CS CM 182 Lab 4

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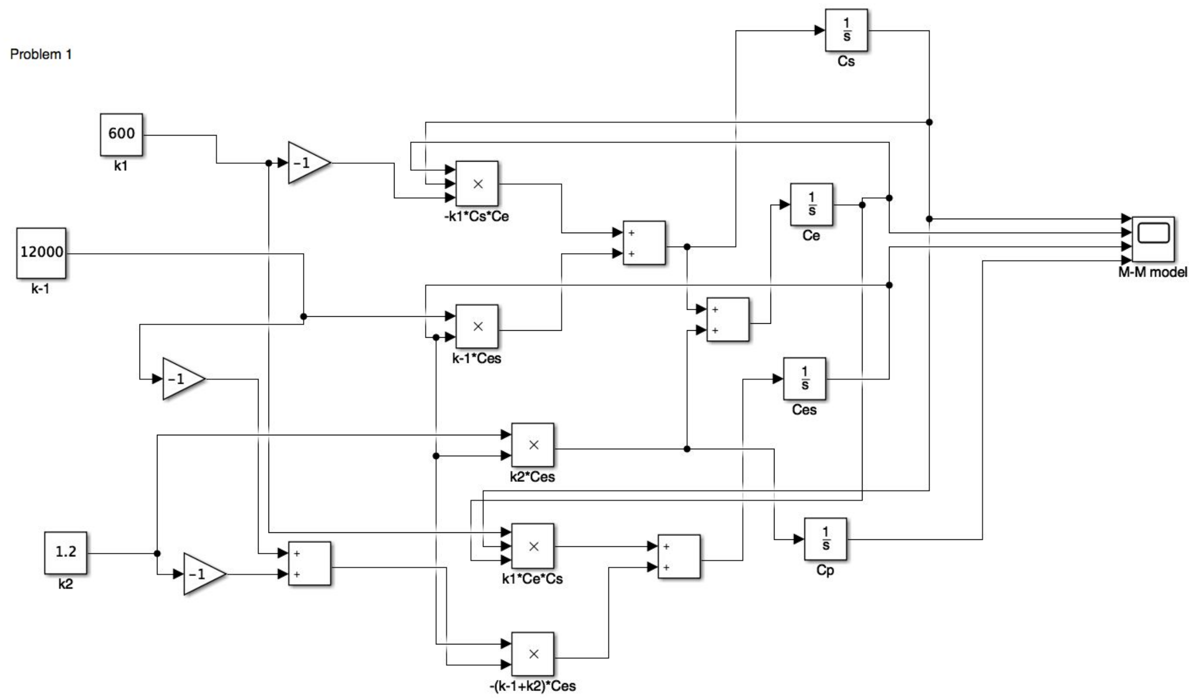
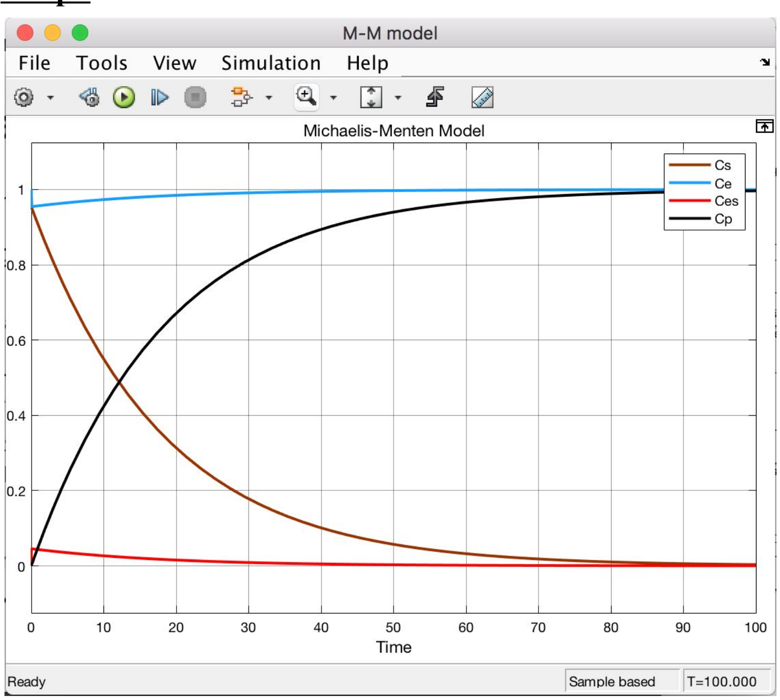
I completed this written part of the homework, lab report, or exam entirely on my own.

Exercise 1

Simulink



Graph

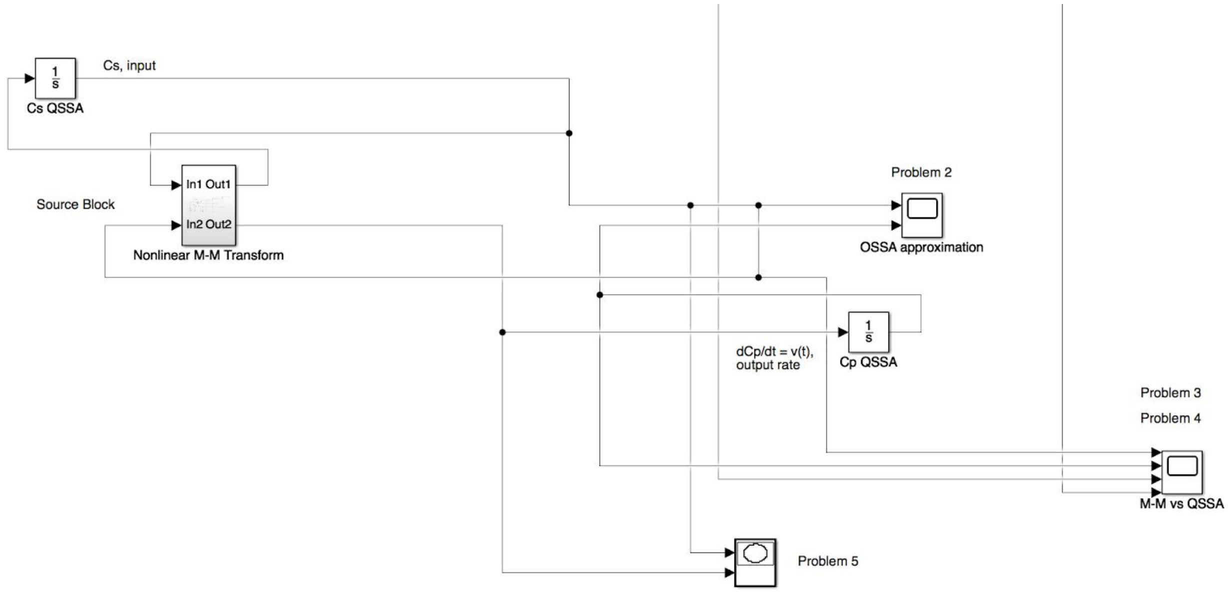


Interpretation

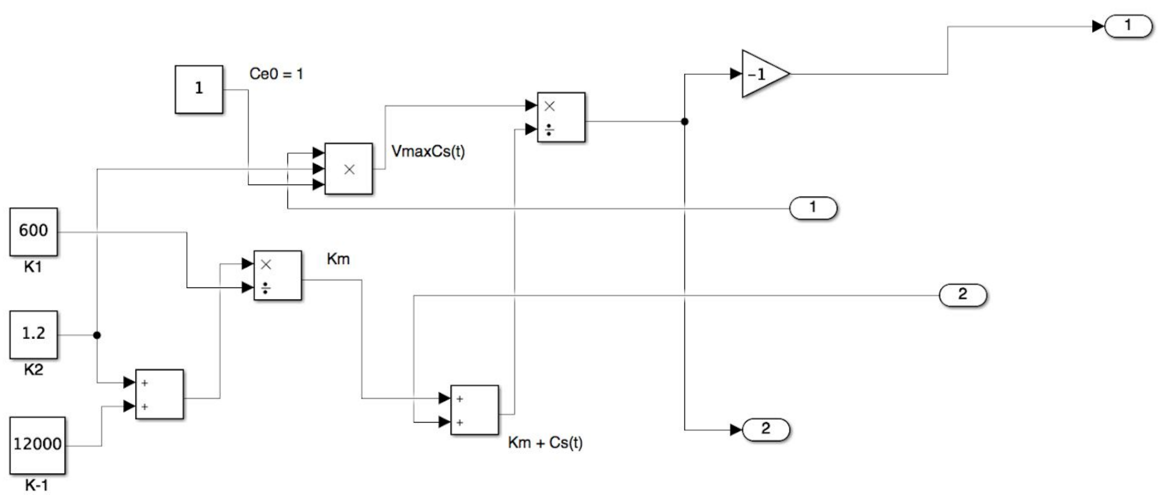
According to the Michaelis-Menten Kinetics ODE equations, an enzyme E binds to a substrateS to form the complex ES. ES then releases the product P and the original enzyme. As substrate becomes a product, this explains the graph Cs start off with 1 and then slowly decrease to 0 while the graph Cp start off with 0 and then slowly increase to 1. Both Ces and Ce graphs look constant over the process because as substrate becomes a product, it needs to first turn into complex ES. However, the complex is both turning into a product with enzyme and turning back to substrate and enzyme. Therefore, enzymes and complexes do not have much change due to this opposite direction change cancelling each other over the process.

Exercise 2

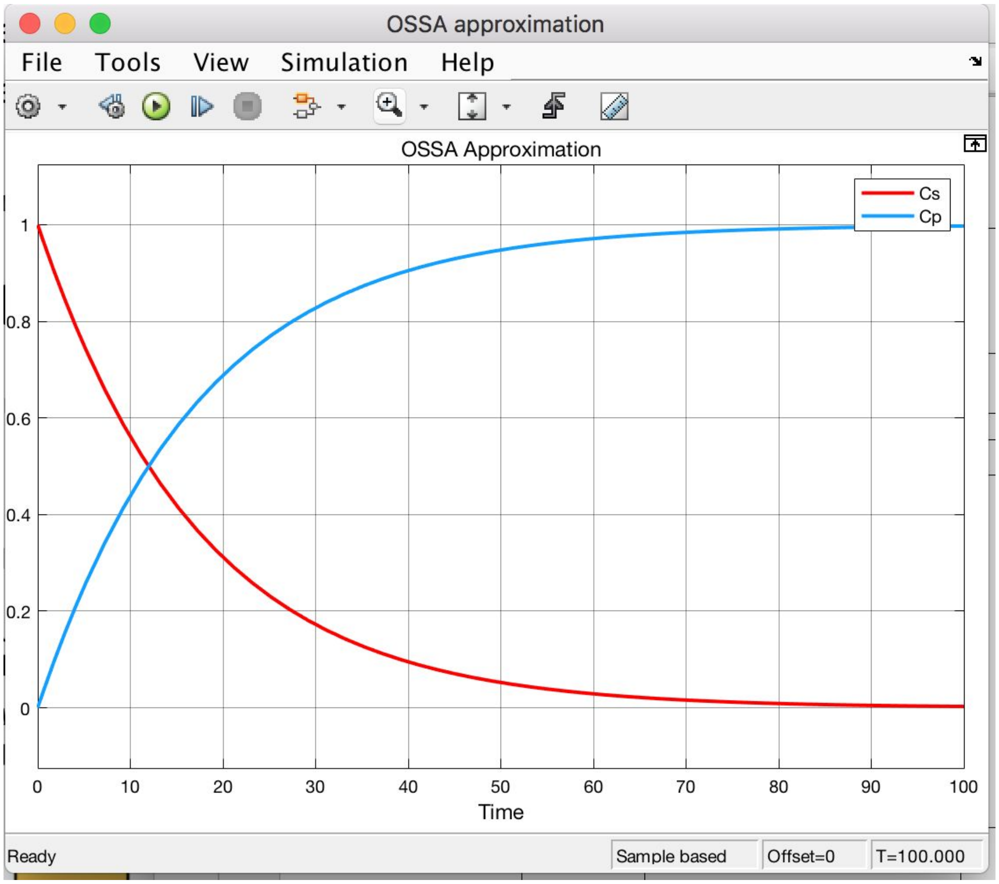
Simulink- Overall



Simulink- Inside the subsystem block

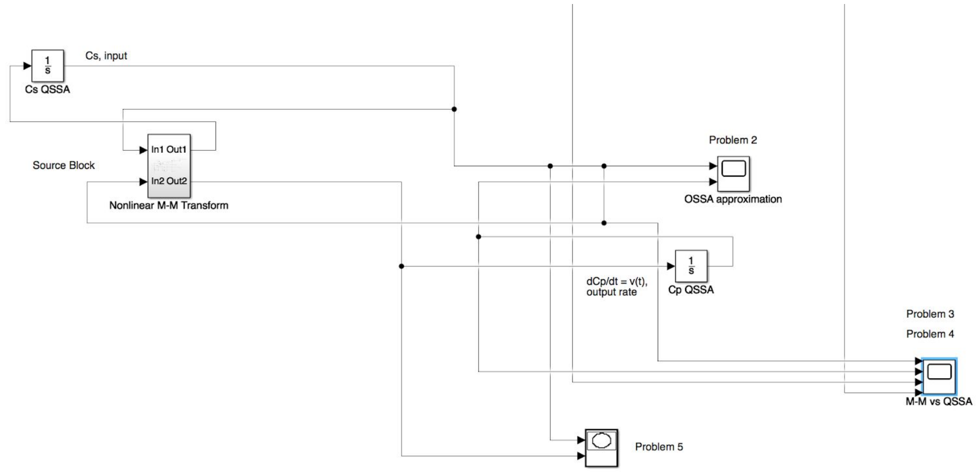


Graph

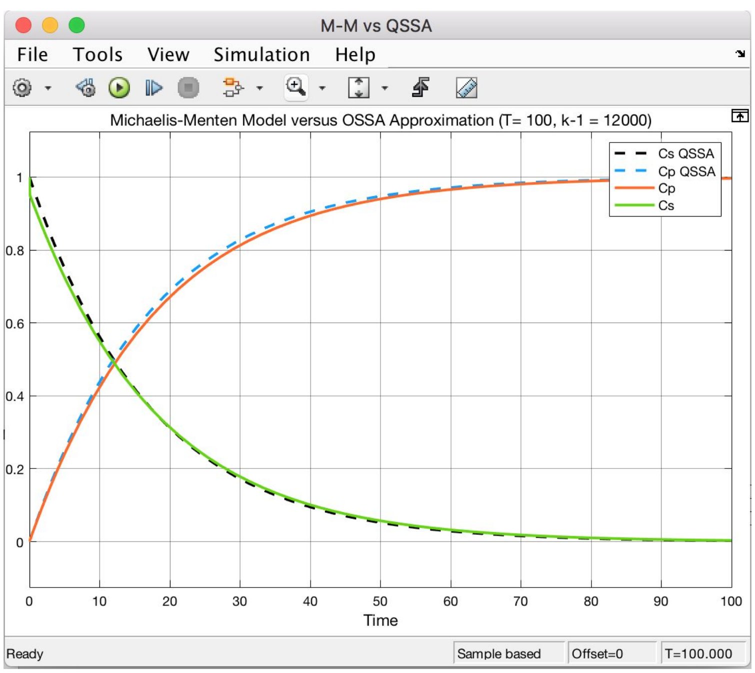

OSSA approximation
File
Tools
View
Simulation
Help
OSSA Approximation
Cs
Cp
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
90
100
Time
Ready
Sample based
Offset=0
T=100.000

Exercise 3

Simulink



Graph



Analysis

Yes, it is a good approximation because the Cs and Cp which are calculated from QSSA approximation are really close to the actual Cs and Cp which are based from the Michaelis-Menten Model as long as the OSSA inequality $K_m + C_s$ (0) >> C_E (0) holds. Since the value of K_m is significantly large due to the fact of large value of K_{-1}, therefore the sum of $K_m + C_s$ (0) is way larger than C_E (0). As a result, the OSSA inequality holds. The inequality is verified by the following calculation.

Valid IF : $K_m + C_s(0) >> C_E(0)$

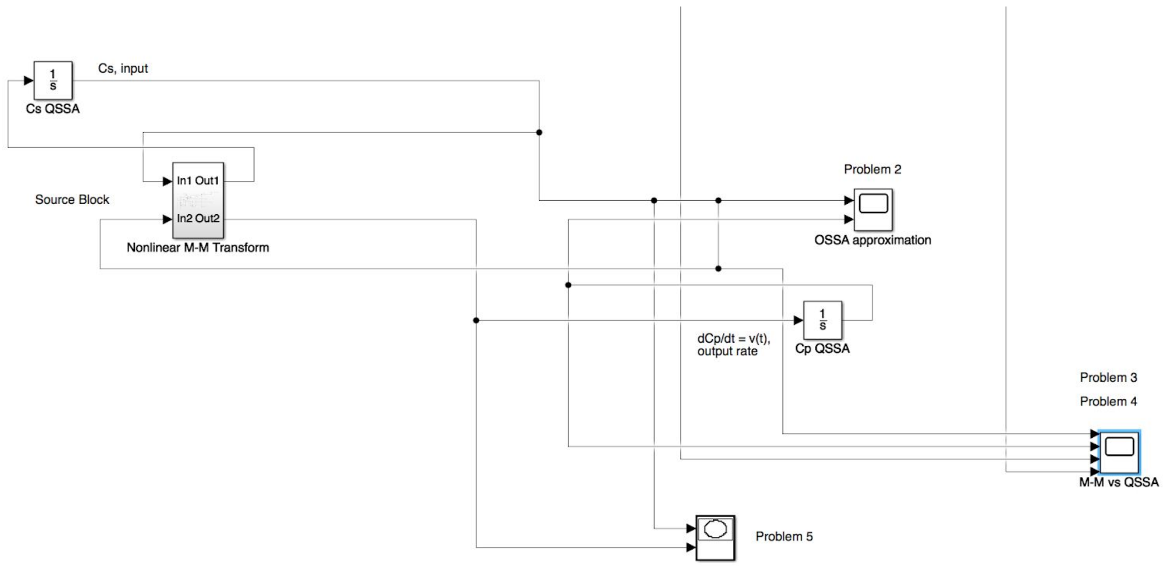
$$\frac{k_{-1} + k_2}{k_1} + 1 >> 1$$

$$\frac{(12000) + 1.2}{600} + 1 >> 1$$

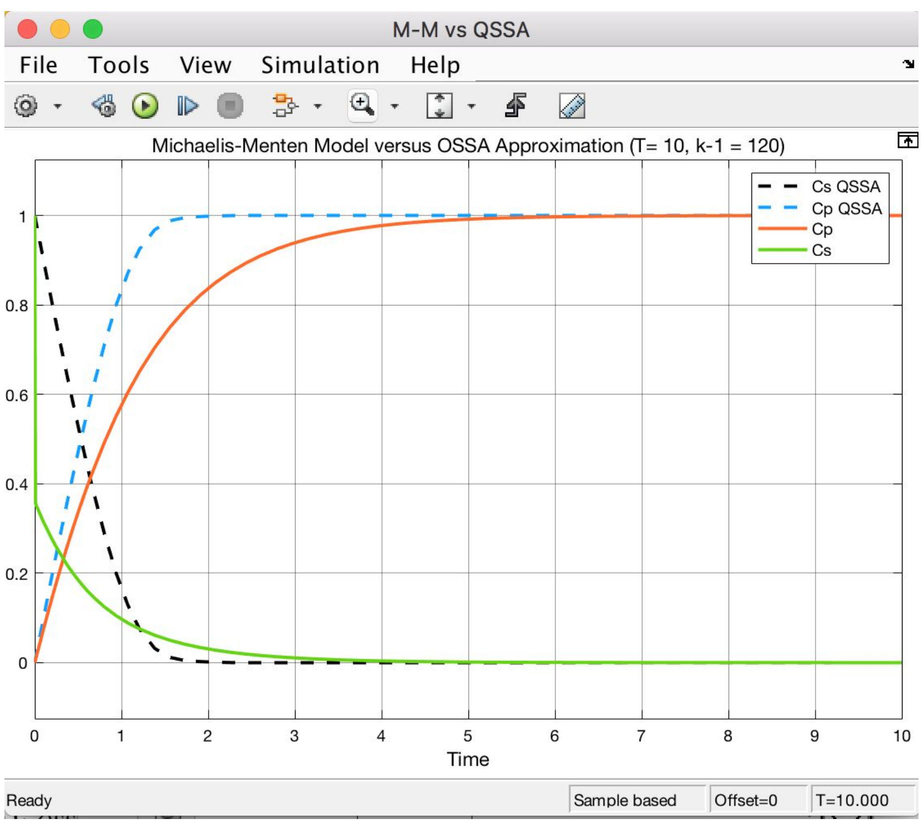
$$21.002 >> 1$$

Exercise 4

Simulink



Graph



Analysis

No, it is not a very good approximation because the Cs and Cp which are calculated from QSSA approximation are quite far from the actual Cs and Cp which are based from the Michaelis-Menten Model. Since the value of K_m is significantly small due to the fact of small value of K_{-1}, therefore the sum of $K_m + C_s$ (0) is not quite large compare to the value of C_E (0). As a result, the OSSA inequality does not really hold.
The verification of the inequality is shown as below.

Inequality: $\underbrace{K_m}_{\frac{K_{-1}+k_2}{K_1}} + \underbrace{C_s(0)}_{1}$

$$\frac{K_{-1}+k_2}{K_1} + 1$$

$$= \frac{(120)+1.2}{600} + 1 = 1.202$$

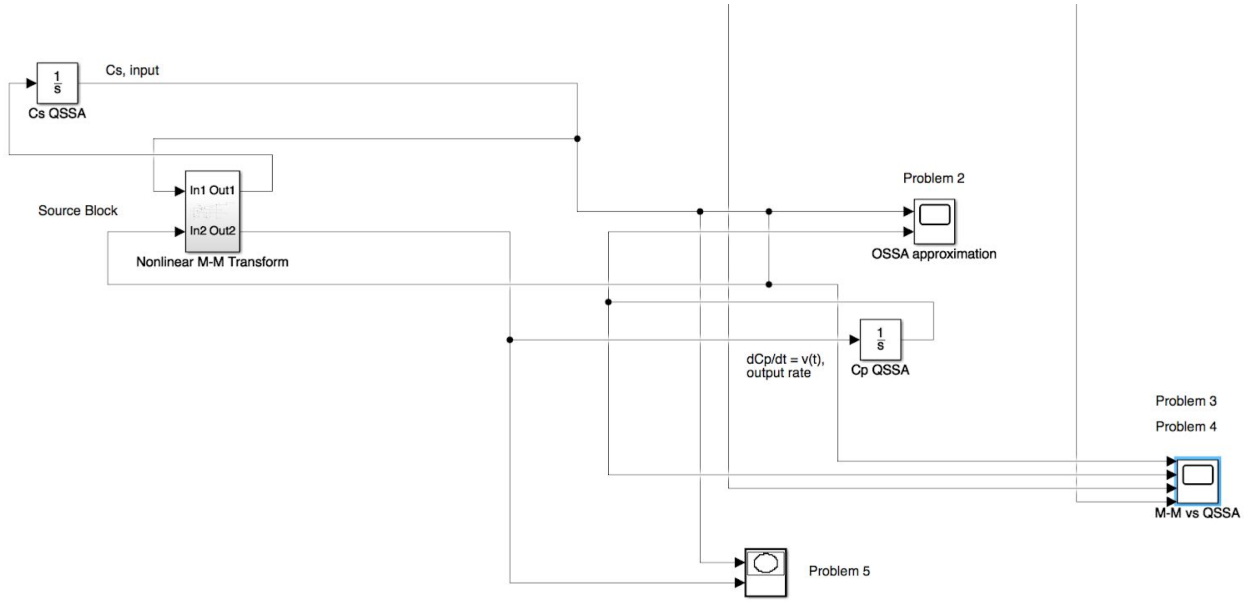
$$1.202 \not\gg \underbrace{1}_{C_E(0)}$$

not significantly larger

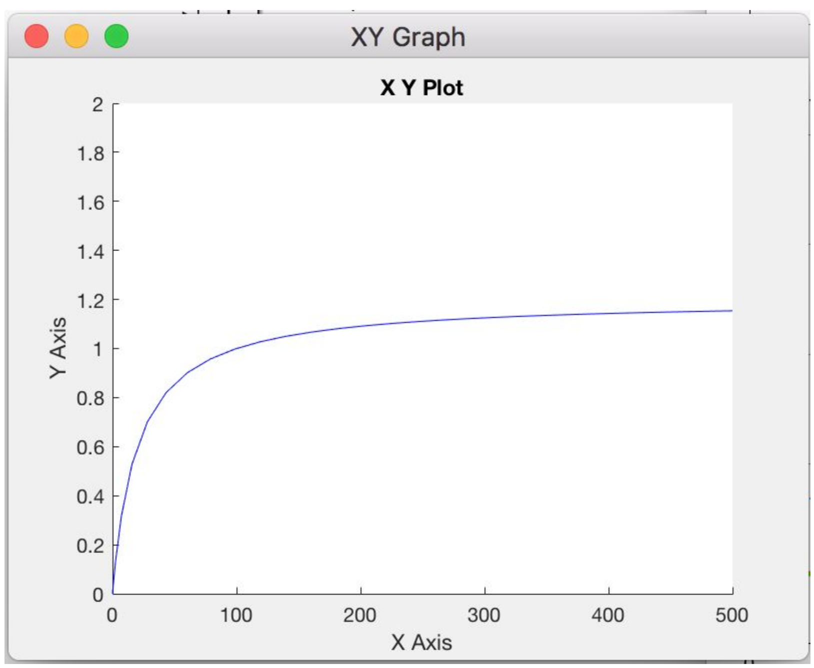
The equality $K_m + C_s(0) \gg C_E(0)$ does not really holds.

Exercise 5

Simulink



Graph



Analysis

As C_{sQSSA} becomes large, v(t) approaching 1 which is the Vmax in our case according to the graph above. The graph is similar to the Michaelis-Menten Kinetics normalized reaction plot. The verification is shown below.

$$\frac{dC_P}{dt} \cong \frac{V_{max} C_S(t)}{K_m + C_S(t)}$$

As $C_S \rightarrow \infty$, K_m is negligible,

$$\text{so} \quad \frac{V_{max} \cancel{C_S(t)}}{\cancel{C_S(t)}} = V_{max} = k_2 C_{E0}$$

$$= (1.2)(1)$$

$$= 1.2$$

close to 1