Leonardo Carrico
MATH 240

Lab 8

Exercise 1:

The functions for each method are inside the lib.py program.
They are respectively called:

- eulerExplicit
- eulerImplicit
- rungeKutta2
- rungeKutta4

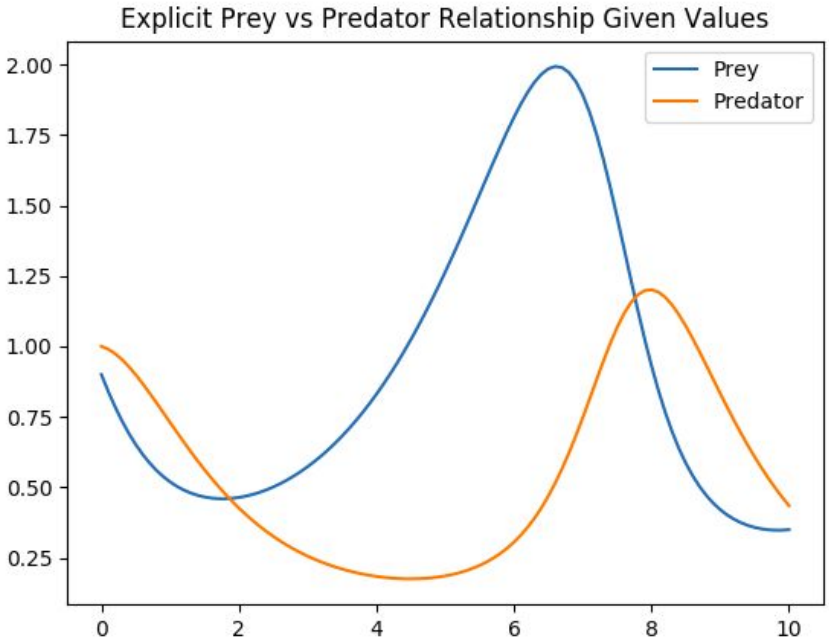
Exercise 2:

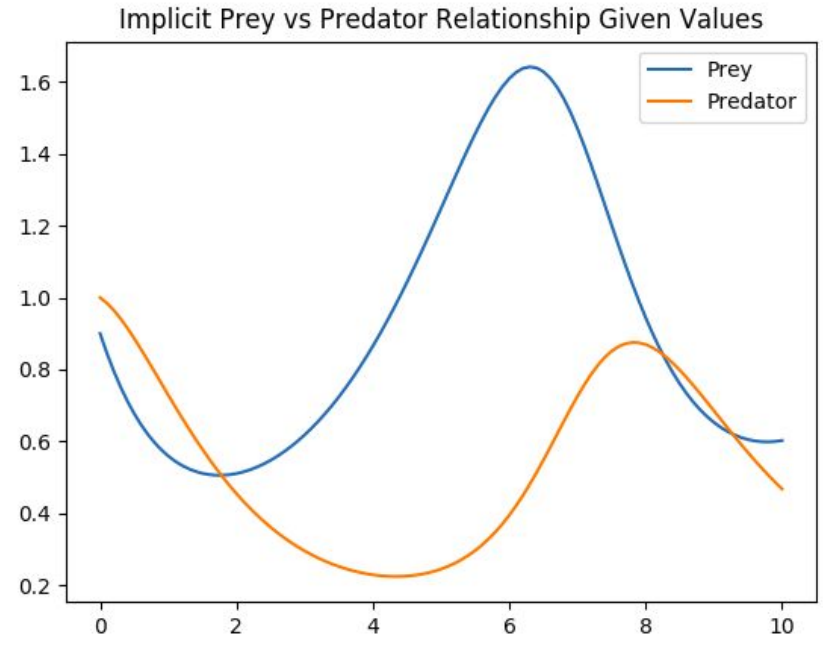
This exercise is to solve the Lotka-Volterra Equations with given values and random chosen values.

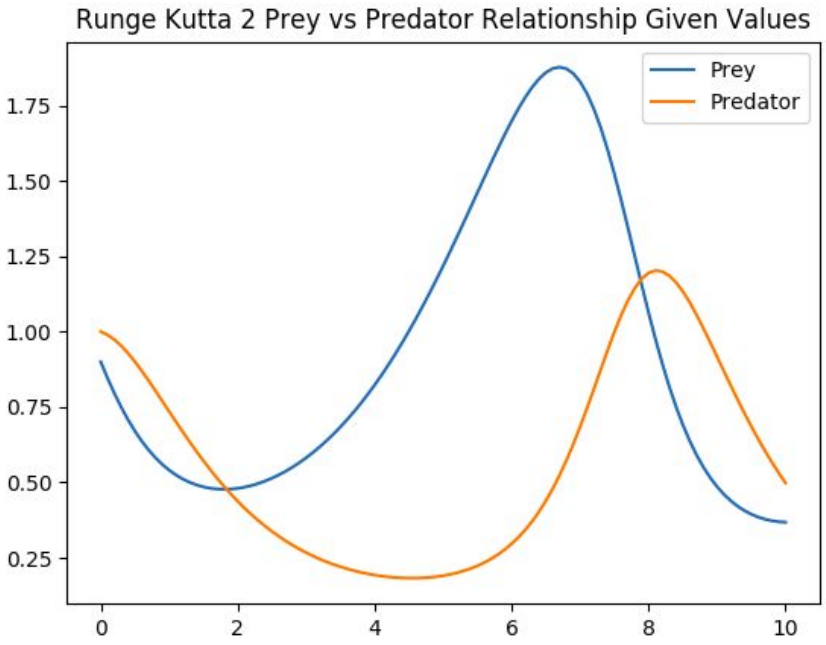
With the values given, the system we're solving for is:

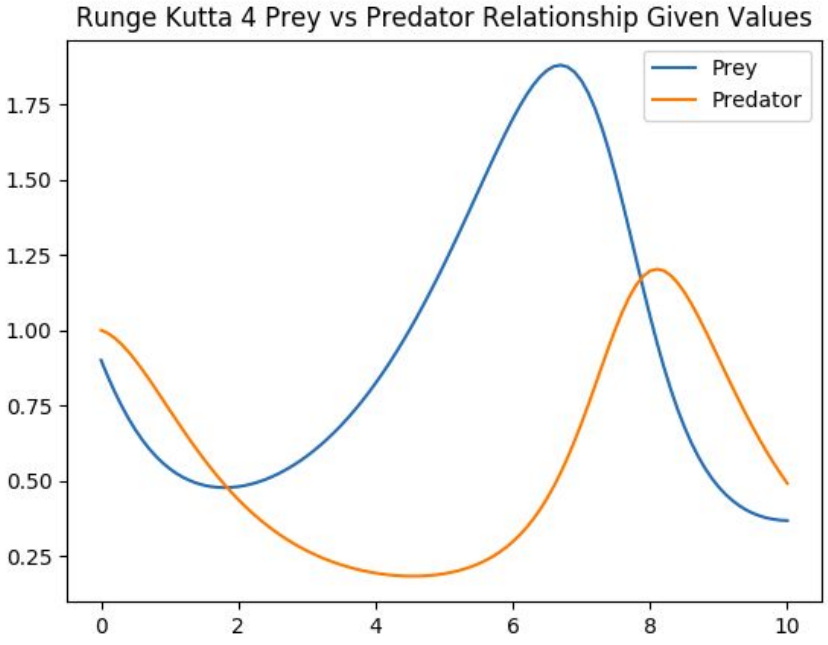
$$\begin{Bmatrix} \frac{2}{3} \cdot x1 - \frac{4}{3} \cdot x1 \cdot x2 \\ 1 \cdot x1 \cdot x2 - 1 \cdot x2 \end{Bmatrix}$$

Here are the graphed solutions:





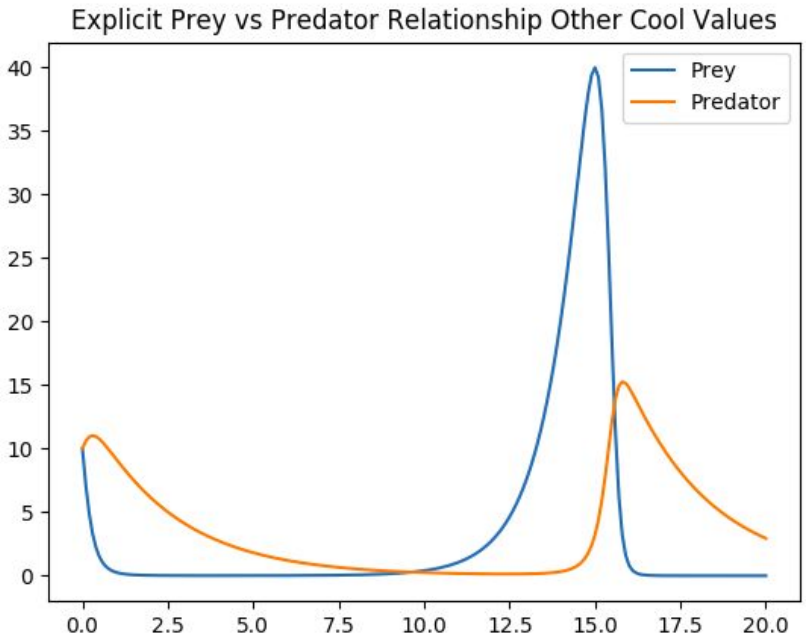

Runge Kutta 2 Prey vs Predator Relationship Given Values
Prey
Predator
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0
2
4
6
8
10

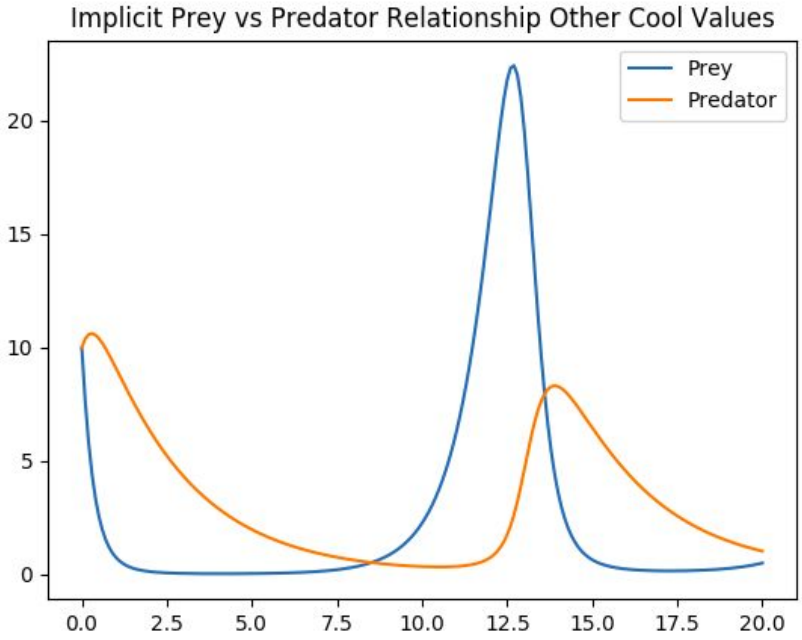

Runge Kutta 4 Prey vs Predator Relationship Given Values
Prey
Predator
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0
2
4
6
8
10

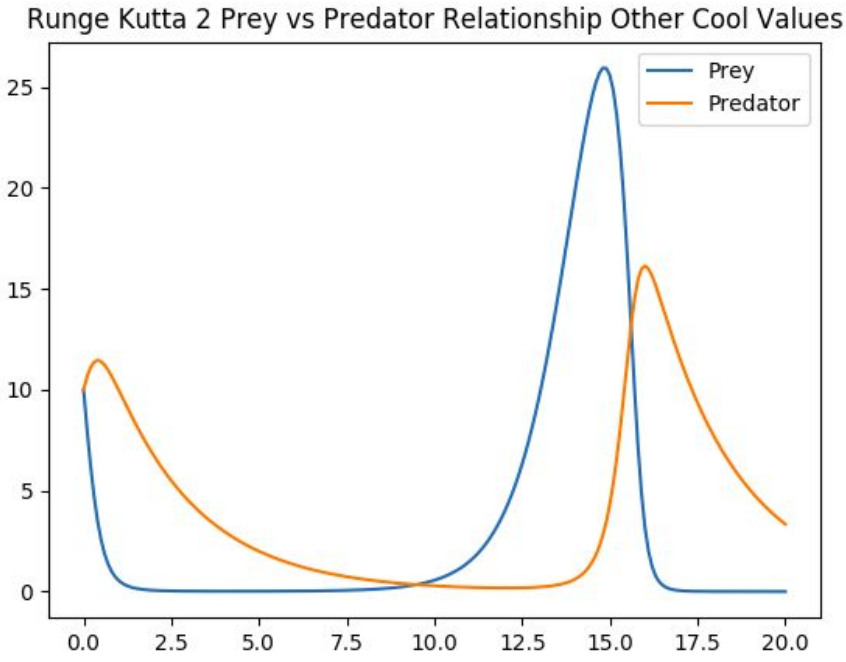
For the Cool Values that I made up, here are the system of equations:

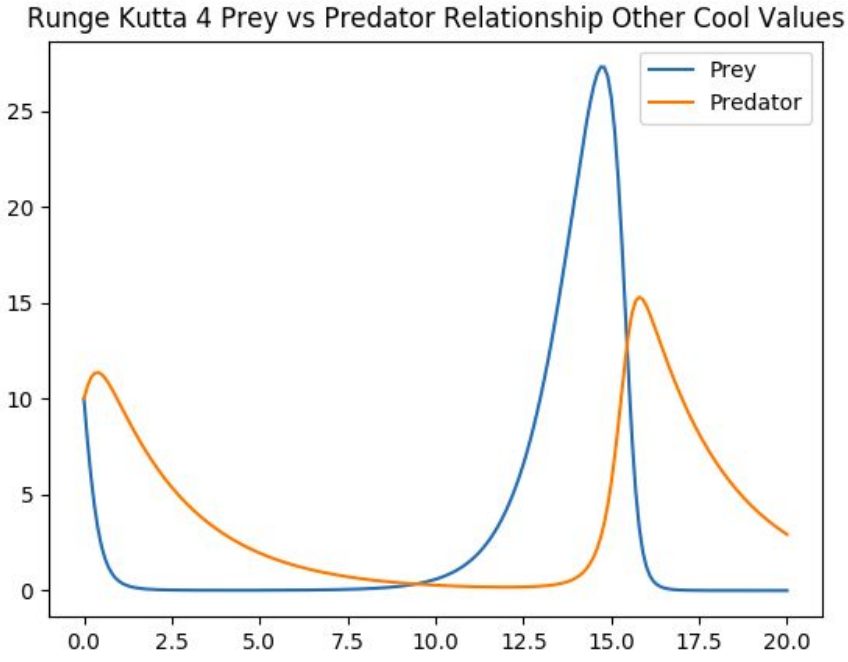
$$\begin{Bmatrix} 1.1 \cdot x1 - 0.4 \cdot x1 \cdot x2 \\ 0.1 \cdot x1 \cdot x2 - 0.4 \cdot x2 \end{Bmatrix}$$

Here are the graphed solutions:





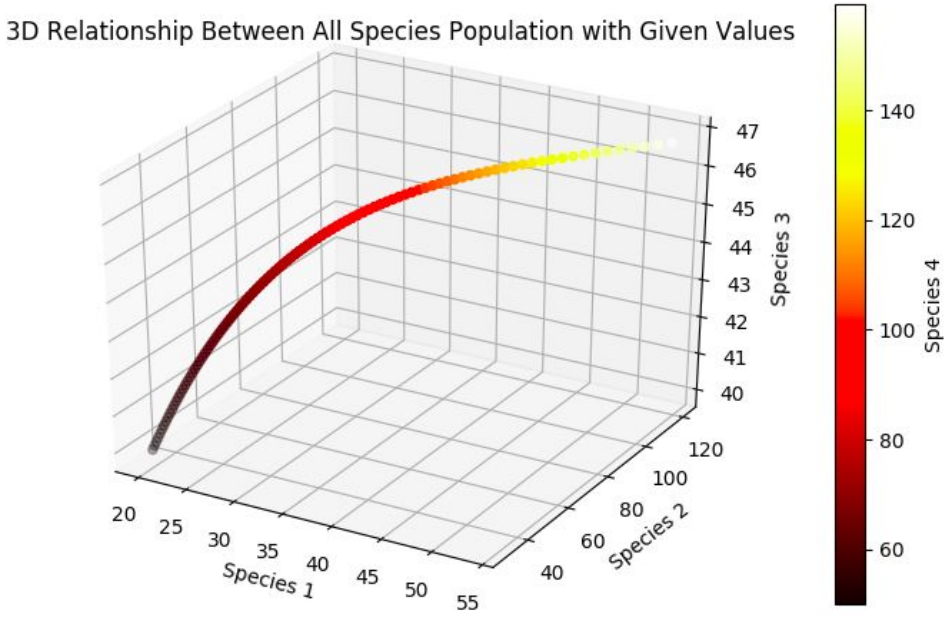

Runge Kutta 2 Prey vs Predator Relationship Other Cool Values
Prey
Predator
25
20
15
10
5
0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0


Runge Kutta 4 Prey vs Predator Relationship Other Cool Values
Prey
Predator
25
20
15
10
5
0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0

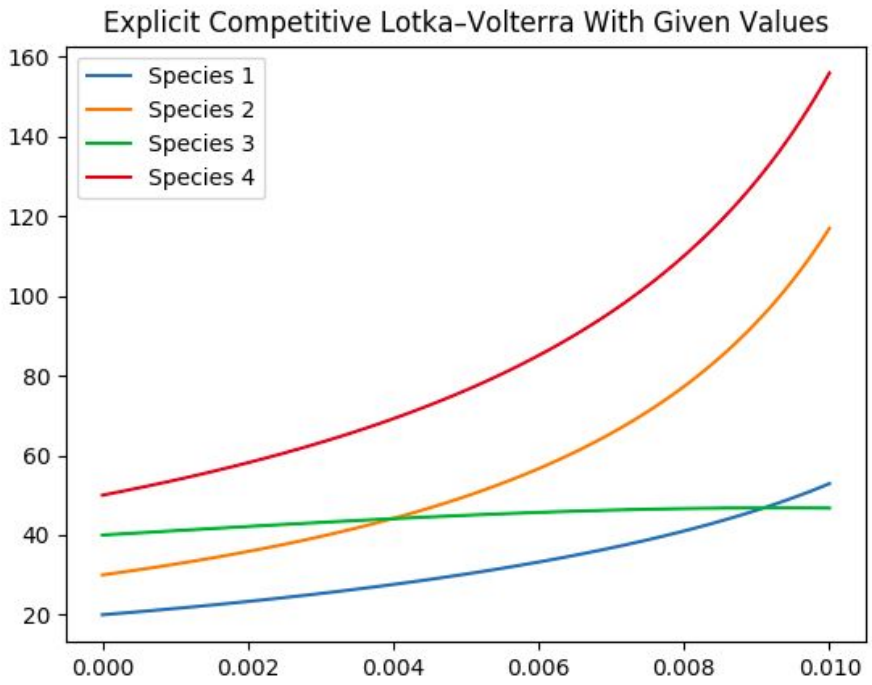
Exercise 3:
This exercise is to use the functions to solve a set of Competitive Lotka-Volterra equations. In this exercise, we have a total of 4 competing species, giving us our system of equations:

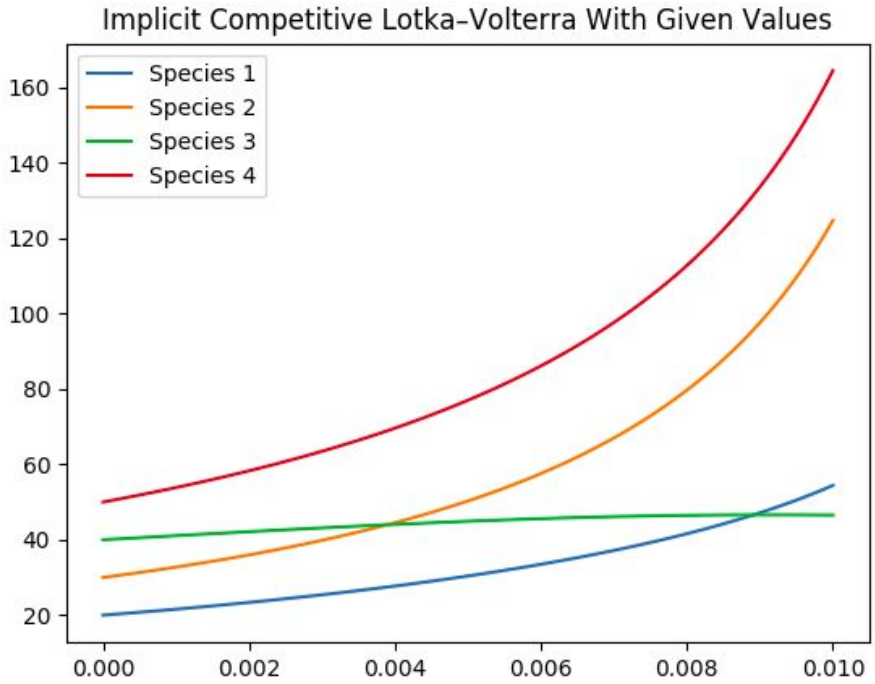
$$\left\{\begin{array}{c} 1 \cdot x1 \cdot (1 - 1 \cdot x1 + 1.09 \cdot x2 + 1.52 \cdot x3 + 0 \cdot x4) \\ 0.72 \cdot x2 \cdot (1 - 0 \cdot x1 + 1 \cdot x2 + 0.44 \cdot x3 + 1.36 \cdot x4) \\ 1.53 \cdot x3 \cdot (1 - 2.33 \cdot x1 + 0 \cdot x2 + 1 \cdot x3 + 0.47 \cdot x4) \\ 1.27 \cdot x4 \cdot (1 - 1.21 \cdot x1 + 0.51 \cdot x2 + 0.35 \cdot x3 + 1 \cdot x4) \end{array}\right\}$$

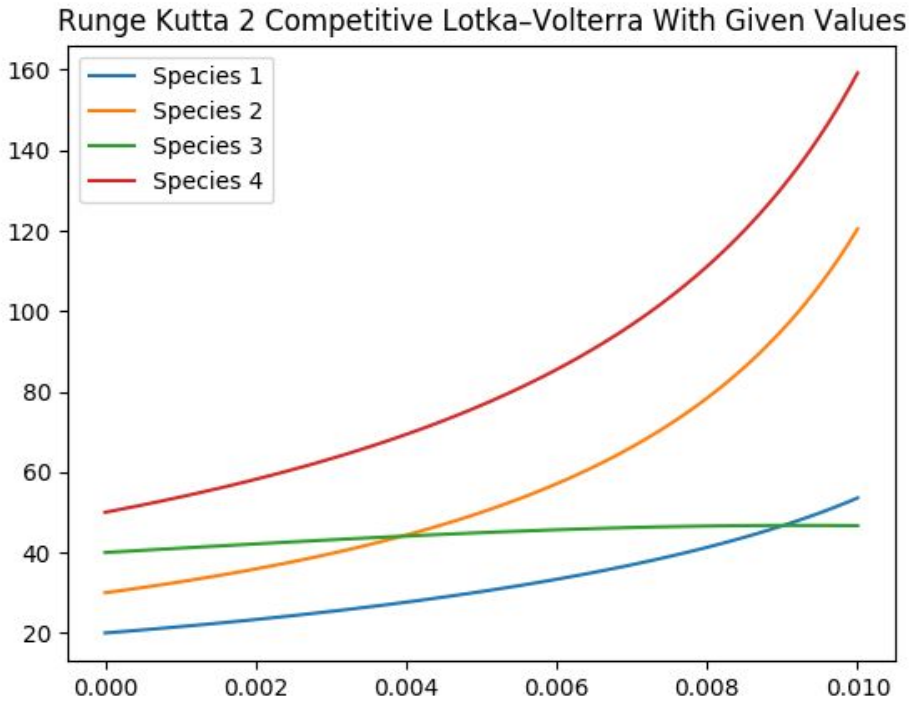
Here is the graphical 3D solution:

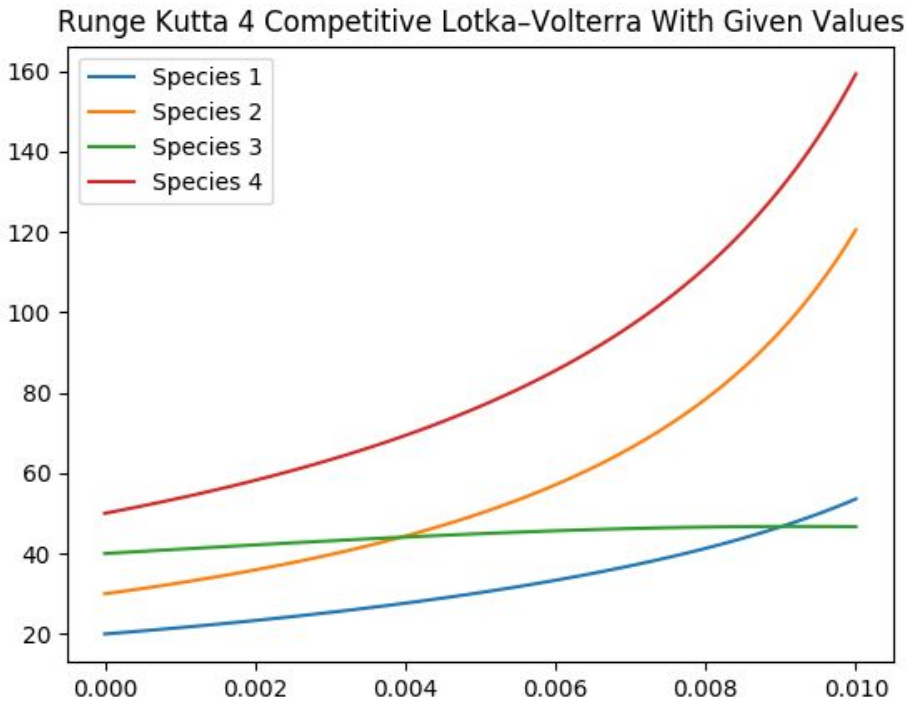


Here are the graphical solutions:





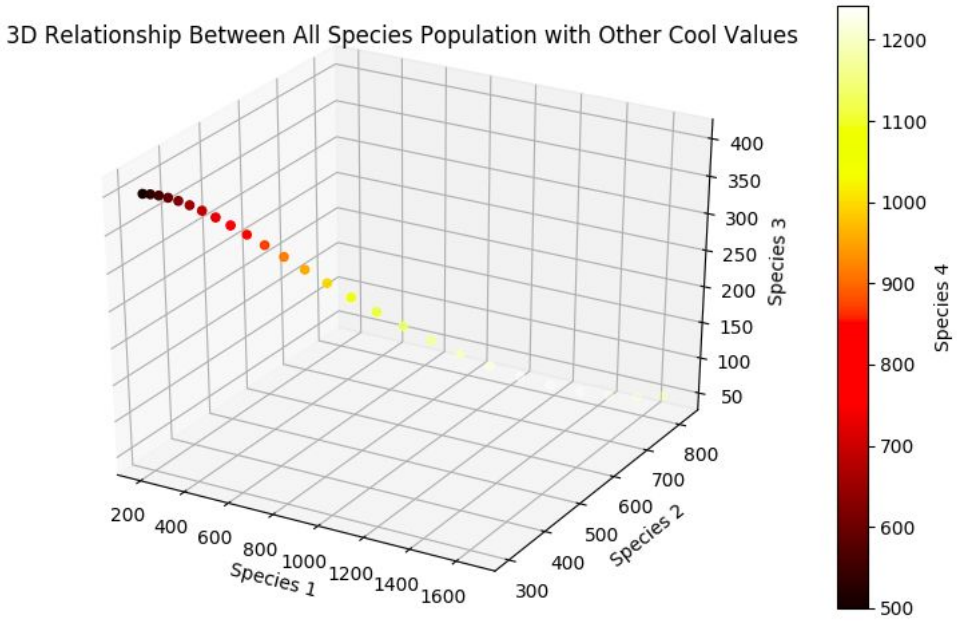

Runge Kutta 2 Competitive Lotka–Volterra With Given Values
Species 1
Species 2
Species 3
Species 4
160
140
120
100
80
60
40
20
0.000
0.002
0.004
0.006
0.008
0.010


Runge Kutta 4 Competitive Lotka–Volterra With Given Values
Species 1
Species 2
Species 3
Species 4
160
140
120
100
80
60
40
20
0.000
0.002
0.004
0.006
0.008
0.010

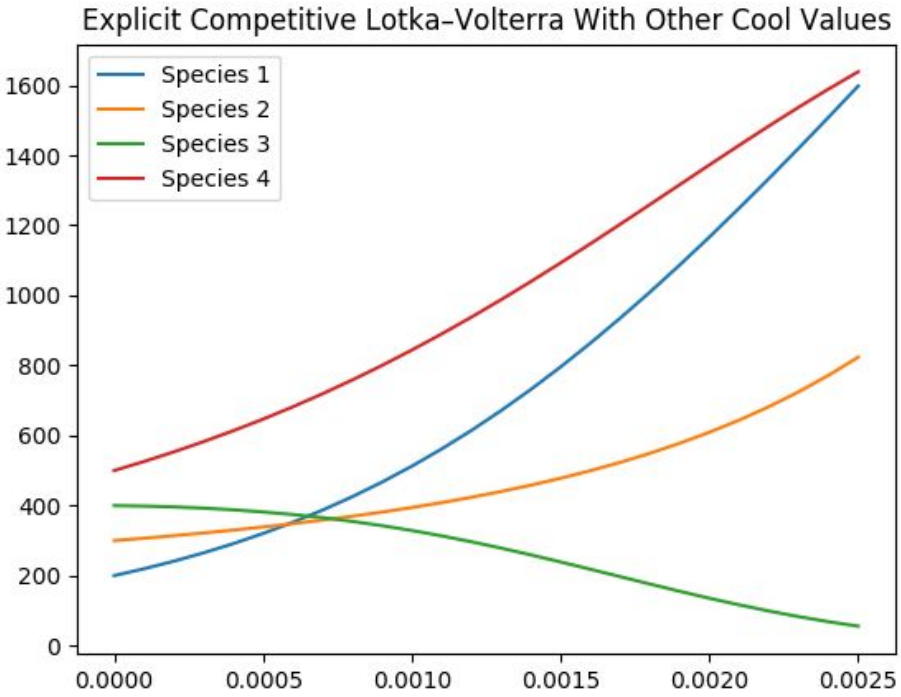
For the Cool Values that I made up, here are the equations:

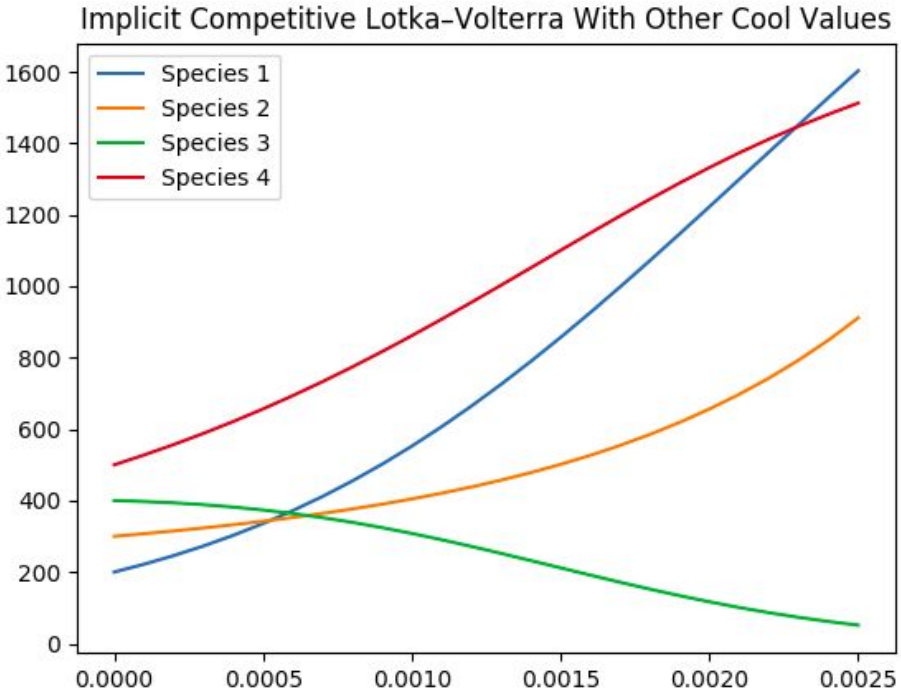
$$\left\{\begin{array}{c} 1 \cdot x1 \cdot (1 - 1 \cdot x1 + 1.09 \cdot x2 + 1.52 \cdot x3 + 0 \cdot x4) \\ 0.72 \cdot x2 \cdot (1 - 0 \cdot x1 + 1 \cdot x2 + 0.44 \cdot x3 + 1.36 \cdot x4) \\ 1.53 \cdot x3 \cdot (1 - 2.33 \cdot x1 + 0 \cdot x2 + 1 \cdot x3 + 0.47 \cdot x4) \\ 1.27 \cdot x4 \cdot (1 - 1.21 \cdot x1 + 0.51 \cdot x2 + 0.35 \cdot x3 + 1 \cdot x4) \end{array}\right\}$$

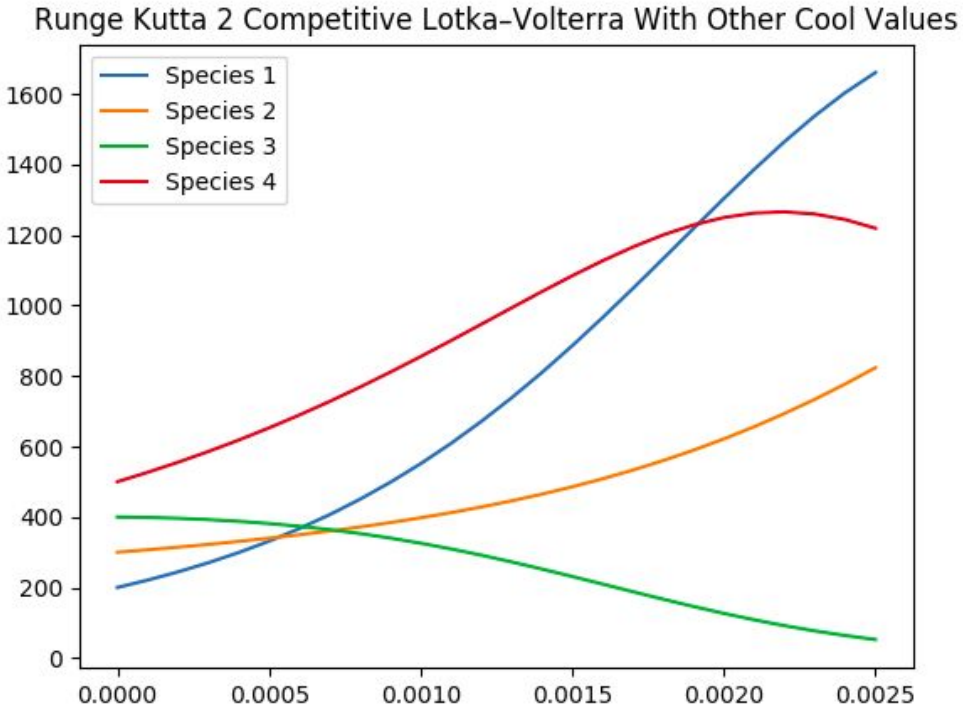
Here is the graphical 3D solution:

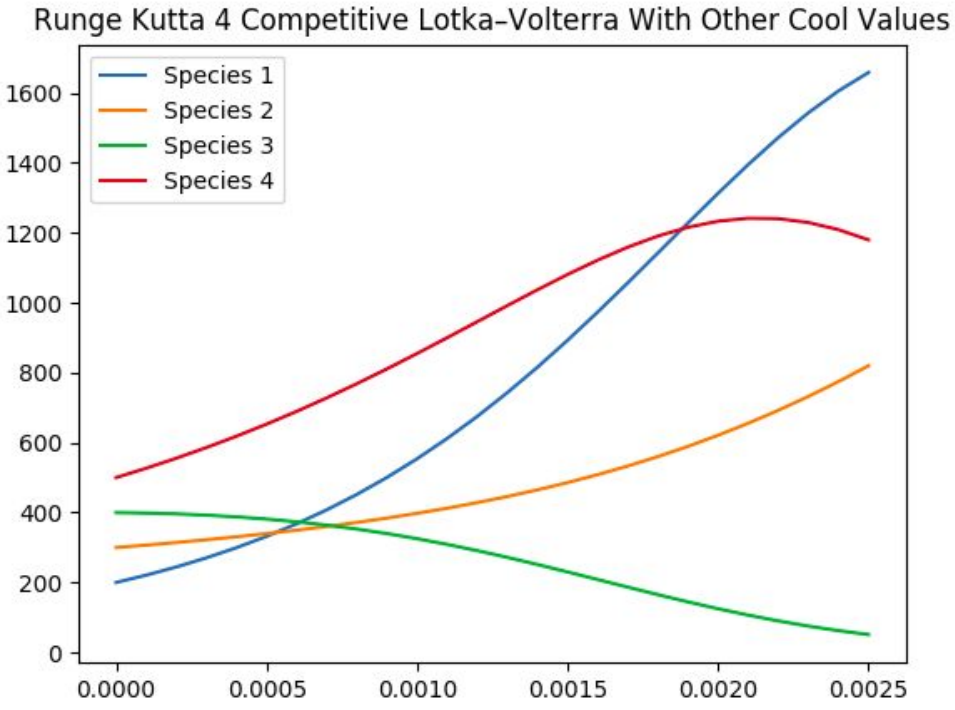


Here are the rest of the graphical solutions:






Runge Kutta 2 Competitive Lotka–Volterra With Other Cool Values
Species 1
Species 2
Species 3
Species 4
1600
1400
1200
1000
800
600
400
200
0
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025


Runge Kutta 4 Competitive Lotka–Volterra With Other Cool Values
Species 1
Species 2
Species 3
Species 4
1600
1400
1200
1000
800
600
400
200
0
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025