BT6270 - Computational Neuroscience
Assignment 2

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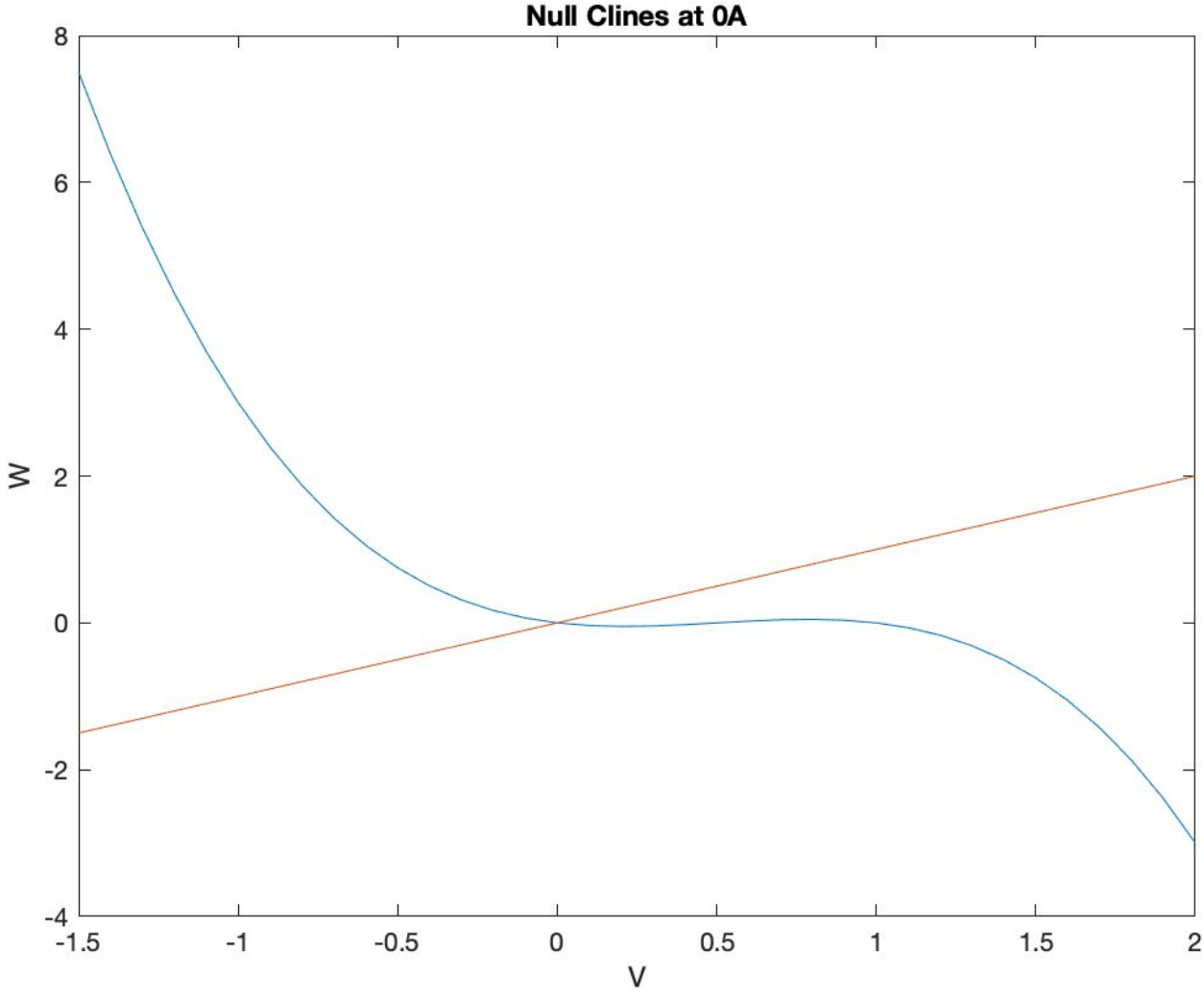
BE17B024

Simulating the two variable FitzHugh-Nagumo neuron model

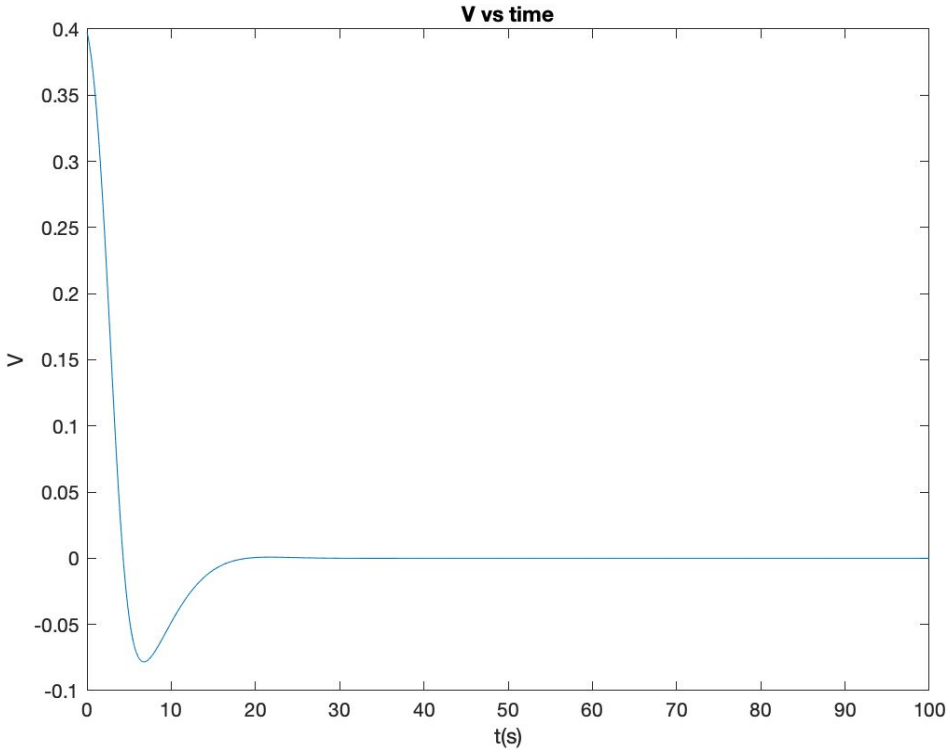
Case 1
$I_{ext} = 0$

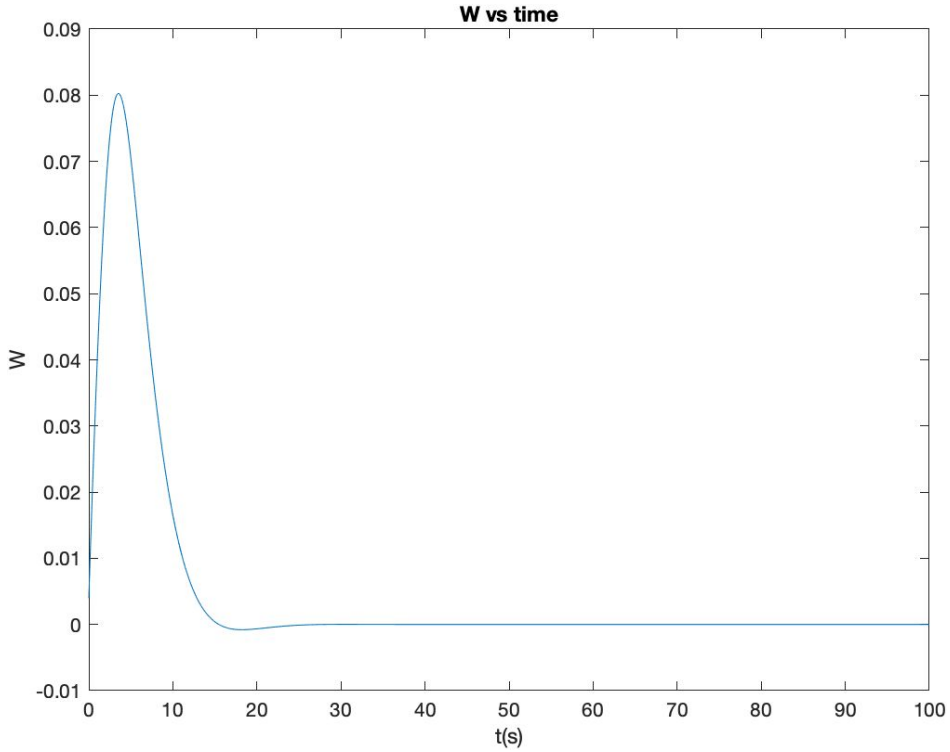
a) Phase Plot

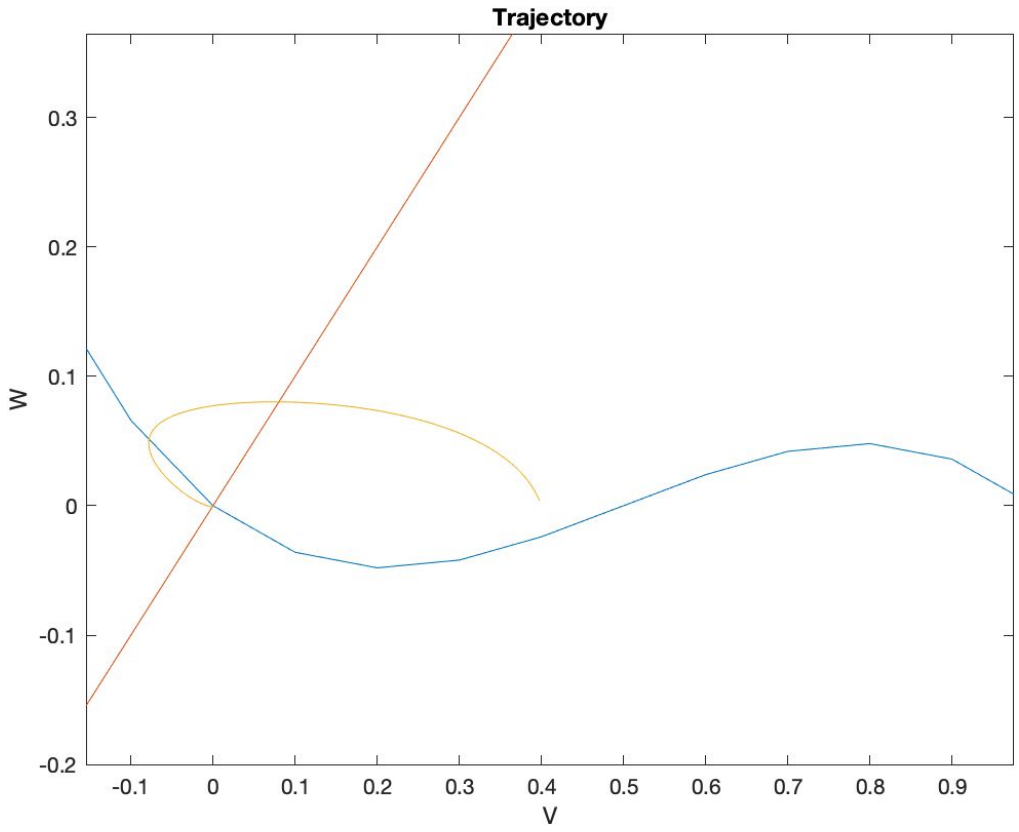


b) V(t) vs t, W(t) vs t, Trajectories

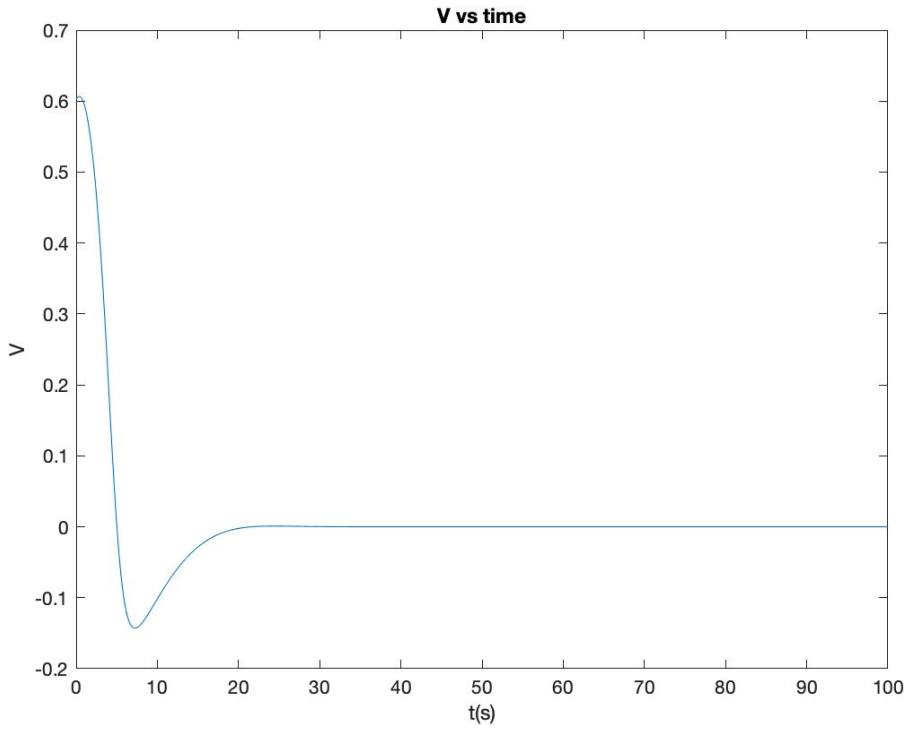
i) V(0) < a, W(0) = 0

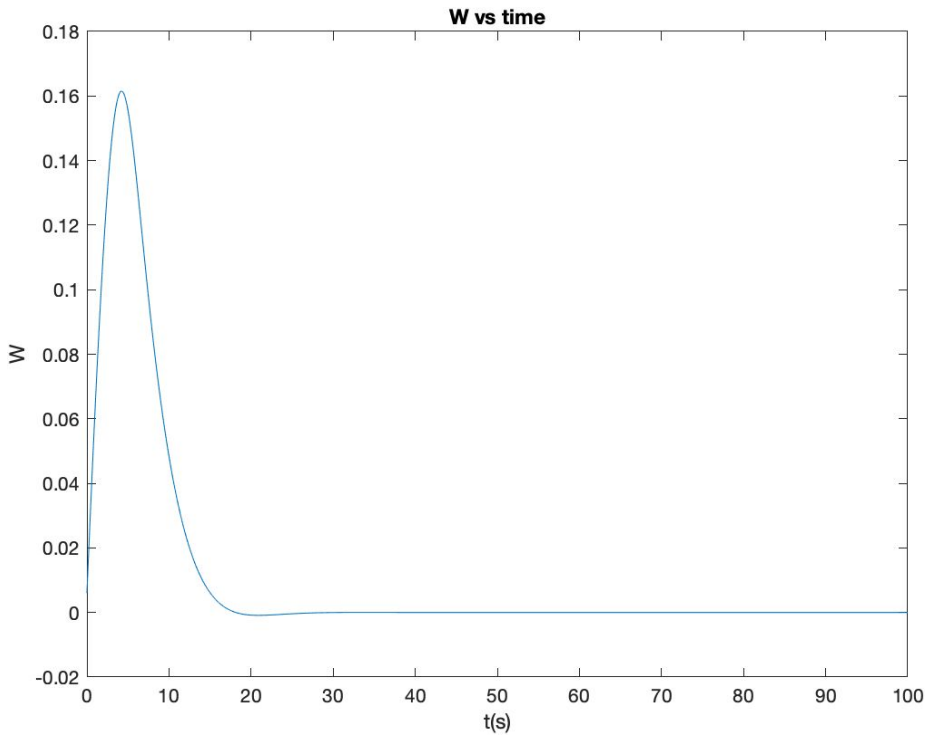


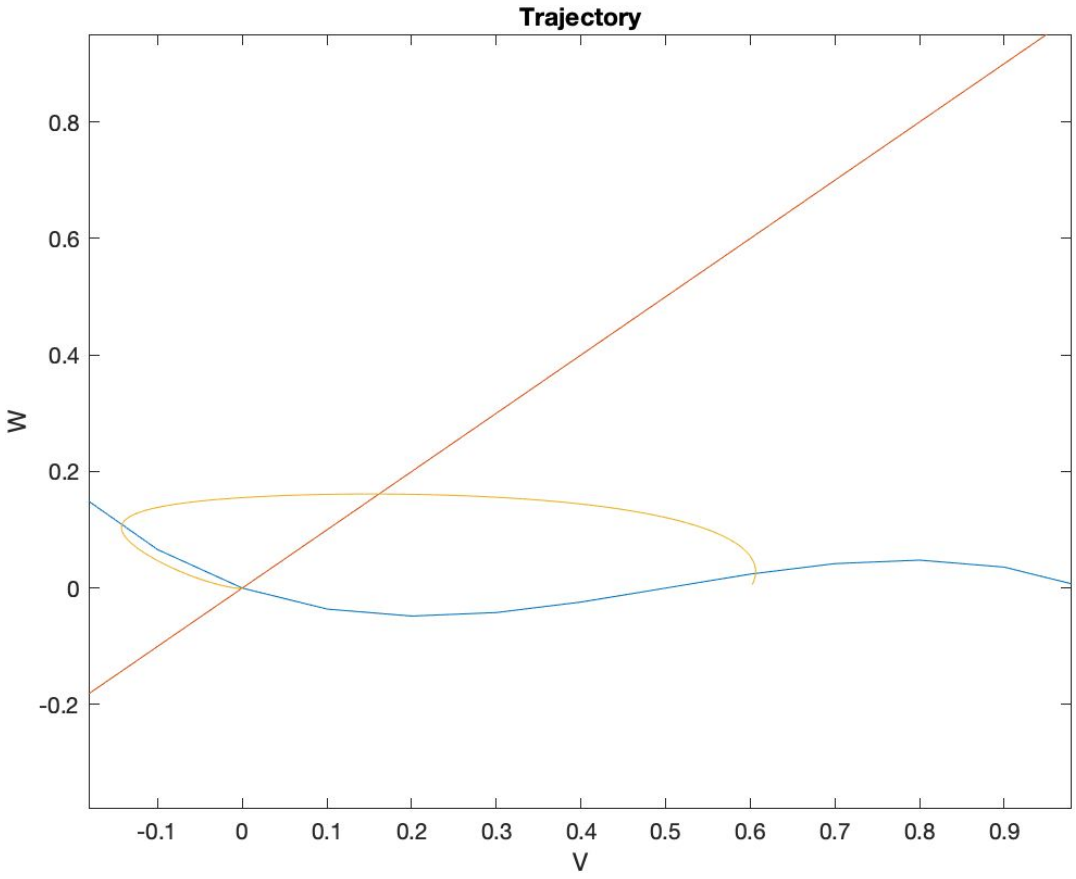



Trajectory
W
V
0.3
0.2
0.1
0
-0.1
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

ii) V(0) > a, W(0) = 0


V vs time
V
t(s)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
10
20
30
40
50
60
70
80
90
100


W vs time
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
W
0
10
20
30
40
50
60
70
80
90
100
t(s)


Trajectory
0.8
0.6
0.4
0.2
0
-0.2
W
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
V

Case 2

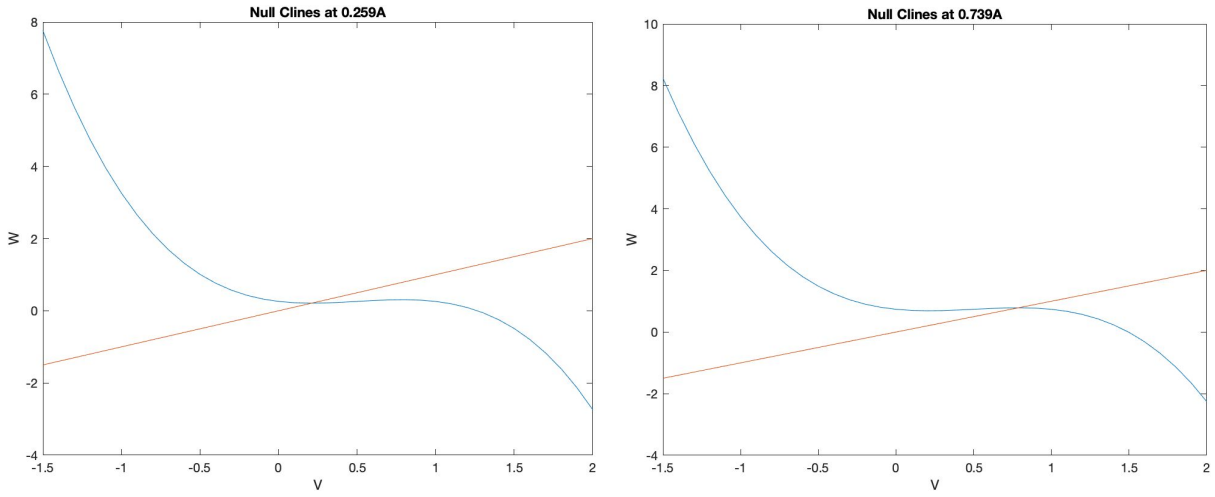
$I1 < I_{ext} < I2$

We need oscillations in this case.

To find I1 and I2, we need to find the extremas of the equation.

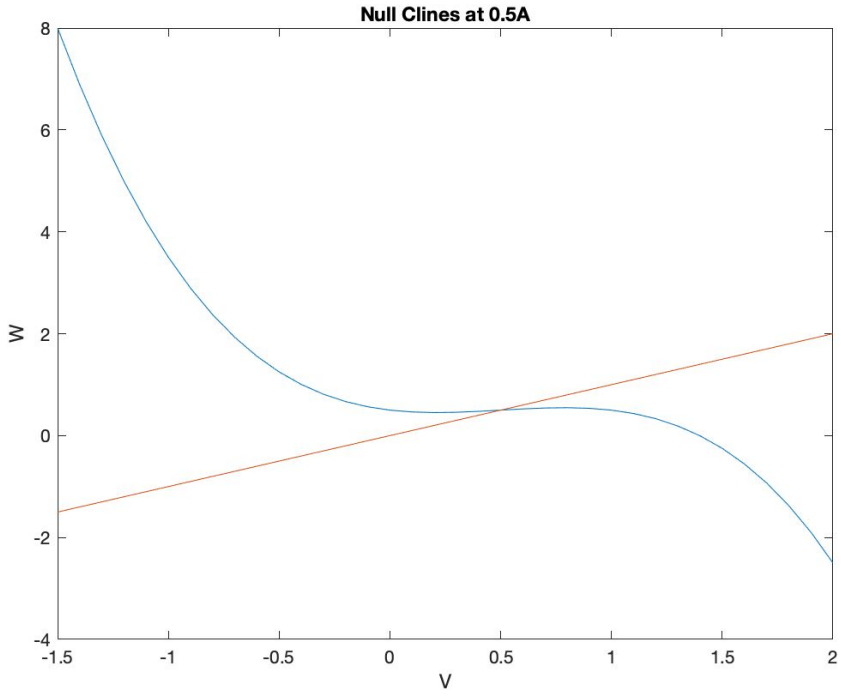
We solve the equation F'(x) = 0 to get the roots, and then solve the F(x) to get the corresponding values of I1 and I2.

I1 = 0.259 and I1 = 0.739

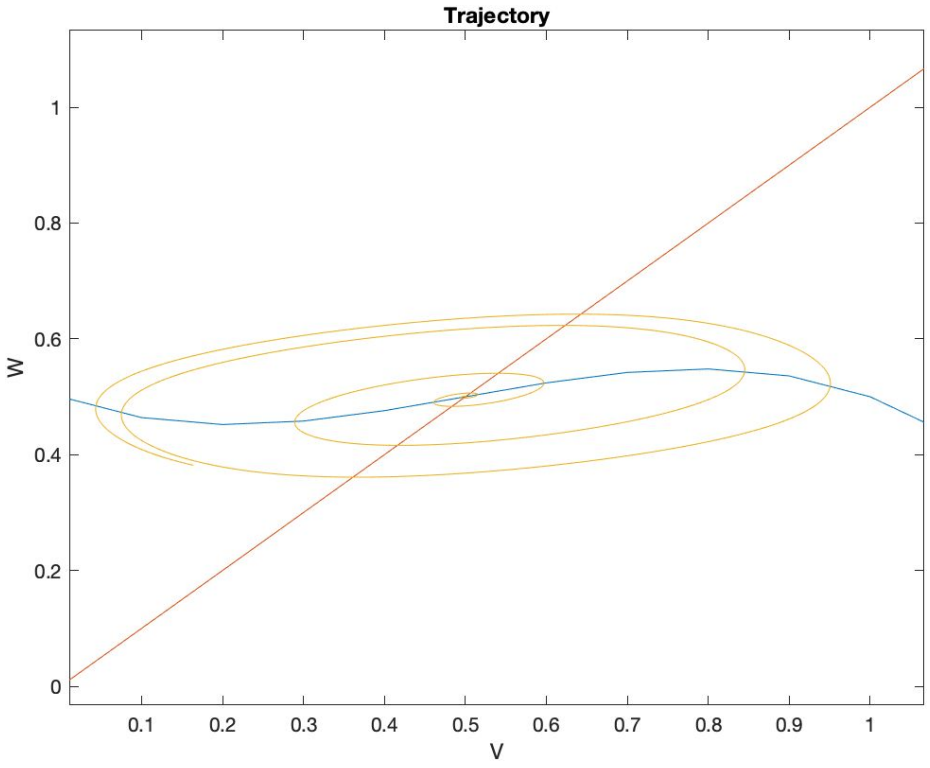


Phase plots of I1 and I2

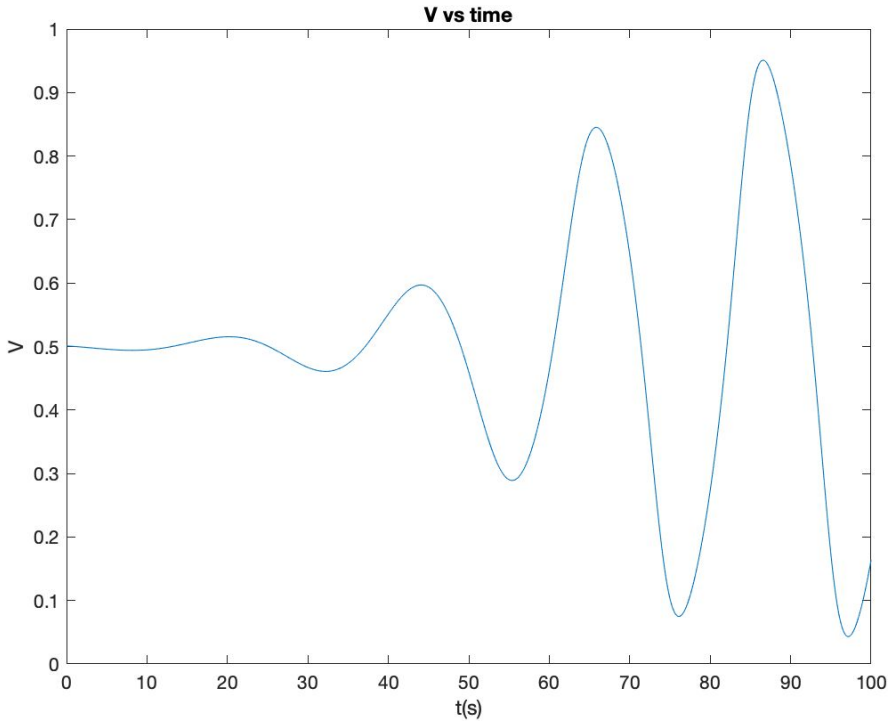
a) Phase Plot for I = 0.5

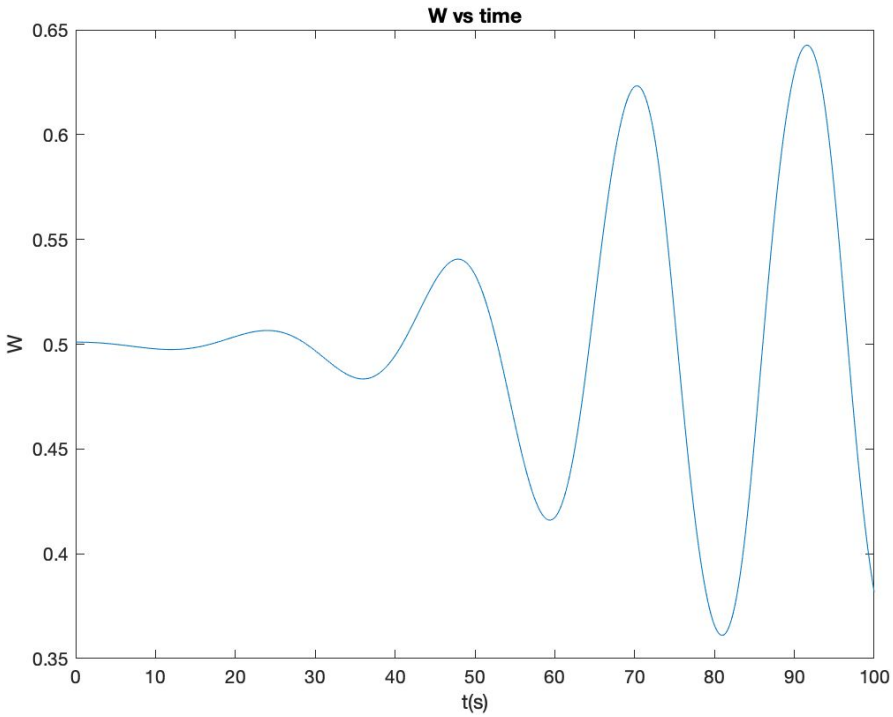


b) Fixed point (0.5, 0.5) is unstable
A small disturbance of (0.001, 0.001) causes it to spiral into a limit cycle.



c) V(t) vs t, W(t) vs t





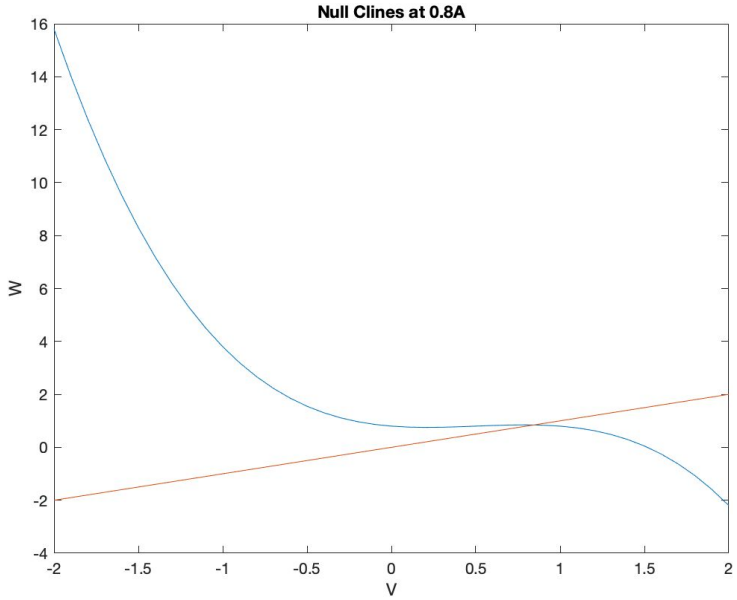
Both V(t) and W(t) show periodic ossicallations

Case 3

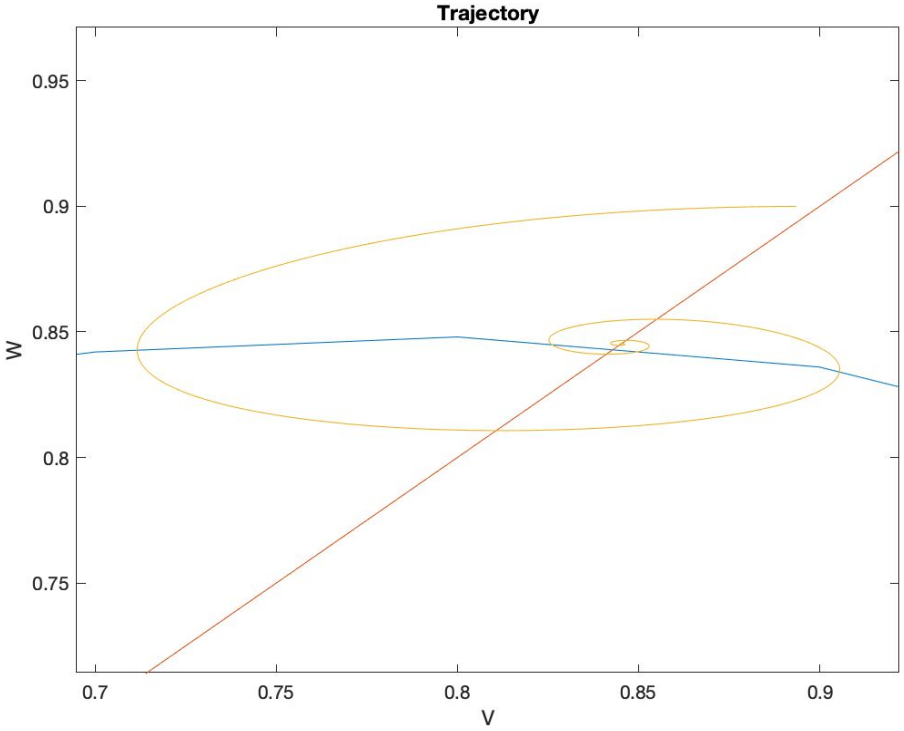
I_{ext} > I2

I_{ext} = 0.8 A

a) Phase Plot

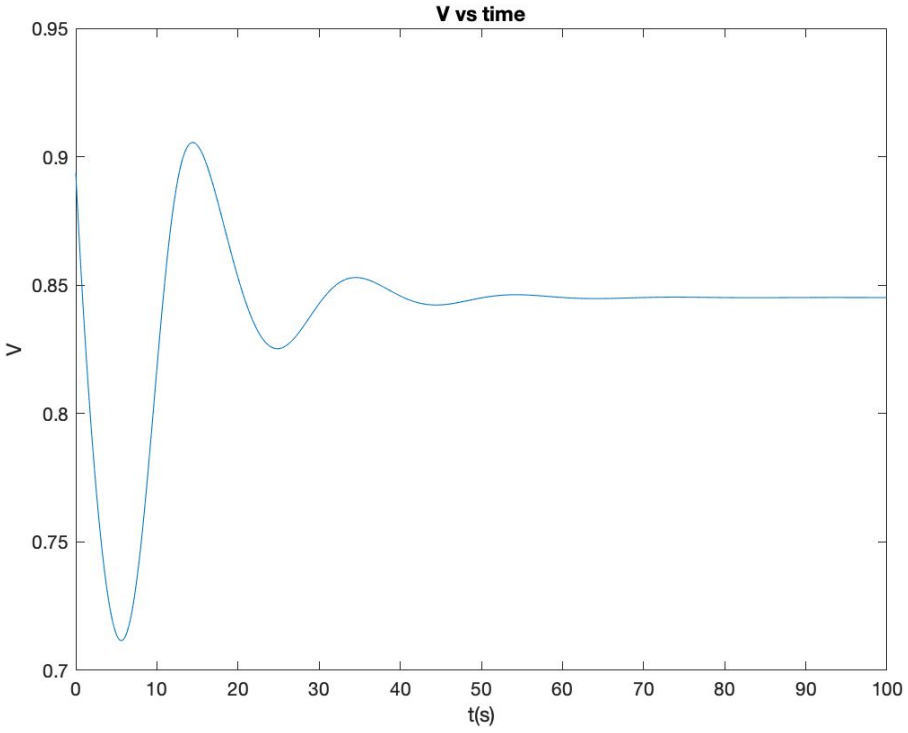


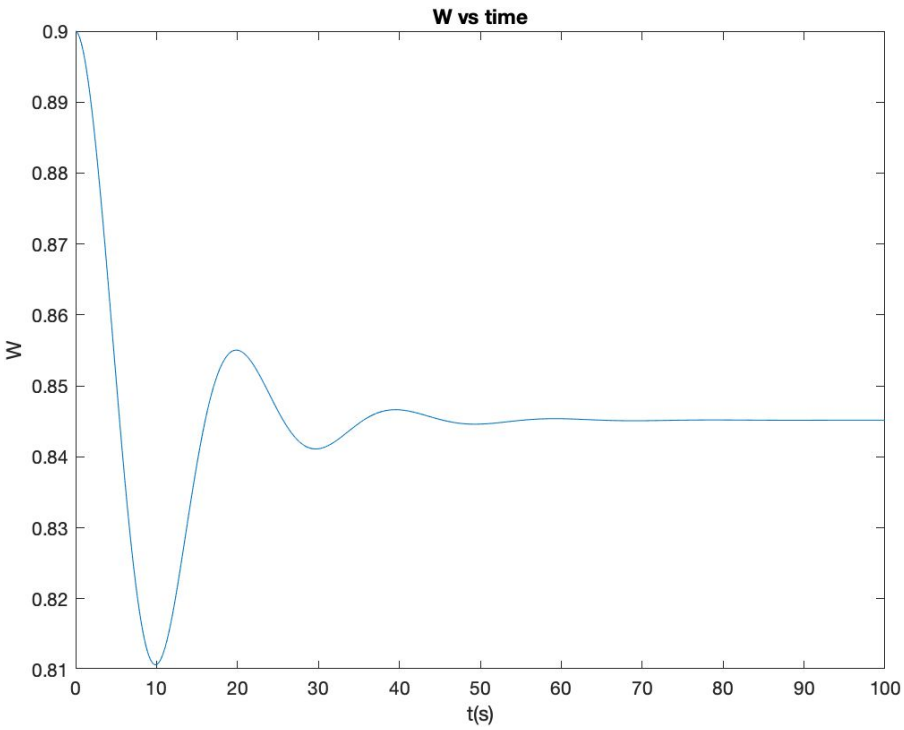
b) The steady state is at (0.845,0.845)
We start from a point (0.9,0.9)



The trajectory spins back, hence it is a stable fixed point

c) V(t) vs t, W(t) vs t



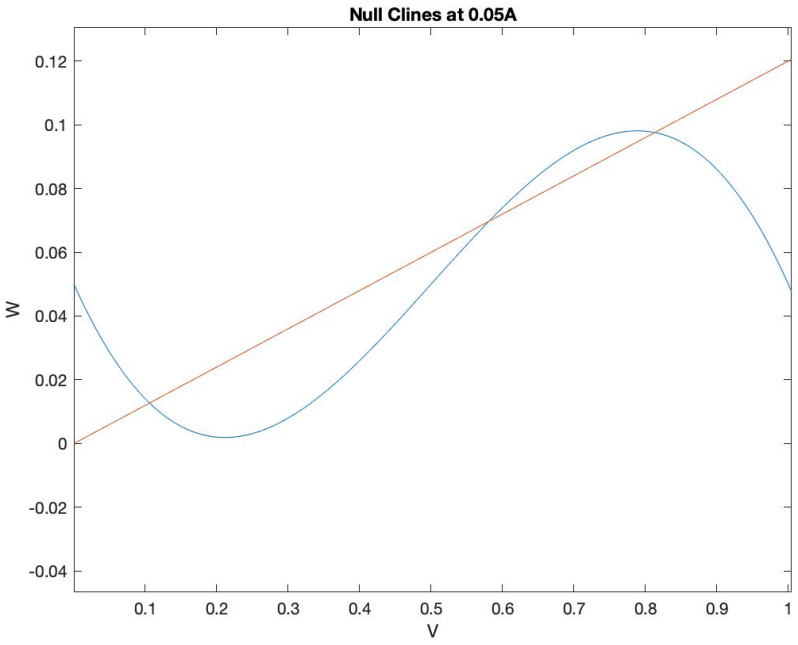


Both the trajectories spiral back to the fixed point

Case 4

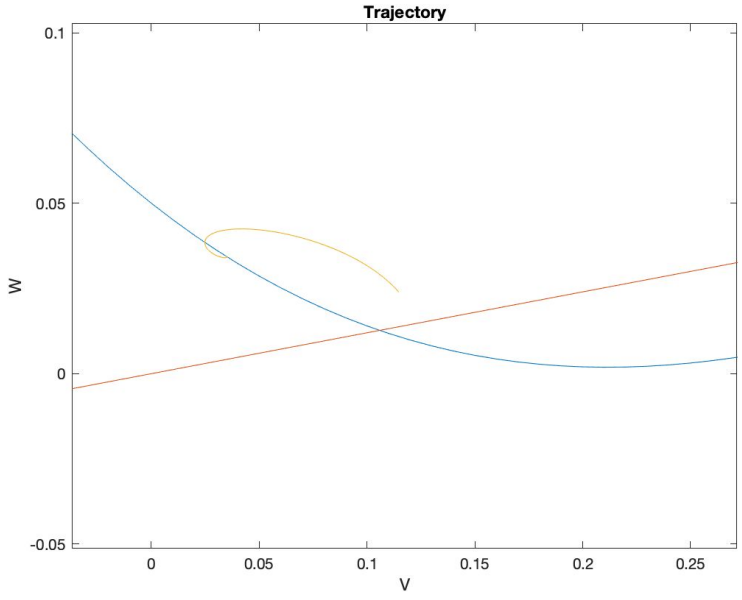
The minima of the v null cline lies below w null cline, and maxima lies above it.
The slope b/r needs to be smaller than slope connecting the minima and maxima.
b/r < 0.1667
Let's consider b/r value of 0.12
b = 0.012
r = 0.01
I = 0.05

a) Phase plot for I = 0.05 A

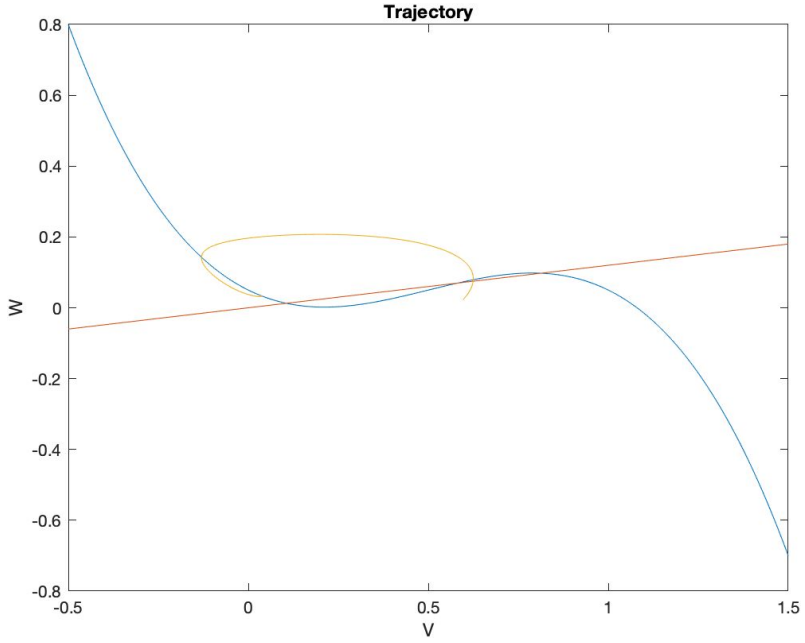


b)
P1=(0.106, 0.013)
P2=(0.581, 0.070)
P3=(0.813, 0.097)

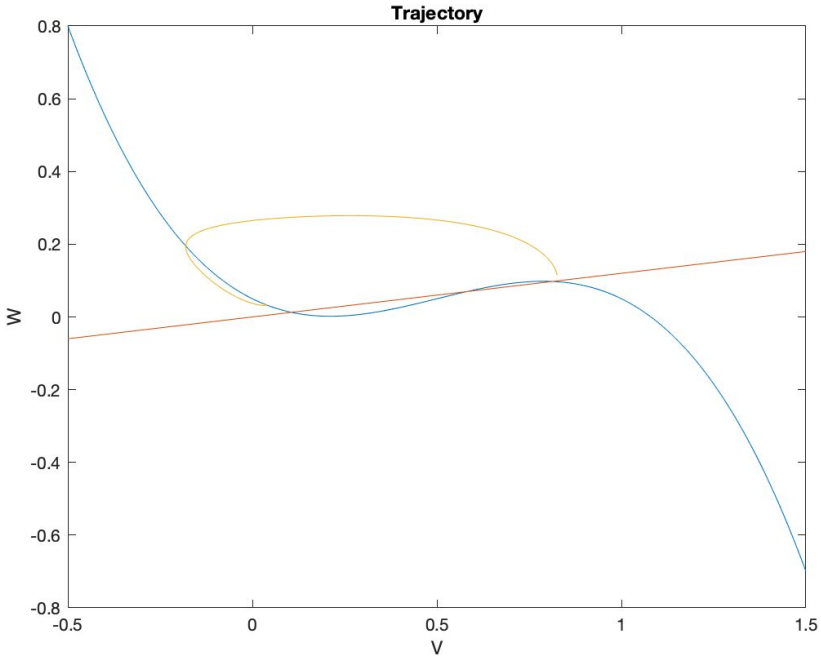
P1 - Stable as it converges



P2 - Stable as it converges

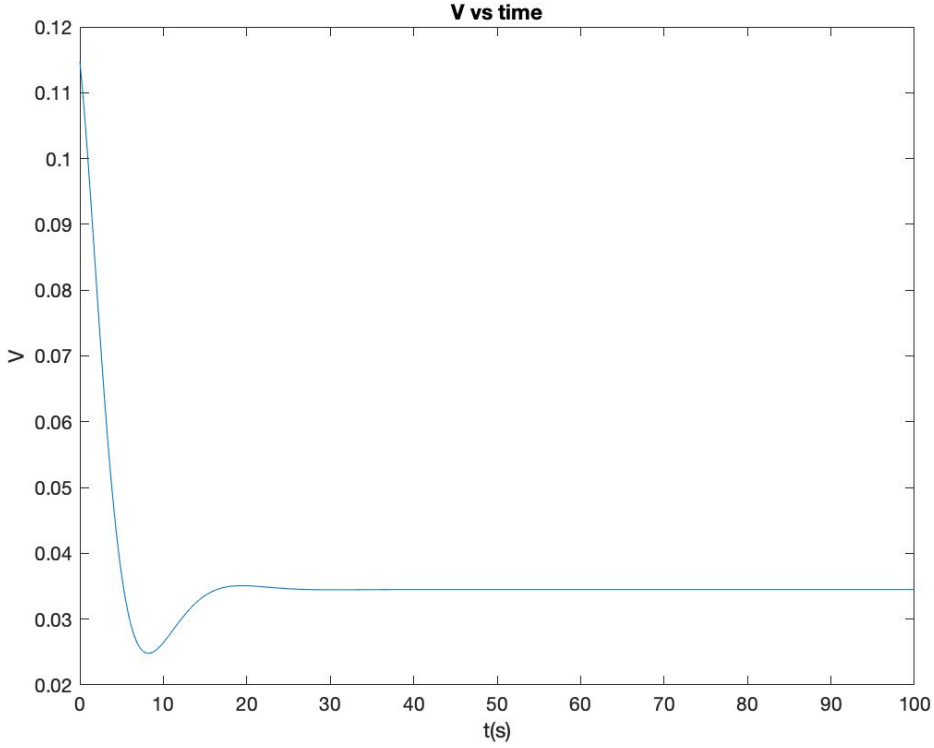


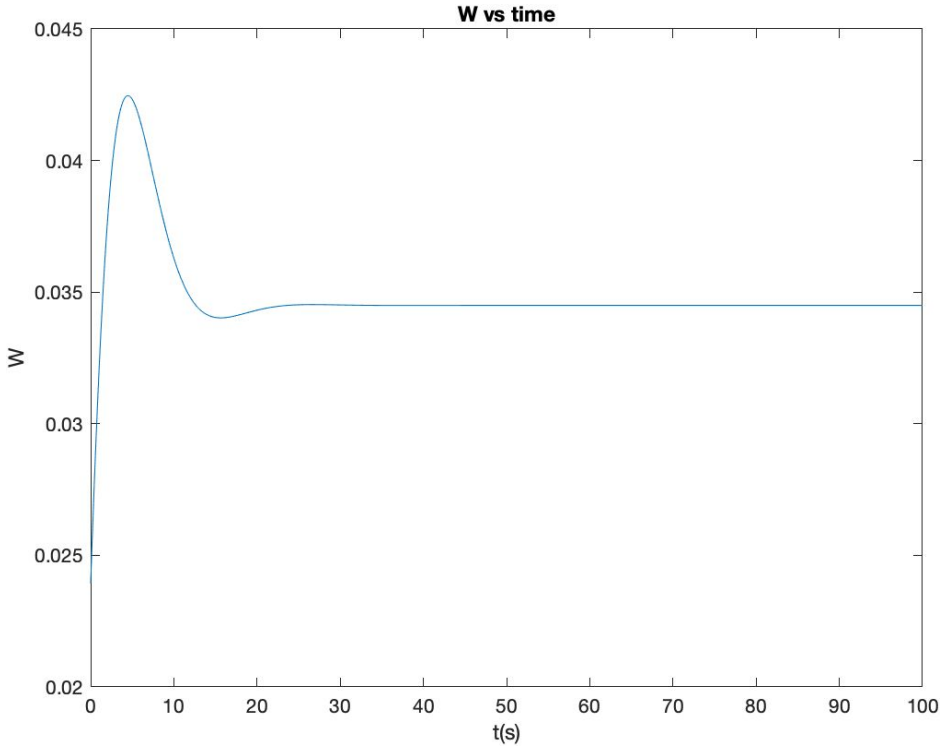
P3 - Stable as it converges



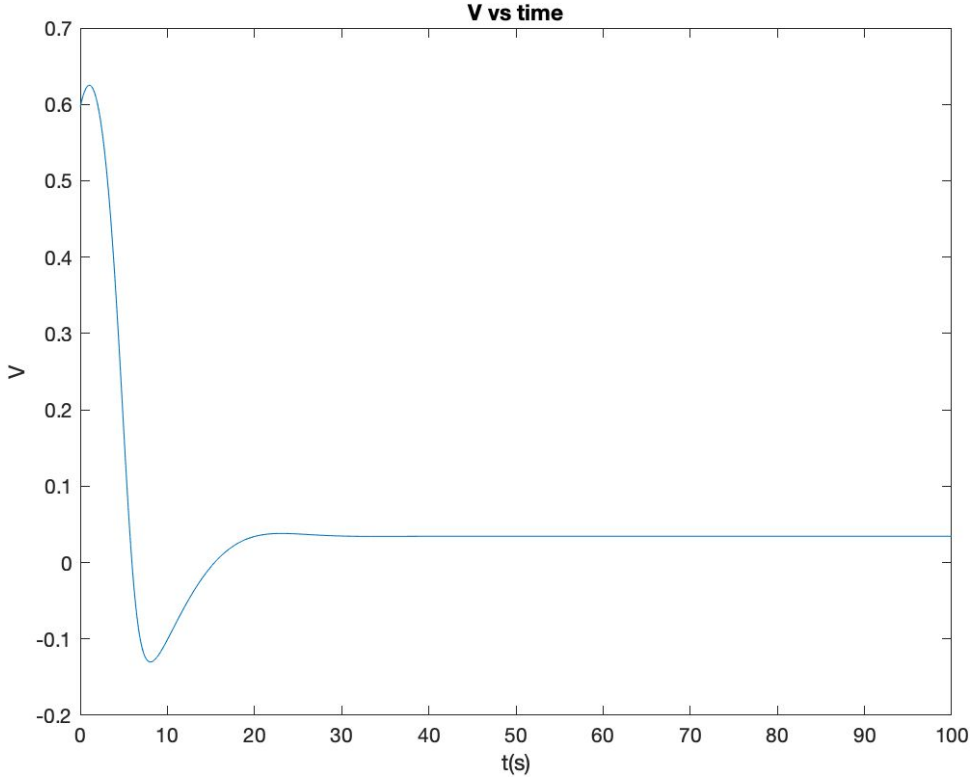
c) V(t) vs t, W(t) vs t

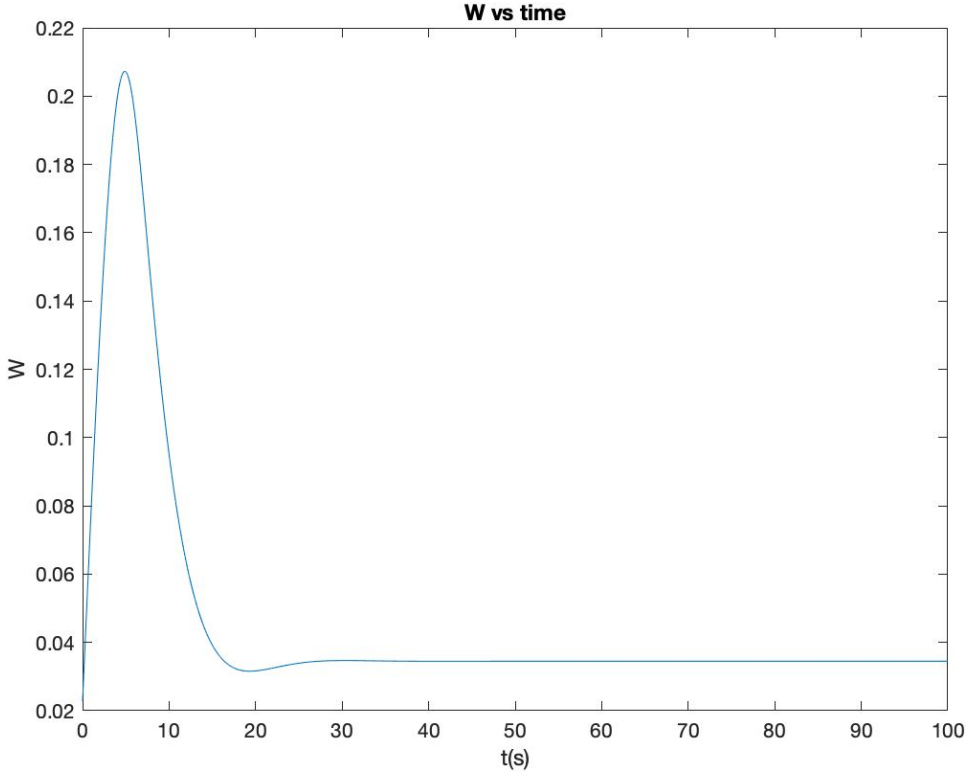
P1=(0.106, 0.013)



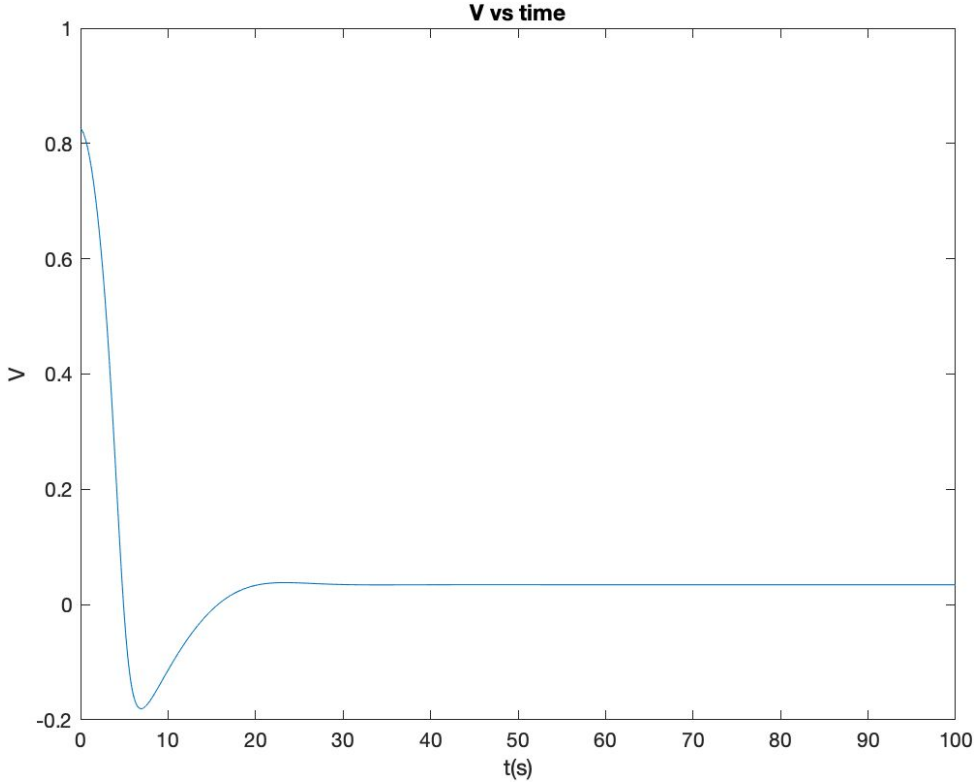


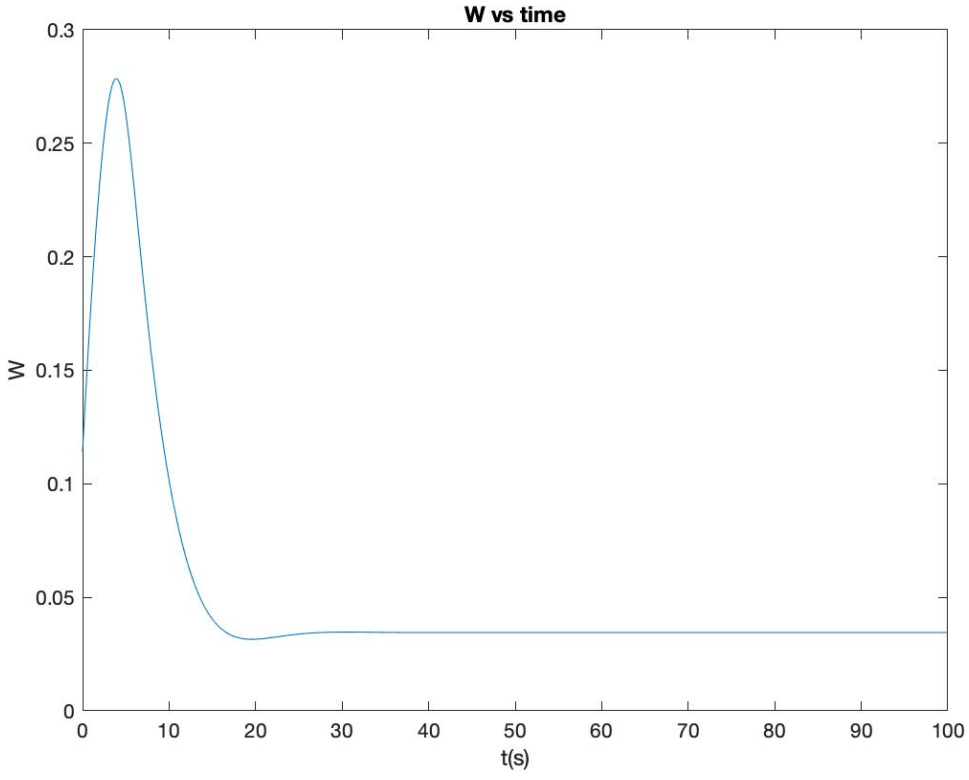
P2=(0.581, 0.070)


V vs time
V
t(s)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
10
20
30
40
50
60
70
80
90
100


W vs time
W
t(s)
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10
20
30
40
50
60
70
80
90
100

P3=(0.813, 0.097)


V vs time
V
t(s)
1
0.8
0.6
0.4
0.2
0
-0.2
0
10
20
30
40
50
60
70
80
90
100


W vs time
W
t(s)
0.3
0.25
0.2
0.15
0.1
0.05
0
0
10
20
30
40
50
60
70
80
90
100