OK to post

Anusha Nagar, Homework 19, 11.06.2021

MAPLE CODE is after handwritten portion

① (i) $\beta = 0.3 \frac{V}{N} \Rightarrow R = N - IN - S$

$R @ t=10 \Rightarrow 1000 - 996.7 - 2.979$

$R = 6.279$

$\beta = 0.9 \frac{V}{N} \Rightarrow R = 1000 - 988.3315 - 8.99$

$R = 2.678$

$\beta = 3.9 \frac{V}{N} \Rightarrow R = 1000 - 914.6283 - 40.00$

$R = 45.372$

(ii) $\beta = 0.3 \frac{V}{N} \Rightarrow R = 1000 - 996.402 - 2.958$

$R = 0.64$

$\beta = 0.9 \frac{V}{N} \Rightarrow R = 1000 - 985.6773 - 8.9797$

$R = 5.343$

$\beta = 3.9 \frac{V}{N} \Rightarrow R = 1000 - 872.5259 - 40.8742$

$R = 86.60$

(iii) $\beta = 0.3 \frac{V}{N} \Rightarrow 1000 - 996.62 - 2.94$

$R = 0.44$

$\beta = 0.9 \frac{V}{N} \Rightarrow 1000 - 987.57 - 8.97$

$R = 3.46$

$\beta = 3.9 \frac{V}{N} \Rightarrow 1000 - 902.19 - 41.95$

$R = 55.86$

② ✓

(See maple code)

③ ✓

④ Chemostat (N, C, a1, a2)

> *#OKay to Post*

> *#Anusha Nagar, Homework 19, 11.06.2021*

> **read** "C://Users/an646/Documents/M19.txt"

> *#Problem 1*

> *#N = 1000, I0 = 200, R0 = 0. (Susceptible0 = 800)*

> *#I Think there's a typo - I'm going to be using beta = 0.3·nu div N, 0.9·nu div N, 3.9·nu div N (I think nu and N are switched in the homework problem)*

> *#(i) Where nu = 1, gamma = 3*

> *SIRSdemo*(1000, 200, 3, 1, 0.01, 10)

This is a numerical demonstration of the R0 phenomenon in the SIRS model using discretization with mesh size=, 0.01, *and letting it run until time t=*, 10

with population size, 1000, *and fixed parameters nu=*, 1, *and gamma=*, 3

*where we change beta from 0.2*nu/N to 4*nu/N*

Recall that the epidemic will persist if beta exceeds nu/N, that in this case is, $\frac{1}{1000}$

We start with , 200, *infected individuals, 0 removed and hence*, 800, *susceptible*

We will show what happens once time is close to, 10

beta is, $\frac{1}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [998.9666995, 0.9909989667]], [9.99, [998.9666995, 0.9909989667]], [10.00, [998.9666995, 0.9909989667]], [10.01, [998.9666995, 0.9909989667]]]

beta is, $\frac{3}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [996.7009881, 2.978970309]], [9.99, [996.7009881, 2.978970309]], [10.00, [996.7009881, 2.978970309]], [10.01, [996.7009881, 2.978970309]]]

beta is, $\frac{1}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [994.1715221, 4.974854288]], [9.99, [994.1715221, 4.974854288]], [10.00, [994.1715221, 4.974854288]], [10.01, [994.1715221, 4.974854288]]]

beta is, $\frac{7}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [991.3807432, 6.978577656]], [9.99, [991.3807432, 6.978577656]], [10.00, [991.3807432, 6.978577656]], [10.01, [991.3807432, 6.978577656]]]

beta is, $\frac{9}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [988.3315033, 8.990054852]], [9.99, [988.3315033, 8.990054852]], [10.00, [988.3315033, 8.990054852]], [10.01, [988.3315033, 8.990054852]]]

beta is, $\frac{11}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [985.0270559, 11.00918827]], [9.99, [985.0270559, 11.00918827]], [10.00, [985.0270559, 11.00918827]], [10.01, [985.0270559, 11.00918827]]]

beta is, $\frac{13}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [981.4710448, 13.03586861]], [9.99, [981.4710448, 13.03586861]], [10.00, [981.4710448, 13.03586861]], [10.01, [981.4710448, 13.03586861]]]

beta is, $\frac{3}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [977.6674922, 15.06997519]], [9.99, [977.6674922, 15.06997519]], [10.00, [977.6674922, 15.06997519]], [10.01, [977.6674922, 15.06997519]]]

beta is, $\frac{17}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [973.6207848, 17.11137641]], [9.99, [973.6207848, 17.11137641]], [10.00, [973.6207848, 17.11137641]], [10.01, [973.6207848, 17.11137641]]]

beta is, $\frac{19}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [969.3356593, 19.15993017]], [9.99, [969.3356593, 19.15993017]], [10.00, [969.3356593, 19.15993017]], [10.01, [969.3356593, 19.15993017]]]

beta is, $\frac{21}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [964.8171858, 21.21548438]], [9.99, [964.8171858, 21.21548438]], [10.00, [964.8171858, 21.21548438]], [10.01, [964.8171858, 21.21548438]]]

beta is, $\frac{23}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [960.0707508, 23.27787743]], [9.99, [960.0707508, 23.27787743]], [10.00, [960.0707508, 23.27787743]], [10.01, [960.0707508, 23.27787743]]]

beta is, $\frac{5}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [955.1020392, 25.34693877]], [9.99, [955.1020392, 25.34693877]], [10.00, [955.1020392, 25.34693877]], [10.01, [955.1020392, 25.34693877]]]

beta is, $\frac{27}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [949.9170149, 27.42248950]], [9.99, [949.9170149, 27.42248950]], [10.00, [949.9170149, 27.42248950]], [10.01, [949.9170149, 27.42248950]]]

beta is, $\frac{29}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [944.5219011, 29.50434292]], [9.99, [944.5219011, 29.50434292]], [10.00, [944.5219011, 29.50434292]], [10.01, [944.5219011, 29.50434292]]]

beta is, $\frac{31}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [938.9231598, 31.59230516]], [9.99, [938.9231598, 31.59230516]], [10.00, [938.9231598, 31.59230516]], [10.01, [938.9231598, 31.59230516]]]

beta is, $\frac{33}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [933.1274712, 33.68617582]], [9.99, [933.1274712, 33.68617582]], [10.00, [933.1274712, 33.68617582]], [10.01, [933.1274712, 33.68617582]]]

beta is, $\frac{7}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [927.1417118, 35.78574860]], [9.99, [927.1417118, 35.78574860]], [10.00, [927.1417118, 35.78574860]], [10.01, [927.1417118, 35.78574860]]]

beta is, $\frac{37}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [920.9729335, 37.89081195]], [9.99, [920.9729335, 37.89081195]], [10.00, [920.9729335, 37.89081195]], [10.01, [920.9729335, 37.89081195]]]

beta is, $\frac{39}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [914.6283415, 40.00114971]], [9.99, [914.6283415, 40.00114971]], [10.00, [914.6283415, 40.00114971]], [10.01, [914.6283415, 40.00114971]]] **(1)**

> *SIRSdemo*(1000, 200, 3, 2, 0.01, 10)

This is a numerical demonstration of the R0 phenomenon in the SIRS model using discretization with mesh size=, 0.01, *and letting it run until time t=*, 10

with population size, 1000, *and fixed parameters nu=*, 2, *and gamma=*, 3

*where we change beta from 0.2*nu/N to 4*nu/N*

Recall that the epidemic will persist if beta exceeds nu/N, that in this case is, $\frac{1}{500}$

We start with , 200, *infected individuals, 0 removed and hence*, 800, *susceptible*

We will show what happens once time is close to, 10

beta is, $\frac{1}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [998.9334028, 0.9819978668]], [9.99, [998.9334028, 0.9819978668]], [10.00, [998.9334028, 0.9819978668]], [10.01, [998.9334028, 0.9819978668]]]

beta is, $\frac{3}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [996.4021571, 2.957935239]], [9.99, [996.4021571, 2.957935239]], [10.00, [996.4021571, 2.957935239]], [10.01, [996.4021571, 2.957935239]]]

beta is, $\frac{1}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [993.3444243, 4.949667221]], [9.99, [993.3444243, 4.949667221]], [10.00, [993.3444243, 4.949667221]], [10.01, [993.3444243, 4.949667221]]]

beta is, $\frac{7}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [989.7667603, 6.956997143]], [9.99, [989.7667603, 6.956997143]], [10.00, [989.7667603, 6.956997143]], [10.01, [989.7667603, 6.956997143]]]

beta is, $\frac{9}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [985.6773407, 8.979679729]], [9.99, [985.6773407, 8.979679729]], [10.00, [985.6773407, 8.979679729]], [10.01, [985.6773407, 8.979679729]]]

beta is, $\frac{11}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [981.0859054, 11.01742279]], [9.99, [981.0859054, 11.01742279]], [10.00, [981.0859054, 11.01742279]], [10.01, [981.0859054, 11.01742279]]]

beta is, $\frac{13}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [976.0036901, 13.06988925]], [9.99, [976.0036901, 13.06988925]], [10.00, [976.0036901, 13.06988925]], [10.01, [976.0036901, 13.06988925]]]

beta is, $\frac{3}{2}$*, times the threshold value*

the long-term behavior is

[[9.98, [970.4433482, 15.13669951]], [9.99, [970.4433482, 15.13669951]], [10.00, [970.4433482, 15.13669951]], [10.01, [970.4433482, 15.13669951]]]

beta is, $\frac{17}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [964.4188616, 17.21743410]], [9.99, [964.4188616, 17.21743410]], [10.00, [964.4188616, 17.21743410]], [10.01, [964.4188616, 17.21743410]]]

beta is, $\frac{19}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [957.9454447, 19.31163661]], [9.99, [957.9454447, 19.31163661]], [10.00, [957.9454447, 19.31163661]], [10.01, [957.9454447, 19.31163661]]]

beta is, $\frac{21}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [951.0394389, 21.41881679]], [9.99, [951.0394389, 21.41881679]], [10.00, [951.0394389, 21.41881679]], [10.01, [951.0394389, 21.41881679]]]

beta is, $\frac{23}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [943.7182031, 23.53845386]], [9.99, [943.7182031, 23.53845386]], [10.00, [943.7182031, 23.53845386]], [10.01, [943.7182031, 23.53845386]]]

beta is, $\frac{5}{2}$*, times the threshold value*

the long-term behavior is

[[9.98, [935.9999984, 25.67000000]], [9.99, [935.9999984, 25.67000000]], [10.00, [935.9999984, 25.67000000]], [10.01, [935.9999984, 25.67000000]]]

beta is, $\frac{27}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [927.9038703, 27.81288384]], [9.99, [927.9038703, 27.81288384]], [10.00, [927.9038703, 27.81288384]], [10.01, [927.9038703, 27.81288384]]]

beta is, $\frac{29}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [919.4495282, 29.96651411]], [9.99, [919.4495282, 29.96651411]], [10.00, [919.4495282, 29.96651411]], [10.01, [919.4495282, 29.96651411]]]

beta is, $\frac{31}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [910.6572255, 32.13028319]], [9.99, [910.6572255, 32.13028319]], [10.00, [910.6572255, 32.13028319]], [10.01, [910.6572255, 32.13028319]]]

beta is, $\frac{33}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [901.5476397, 34.30357076]], [9.99, [901.5476397, 34.30357076]], [10.00, [901.5476397, 34.30357076]], [10.01, [901.5476397, 34.30357076]]]

beta is, $\frac{7}{2}$*, times the threshold value*

the long-term behavior is

[[9.98, [892.1417551, 36.48574730]], [9.99, [892.1417551, 36.48574730]], [10.00, [892.1417551, 36.48574730]], [10.01, [892.1417551, 36.48574730]]]

beta is, $\frac{37}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [882.4607475, 38.67617753]], [9.99, [882.4607475, 38.67617753]], [10.00, [882.4607475, 38.67617753]], [10.01, [882.4607475, 38.67617753]]]

beta is, $\frac{39}{10}$*, times the threshold value*

the long-term behavior is

[[9.98, [872.5258747, 40.87422371]], [9.99, [872.5258747, 40.87422371]], [10.00, [872.5258747, 40.87422371]], [10.01, [872.5258747, 40.87422371]]] **(2)**

```
> SIRSdemo(1000, 200, 7, 3, 0.01, 10)
```

This is a numerical demonstration of the R0 phenomenon in the SIRS model using discretization with mesh size=, 0.01, *and letting it run until time t=*, 10

with population size, 1000, *and fixed parameters nu=*, 3, *and gamma=*, 7

*where we change beta from 0.2*nu/N to 4*nu/N*

Recall that the epidemic will persist if beta exceeds nu/N, that in this case is, $\frac{3}{1000}$

We start with , 200, *infected individuals, 0 removed and hence*, 800, *susceptible*

We will show what happens once time is close to, 10

beta is, $\frac{1}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [998.9571869, 0.9729968716]], [9.99, [998.9571869, 0.9729968716]], [10.00, [998.9571869, 0.9729968716]], [10.01, [998.9571869, 0.9729968716]]]

beta is, $\frac{3}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [996.6155905, 2.936908621]], [9.99, [996.6155905, 2.936908621]], [10.00, [996.6155905, 2.936908621]], [10.01, [996.6155905, 2.936908621]]]

beta is, $\frac{1}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [993.9350689, 4.924545130]], [9.99, [993.9350689, 4.924545130]], [10.00, [993.9350689, 4.924545130]], [10.01, [993.9350689, 4.924545130]]]

beta is, $\frac{7}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [990.9190693, 6.935665103]], [9.99, [990.9190693, 6.935665103]], [10.00, [990.9190693, 6.935665103]], [10.01, [990.9190693, 6.935665103]]]

beta is, $\frac{9}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [987.5717147, 8.969979927]], [9.99, [987.5717147, 8.969979927]], [10.00, [987.5717147, 8.969979927]], [10.01, [987.5717147, 8.969979927]]]

beta is, $\frac{11}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [983.8977865, 11.02715490]], [9.99, [983.8977865, 11.02715490]], [10.00, [983.8977865, 11.02715490]], [10.01, [983.8977865, 11.02715490]]]

beta is, $\frac{13}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [979.9027040, 13.10681067]], [9.99, [979.9027040, 13.10681067]], [10.00, [979.9027040, 13.10681067]], [10.01, [979.9027040, 13.10681067]]]

beta is, $\frac{3}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [975.5925002, 15.20852494]], [9.99, [975.5925002, 15.20852494]], [10.00, [975.5925002, 15.20852494]], [10.01, [975.5925002, 15.20852494]]]

beta is, $\frac{17}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [970.9737953, 17.33183428]], [9.99, [970.9737953, 17.33183428]], [10.00, [970.9737953, 17.33183428]], [10.01, [970.9737953, 17.33183428]]]

beta is, $\frac{19}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [966.0537675, 19.47623623]], [9.99, [966.0537675, 19.47623623]], [10.00, [966.0537675, 19.47623623]], [10.01, [966.0537675, 19.47623623]]]

beta is, $\frac{21}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [960.8401210, 21.64119148]], [9.99, [960.8401210, 21.64119148]], [10.00, [960.8401210, 21.64119148]], [10.01, [960.8401210, 21.64119148]]]

beta is, $\frac{23}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [955.3410529, 23.82612625]], [9.99, [955.3410529, 23.82612625]], [10.00, [955.3410529, 23.82612625]], [10.01, [955.3410529, 23.82612625]]]

beta is, $\frac{5}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [949.5652167, 26.03043478]], [9.99, [949.5652167, 26.03043478]], [10.00, [949.5652167, 26.03043478]], [10.01, [949.5652167, 26.03043478]]]

beta is, $\frac{27}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [943.5216861, 28.25348193]], [9.99, [943.5216861, 28.25348193]], [10.00, [943.5216861, 28.25348193]], [10.01, [943.5216861, 28.25348193]]]

beta is, $\frac{29}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [937.2199158, 30.49460585]], [9.99, [937.2199158, 30.49460585]], [10.00, [937.2199158, 30.49460585]], [10.01, [937.2199158, 30.49460585]]]

beta is, $\frac{31}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [930.6697029, 32.75312075]], [9.99, [930.6697029, 32.75312075]], [10.00, [930.6697029, 32.75312075]], [10.01, [930.6697029, 32.75312075]]]

beta is, $\frac{33}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [923.8811464, 35.02831970]], [9.99, [923.8811464, 35.02831970]], [10.00, [923.8811464, 35.02831970]], [10.01, [923.8811464, 35.02831970]]]

beta is, $\frac{7}{2}$, *times the threshold value*

the long-term behavior is

[[9.98, [916.8646074, 37.31947743]], [9.99, [916.8646074, 37.31947743]], [10.00, [916.8646074, 37.31947743]], [10.01, [916.8646074, 37.31947743]]]

beta is, $\frac{37}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [909.6306685, 39.62585316]], [9.99, [909.6306685, 39.62585316]], [10.00, [909.6306685, 39.62585316]], [10.01, [909.6306685, 39.62585316]]]

beta is, $\frac{39}{10}$, *times the threshold value*

the long-term behavior is

[[9.98, [902.1900937, 41.94669340]], [9.99, [902.1900937, 41.94669340]], [10.00, [902.1900937, 41.94669340]], [10.01, [902.1900937, 41.94669340]]] **(3)**

\> #Problem 2

\> $f1 := RandNice([x, y], 8)$

$$f1 := [(5 - 7x - 7y)(2 - 5x - 8y), (6 - 2x - 3y)(4 - 4x - 6y)] \quad \textbf{(4)}$$

\> $f2 := RandNice([x, y], 8)$

$$f2 := [(5 - 3x - 8y)(1 - 8x - 5y), (2 - 3x - 2y)(2 - 4x - 8y)] \quad \textbf{(5)}$$

\> $f3 := RandNice([x, y], 8)$

$$f3 := [(3 - 3x - y)(2 - 5x - 4y), (5 - 6x - 2y)(3 - 7x - 8y)] \quad \textbf{(6)}$$

\> $EquPts(f1, [x, y])$

$$\left\{[10, -6], [42, -26], \left[-\frac{27}{7}, \frac{32}{7}\right], \left[\frac{1}{7}, \frac{4}{7}\right]\right\} \quad \textbf{(7)}$$

\> $StEquPts(f1, [x, y])$

$$\emptyset \quad \textbf{(8)}$$

\> $L1 := Dis2(f1, x, y, [10, -6] + [0.1, 0.1], 0.01, 10) : print([op(nops(L1) - 3 .. nops(L1), L1)]) :$

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(9)**

> $L2 := Dis2(f1, x, y, [42, -26] + [0.1, 0.1], 0.01, 10) : print([op(nops(L2)-3..nops(L2), L2)]) :$

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(10)**

> $L3 := Dis2\left(f1, x, y, \left[-\frac{27}{7}, \frac{32}{7}\right] + [0.1, 0.1], 0.01, 10\right) : print([op(nops(L3)-3..nops(L3), L3)]) :$

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(11)**

> $L4 := Dis2\left(f1, x, y, \left[\frac{1}{7}, \frac{4}{7}\right] + [0.1, 0.1], 0.01, 10\right) : print([op(nops(L4)-3..nops(L4), L4)]) :$

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(12)**

> *#f1 does not have stable equilibrium points*

> $EquPts(f2, [x, y])$

$$\left\{[-8, 13], \left[-3, \frac{7}{4}\right], \left[-\frac{1}{22}, \frac{3}{11}\right], \left[\frac{1}{3}, \frac{1}{2}\right]\right\} \quad \textbf{(13)}$$

> $StEquPts(f2, [x, y])$

$$\left\{\left[-\frac{1}{22}, \frac{3}{11}\right]\right\} \quad \textbf{(14)}$$

> $L5 := Dis2\left(f2, x, y, \left[-\frac{1}{22}, \frac{3}{11}\right] + [0.1, 0.1], 0.01, 10\right) : print([op(nops(L5)-3..nops(L5), L5)]) :$

[[9.98, [−0.04545454593, 0.2727272734]], [9.99, [−0.04545454593, 0.2727272734]], [10.00, [−0.04545454593, 0.2727272734]], [10.01, [−0.04545454593, 0.2727272734]]] **(15)**

> *#Stable!*

> $L6 := Dis2(f2, x, y, [-8, 13] + [0.1, 0.1], 0.01, 10) : print([op(nops(L6)-3..nops(L6), L6)]) :$

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(16)**

> $L7 := Dis2\left(f2, x, y, \left[-3, \frac{7}{4}\right] + [0.1, 0.1], 0.01, 10\right) : print([op(nops(L7)-3..nops(L7), L7)]) :$

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(17)**

> $L8 := Dis2\left(f2, x, y, \left[\frac{1}{3}, \frac{1}{2}\right] + [0.1, 0.1], 0.01, 10\right) : print([op(nops(L8)-3..nops(L8), L8)]) :$

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(18)**

> #Rest are unstable

> EquPts(f3, [x, y])

$$\left\{\left[\frac{1}{3}, \frac{1}{12}\right], \left[\frac{8}{7}, -\frac{13}{14}\right], \left[\frac{21}{17}, -\frac{12}{17}\right]\right\} \quad (19)$$

> StEquPts(f3, [x, y])

$$\left\{\left[\frac{1}{3}, \frac{1}{12}\right]\right\} \quad (20)$$

> $L9 := Dis2\left(f3, x, y, \left[\frac{1}{3}, \frac{1}{12}\right] + [0.1, 0.1], 0.01, 10\right)$: print([op(nops(L9)-3 ..nops(L9), L9)]) :

[[9.98, [0.3333333353, 0.08333333161]], [9.99, [0.3333333353, 0.08333333161]], [10.00, [0.3333333353, 0.08333333161]], [10.01, [0.3333333353, 0.08333333161]]] **(21)**

> #Stable!

> $L10 := Dis2\left(f3, x, y, \left[\frac{8}{7}, -\frac{13}{14}\right] + [0.1, 0.1], 0.01, 10\right)$: print([op(nops(L10)-3 ..nops(L10), L10)]) :

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(22)**

> $L11 := Dis2\left(f3, x, y, \left[\frac{21}{17}, -\frac{12}{17}\right] + [0.1, 0.1], 0.01, 10\right)$: print([op(nops(L11)-3 ..nops(L11), L11)]) :

[[9.98, [Float(∞), Float(∞)]], [9.99, [Float(∞), Float(∞)]], [10.00, [Float(∞), Float(∞)]], [10.01, [Float(∞), Float(∞)]]] **(23)**

> #Unstable for the rest

> #Problem 3

> EquPts(SIRS(s, i, beta, gamma, nu, N), [s, i])

$$\left\{[N, 0], \left[\frac{\nu}{\beta}, \frac{\gamma(N\beta - \nu)}{\beta(\gamma + \nu)}\right]\right\} \quad (24)$$

> #We see that values for steady state susceptible and infected align. Since removed is N-S-I, these also align

>

> #Problem 4

```
> Chemostat := proc(N, C, a1, a2) :
[a1 * (C / (1 + C) * N) - N, - C / (1 + C) * N - C + a2] :
end:
```

> EquPts(Chemostat(N, C, a1, a2), [N, C])

$$\left\{[0, a2], \left[\frac{a1\ (a2\ a1 - a2 - 1)}{a1 - 1}, \frac{1}{a1 - 1}\right]\right\} \quad (25)$$

>