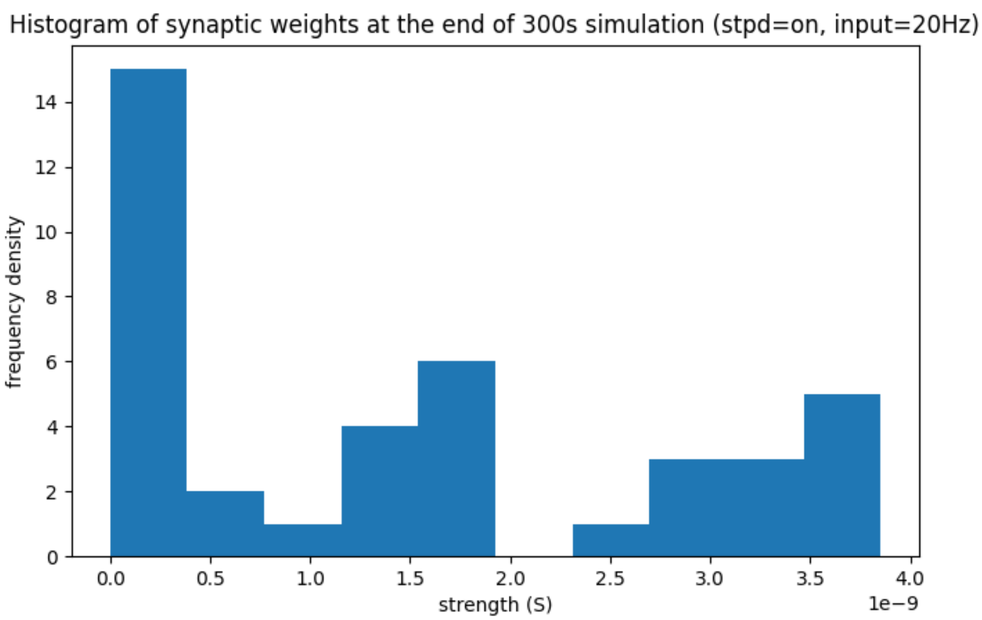
Consider the stpd=on case. With a higher input frequency, depression occurs in the synapses more often and so the synapses tend to contribute less to the post synaptic neuron firing.

Instead when stpd=off, the higher input frequency simply means more synaptic voltage is fed to the post synaptic neuron and so we record a higher output frequency.

The following histograms show the final output strengths for their respective simulations.

With stpd on, 10Hz input signal, 300s simulation, the mean end strength was around 3.185 nS
With stpd on, 20Hz input signal, 300s simulation, the mean end strength was around 1.396 nS

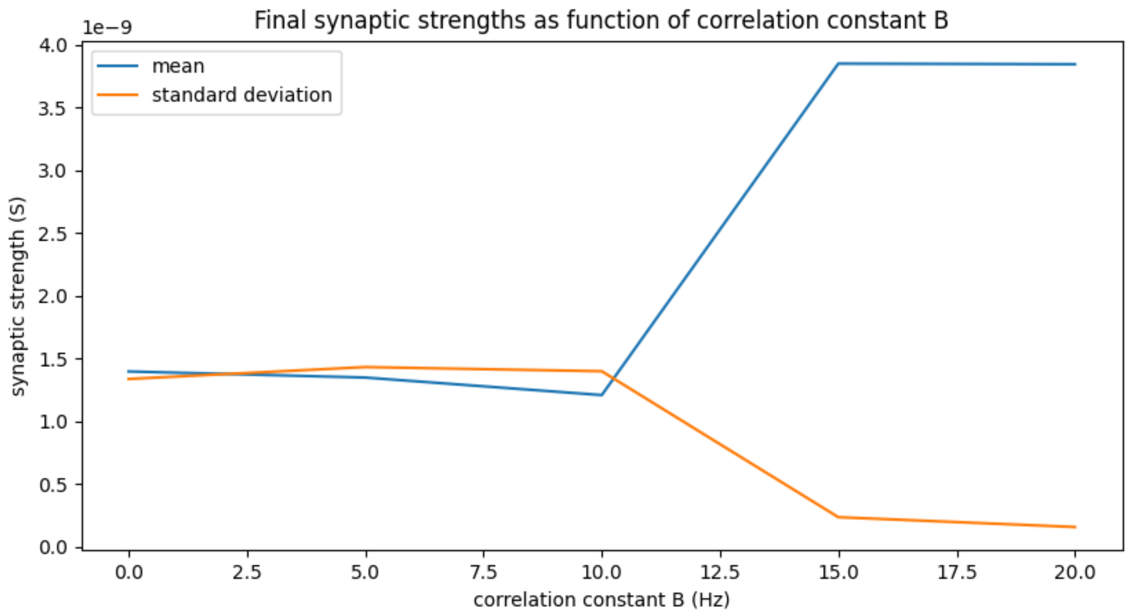




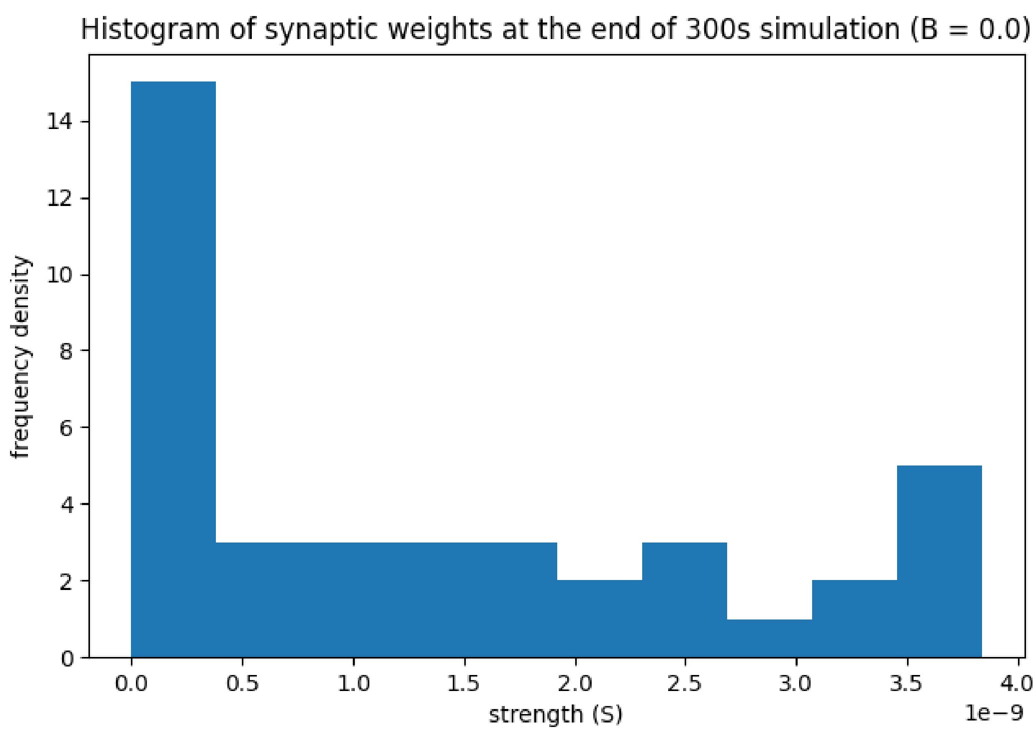
With a lower input frequency, the presynaptic neurons are firing less and so depression in their strengths happens less often. And so their strengths start to spread out towards zero but not very rapidly.

With a higher input frequency, the presynaptic neurones fire more and so depression happens more often. And so at the end we record final synaptic strengths that are way lower.

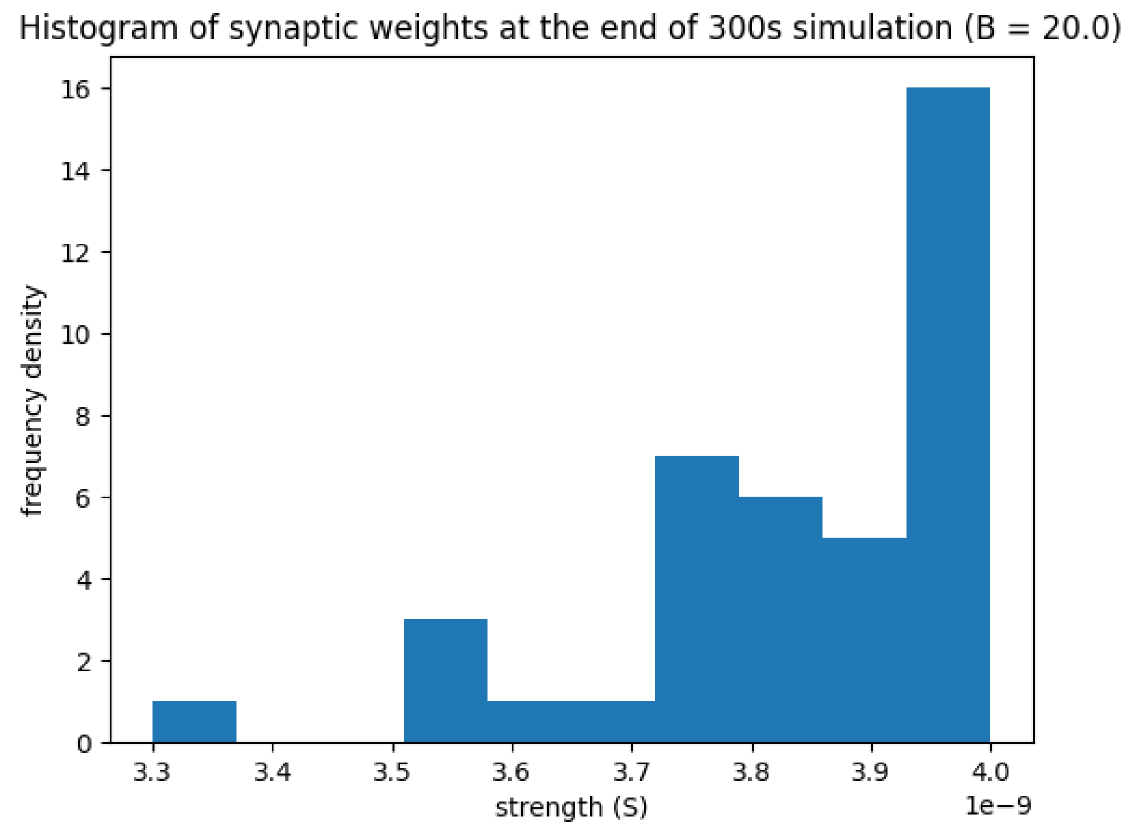
Question 4



Final synaptic strengths as function of correlation constant B
1e−9
mean
standard deviation
synaptic strength (S)
correlation constant B (Hz)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0



Histogram of synaptic weights at the end of 300s simulation (B = 0.0)
frequency density
strength (S)
1e−9
0
2
4
6
8
10
12
14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0



When the pre-synaptic neurons are more correlated, the synaptic strengths converge towards the maximum: 4nS, and they become more consistent with each other as well.

When the pre-synaptic neurons are less correlated, the synaptic strengths sit on the lower end of the range but also vary somewhat amongst themselves.

When B = 0, the firing rate is always just the average. Therefore you get 40 input synapses firing at the same rate but independently. And so we get a situation like question 3 where the synaptic strengths go towards zero.

When B = 20Hz, the firing rate varies between 0Hz and 40Hz since 20 * sin(x) lies in the range 20:20 so average + 20 * sin(x) is in the range 0Hz and 40Hz. So they all fire together in short burts. So what happens is this increases the probability for a postsynaptic spike, which then increases their strengths. So they go towards 4nS