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[> #HW19— Alan Ho
[> #OK to post
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[> read("M19.txt")
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[> #Ii)
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[> SIRSdemo(1000, 200, 3, 1, 0.01, 10)
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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)

> #About 46 people died

> 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 $0.2 \cdot \text{nu}/N$ to $4 \cdot \text{nu}/N$

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)

> #about 87 people died

> 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)

> #about 56 people died

> #2)

> $F := \text{RandNice}([x, y], 8)$

$F := [(5 - 3x - 8y)(1 - 8x - 5y), (2 - 3x - 2y)(2 - 4x - 8y)]$

(4)

> $\text{EquPts}(F, [x, y])$

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

(5)

> $\text{StEquPts}(F, [x, y])$

$\left\{ \left[-\frac{1}{22}, \frac{3}{11}\right] \right\}$

(6)

> $\text{Dis2}(F, x, y, [-7.9, 13.1], 0.01, 10)$

$[[0.01, [-7.9, 13.1]], [0.02, [-6.9107, 13.4560]], [0.03, [2.095461710, 16.71653936]], [0.04, [136.2316666, 69.56684993]], [0.05, [13931.73396, 6070.743074]], [0.06, [1.281448992 \times 10^8, 5.625503173 \times 10^7]], [0.07, [1.090186749 \times 10^{16}, 4.783688944 \times 10^{15}]], [0.08, [7.887704643 \times 10^{31}, 3.461184031 \times 10^{31}]], [0.09, [4.129136016$

(7)

$\times 10^{63}$, $1.811892848 \times 10^{63}$]], [0.10, [$1.131555179 \times 10^{127}$, $4.965341265 \times 10^{126}$]],
 [0.11, [$8.497846170 \times 10^{253}$, $3.728912809 \times 10^{253}$]], [0.12, [$4.792643445 \times 10^{507}$,
 $2.103044604 \times 10^{507}$]], [0.13, [$1.524430505 \times 10^{1015}$, $6.689304942 \times 10^{1014}$]], [0.14,
 $1.542313470 \times 10^{2030}$, $6.767776608 \times 10^{2029}$]], [0.15, [$1.578711211 \times 10^{4060}$,
 $6.927492382 \times 10^{4059}$]], [0.16, [$1.654103865 \times 10^{8120}$, $7.258320480 \times 10^{8119}$]], [0.17,
 $1.815862429 \times 10^{16240}$, $7.968128079 \times 10^{16239}$]], [0.18, [$2.188382715 \times 10^{32480}$,
 $9.602772486 \times 10^{32479}$]], [0.19, [$3.178366259 \times 10^{64960}$, $1.394688774 \times 10^{64960}$]], [0.20,
 $6.704482684 \times 10^{129920}$, $2.941972690 \times 10^{129920}$]], [0.21, [$2.983238237 \times 10^{259841}$,
 $1.309065268 \times 10^{259841}$]], [0.22, [$5.906541555 \times 10^{519682}$, $2.591830686 \times 10^{519682}$]],
 [0.23, [$2.315388744 \times 10^{1039365}$, $1.016008359 \times 10^{1039365}$]], [0.24, [3.557994112
 $\times 10^{2078730}$, $1.561272064 \times 10^{2078730}$]], [0.25, [$8.401712970 \times 10^{4157460}$, 3.686728906
 $\times 10^{4157460}$]], [0.26, [$4.684821748 \times 10^{8314921}$, $2.055731708 \times 10^{8314921}$]], [0.27,
 $1.456610822 \times 10^{16629843}$, $6.391707549 \times 10^{16629842}$]], [0.28, [$1.408135523 \times 10^{33259686}$,
 $6.178994636 \times 10^{33259685}$]], [0.29, [$1.315970941 \times 10^{66519372}$, 5.774570166
 $\times 10^{66519371}$]], [0.30, [$1.149343883 \times 10^{133038744}$, $5.043399282 \times 10^{133038743}$]], [0.31,
 $8.767128407 \times 10^{266077487}$, $3.847075691 \times 10^{266077487}$]], [0.32, [5.101197347
 $\times 10^{532154975}$, $2.238440158 \times 10^{532154975}$]], [0.33, [$1.727036993 \times 10^{1064309951}$,
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$\times 10^{139501233905239}]$], [0.51, [3.778208847 $\times 10^{279002467810478}$, 1.657903789
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 $\times 10^{558004935620956}]$], [0.53, [5.956841063 $\times 10^{1116009871241913}$, 2.613902452
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 $\times 10^{2232019742483827}]$], [0.55, [3.680749153 $\times 10^{4464039484967654}$, 1.615137812
 $\times 10^{4464039484967654}]$], [0.56, [8.991452036 $\times 10^{8928078969935308}$, 3.945510426
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 $\times 10^{35712315879741234}]$], [0.59, [2.422927315 $\times 10^{71424631759482470}$, 1.063197016
 $\times 10^{71424631759482470}]$], [0.60, [3.896172365 $\times 10^{142849263518964940}$, 1.709666985
 $\times 10^{142849263518964940}]$], [0.61, [1.007473690 $\times 10^{285698527037929881}$, 4.420863208
 $\times 10^{285698527037929880}]$], [0.62, [6.736352685 $\times 10^{571397054075859761}$, 2.955957466
 $\times 10^{571397054075859761}]$], [0.63, [3.011667511 $\times 10^{1142794108151719523}$, 1.321540227
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> #(-8,13) is not a stable fixed point

> Dis2(F, x, y, [-1/22 + 0.1, 3/11 + 0.1], 0.01, 10)

[[0.01, [0.05454545455, 0.3727272727]], [0.02, [0.03043636365, 0.3596363636]], [0.03, [0.00927374053, 0.3477560223]], [0.04, [-0.00853136500, 0.3372982943]], [0.05, [-0.02291910698, 0.3283241462]], [0.06, [-0.03411076074, 0.3207705386]], [0.07, [-0.04250462983, 0.3144932081]], [0.08, [-0.04857467177, 0.3093093948]], [0.09, [-0.05279389866, 0.3050308053]], [0.10, [-0.05558821882, 0.3014840554]], [0.11, [-0.05731593641, 0.2985203549]], [0.12, [-0.05826449118, 0.2960178418]], [0.13, [-0.05865667235, 0.2938797771]], [0.14, [-0.05866078282, 0.2920309170]], [0.15,

(8)

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> #this is a stable fixed point as it converges to $\left(-\frac{1}{22}, \frac{3}{11}\right)$

> F2 := RandNice([x, y], 8)
F2 := [(5 - 4x - 5y) (6 - 2x - 3y), (7 - 8x - 2y) (6 - 4x - y)] (9)

> EquPts(F2, [x, y])
 $\left\{ \left[\frac{6}{5}, \frac{6}{5} \right], \left[\frac{9}{20}, \frac{17}{10} \right], \left[\frac{25}{16}, -\frac{1}{4} \right], \left[\frac{25}{32}, \frac{3}{8} \right] \right\}$ (10)

> StEquPts(F2, [x, y])
 $\left\{ \left[\frac{25}{16}, -\frac{1}{4} \right] \right\}$ (11)

> Dis2(F2, x, y, $\left[\frac{6}{5} + 0.1, \frac{6}{5} + 0.1 \right], 0.01, 10)$
[[0.01, [1.300000000, 1.300000000]], [0.02, [1.333500000, 1.330000000]], [0.03, (12)

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> # $\left(\frac{6}{5}, \frac{6}{5}\right)$ is **not** a stable fixed point

> Dis2 $\left(F2, x, y, \left[\left(\frac{25}{16}\right) + 0.1, \left(-\frac{1}{4}\right) + 0.1\right], 0.01, 10\right)$

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> #this is a stable fixed point as it converges to $\left(\frac{25}{16}, -\frac{1}{4}\right)$

> F3 := RandNice([x, y], 8)
 F3 := [(5 - 3x - 8y) (1 - 6x - 5y), (6 - 7x - 4y) (7 - 3x - 6y)] (14)

> EquPts(F3, [x, y])
 $\left\{ \left[-\frac{29}{21}, \frac{13}{7} \right], \left[\frac{7}{11}, \frac{17}{44} \right], \left[\frac{13}{3}, -1 \right], \left[\frac{26}{11}, -\frac{29}{11} \right] \right\}$ (15)

> StEquPts(F3, [x, y])
 \emptyset (16)

> Dis2(F3, x, y, $\left[-\frac{29}{21} + 0.1, \frac{13}{7} + 0.1 \right], 0.01, 10)$ (17)
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Float(∞) ]], [10.01, [Float(∞), Float(∞) ]]]

```

```
> #There are no stable fixed points
```

```
> #3)
```

```
> print(EquPts)
```

```
proc(F, var)
```

```
    local sol, iI;
```

```
    if nops(F) <> nops(var) then RETURN(FAIL) end if;
```

```
    sol := {solve({op(F)}, {op(var)})};
```

```
    {seq(subs(sol[iI], var), iI = 1 ..nops(sol)) }
```

```
end proc
```

```
> print(SIRS)
```

```
    proc(s, i, β, γ, v, N) [ - s*i*β + γ*(N - s - i), s*i*β - v*i ] end proc
```

(18)

(19)

$$\begin{aligned}
& \text{[> EquPts}(SIRS(s, i, \beta, \text{gamma}, v, N), [s, i]) \\
& \qquad \qquad \qquad \left\{ [N, 0], \left[\frac{v}{\beta}, \frac{\gamma(N\beta - v)}{\beta(\gamma + v)} \right] \right\} \\
& \text{[> \#The SIRS model has two steady states as given above}
\end{aligned}
\tag{20}$$

$$\begin{aligned}
& \text{[> \#4)} \\
& \text{[> Chemostat :=proc}(N, C, a1, a2) : \\
& \quad \left[a1 \cdot \left(\frac{C}{1 + C} \right) \cdot N - N, - \left(\frac{C}{1 + C} \right) \cdot N - C + a2 \right] : \\
& \quad \text{end:} \\
& \text{[> EquPts}(Chemostat(N, C, a1, a2), [N, C]) \\
& \qquad \qquad \qquad \left\{ [0, a2], \left[\frac{a1(a2 - a1 - 1)}{a1 - 1}, \frac{1}{a1 - 1} \right] \right\} \\
& \text{[> \#confirmed by equations 25a and 25b in section 4.5}
\end{aligned}
\tag{21}$$