```
> read `DMB.txt`
```

For a list of the Main procedures type: Help(); for help with a specific procedure type: Help (ProcedureName); for example Help(Feig);

For a list of the Continuous Dynamical Models procedures type: HelpC(); for help with a specific procedure type: Help(ProcedureName); for example Help(Feig); **(1)**

```
> read `L18.txt`
```

For a list of the Main procedures type: Help(); for help with a specific procedure type: Help (ProcedureName); for example Help(Feig);

For a list of the Continuous Dynamical Models procedures type: HelpC(); for help with a specific procedure type: Help(ProcedureName); for example Help(Feig); **(2)**

```
> Help(SIRSdemo)
```

SIRSdemo(N,IN,gamma,nu,h,A): A demonstartion of the SIRS model with NUMBERS N: The total population, IN: The number of infected individuals at the start

parameters gamma, and nu and various beta changing from 0.1(nu/N) to 4*(nu/N) . Using a discretization with mesh size h and going until t=A.*

Try:

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

```
>
```

```
SIRSdemo(1000, 10, 1.2, 1.2, 0.01, 20)
```

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=*, 20

with population size, 1000, *and fixed parameters nu=*, 1.2, *and gamma=*, 1.2

*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, 0.001200000000

We start with , 10, *infected individuals, 0 removed and hence*, 990, *susceptible*

We will show what happens once time is close to, 20

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

the long-term behavior is

$$[[19.98, [999.9999959, 3.814066385 \times 10^{-9}]], [19.99, [999.9999959, 3.772874468 \times 10^{-9}]], [20.00, [999.9999959, 3.732127423 \times 10^{-9}]], [20.01, [999.9999959, 3.691820447 \times 10^{-9}]]]$$

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

the long-term behavior is

$$[[19.98, [999.9999959, 4.789446054 \times 10^{-7}]], [19.99, [999.9999959, 4.749214707 \times 10^{-7}]], [20.00, [999.9999959, 4.709321304 \times 10^{-7}]], [20.01, [999.9999959, 4.669763005 \times 10^{-7}]]]$$

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

$$\textit{the long-term behavior is}$$

$$[[19.98, [999.9998224, 0.00005914845047]], [19.99, [999.9998234, 0.00005879355970]], [20.00, [999.9998244, 0.00005844079828]], [20.01, [999.9998254, 0.00005809015343]]]$$

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

$$\textit{the long-term behavior is}$$

$$[[19.98, [999.9827187, 0.007115776991]], [19.99, [999.9827809, 0.007090159161]], [20.00, [999.9828428, 0.007064633562]], [20.01, [999.9829046, 0.007039199863]]]$$

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

$$\textit{the long-term behavior is}$$

$$[[19.98, [998.3489788, 0.7812955740]], [19.99, [998.3509915, 0.7803440880]], [20.00, [998.3530017, 0.7793937777]], [20.01, [998.3550094, 0.7784446417]]]$$

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

$$\textit{the long-term behavior is}$$

$$[[19.98, [930.9325784, 34.97628213]], [19.99, [930.9118727, 34.98636614]], [20.00, [930.8911800, 34.99644350]], [20.01, [930.8705005, 35.00651420]]]$$

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

$$\textit{the long-term behavior is}$$

$$[[19.98, [769.9458942, 115.1141924]], [19.99, [769.9425187, 115.1154766]], [20.00, [769.9391589, 115.1167548]], [20.01, [769.9358147, 115.1180269]]]$$

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

$$\textit{the long-term behavior is}$$

$$[[19.98, [666.6669826, 166.6659786]], [19.99, [666.6669944, 166.6659796]], [20.00, [666.6670060, 166.6659805]], [20.01, [666.6670173, 166.6659815]]]$$

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

$$\textit{the long-term behavior is}$$

[[19.98, [588.2348554, 205.8825499]], [19.99, [588.2348577, 205.8825481]], [20.00, [588.2348601, 205.8825462]], [20.01, [588.2348625, 205.8825443]]]

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

the long-term behavior is

[[19.98, [526.3158847, 236.8420581]], [19.99, [526.3158842, 236.8420586]], [20.00, [526.3158837, 236.8420591]], [20.01, [526.3158832, 236.8420596]]]

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

the long-term behavior is

[[19.98, [476.1904618, 261.9047791]], [19.99, [476.1904617, 261.9047791]], [20.00, [476.1904616, 261.9047791]], [20.01, [476.1904615, 261.9047791]]]

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

the long-term behavior is

[[19.98, [434.7826042, 282.6086958]], [19.99, [434.7826042, 282.6086958]], [20.00, [434.7826042, 282.6086958]], [20.01, [434.7826042, 282.6086958]]]

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

the long-term behavior is

[[19.98, [400.0000002, 299.9999959]], [19.99, [400.0000002, 299.9999959]], [20.00, [400.0000002, 299.9999959]], [20.01, [400.0000002, 299.9999959]]]

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

the long-term behavior is

[[19.98, [370.3703731, 314.8148102]], [19.99, [370.3703731, 314.8148102]], [20.00, [370.3703731, 314.8148102]], [20.01, [370.3703731, 314.8148102]]]

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

the long-term behavior is

[[19.98, [344.8275914, 327.5862042]], [19.99, [344.8275914, 327.5862042]], [20.00, [344.8275914, 327.5862042]], [20.01, [344.8275914, 327.5862042]]]

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

the long-term behavior is

[[19.98, [322.5806494, 338.7096709]], [19.99, [322.5806494, 338.7096709]], [20.00, [322.5806494, 338.7096709]], [20.01, [322.5806494, 338.7096709]]]

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

the long-term behavior is

[[19.98, [303.0303041, 348.4848460]], [19.99, [303.0303041, 348.4848460]], [20.00, [303.0303041, 348.4848460]], [20.01, [303.0303041, 348.4848460]]]

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

the long-term behavior is

[[19.98, [285.7142922, 357.1428542]], [19.99, [285.7142922, 357.1428542]], [20.00, [285.7142922, 357.1428542]], [20.01, [285.7142922, 357.1428542]]]

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

the long-term behavior is

[[19.98, [270.2702763, 364.8648544]], [19.99, [270.2702763, 364.8648544]], [20.00, [270.2702763, 364.8648544]], [20.01, [270.2702763, 364.8648544]]]

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

the long-term behavior is

[[19.98, [256.4102563, 371.7948710]], [19.99, [256.4102563, 371.7948710]], [20.00, [256.4102563, 371.7948710]], [20.01, [256.4102563, 371.7948710]]] **(4)**

> **for** *i* **from** 1 **to** 20 **do** $a1 := rand(1..100)() : a2 := rand(1..100)() : [a1, a2];$ $SEquP(ChemoStat(N, C, a1, a2), [N, C])$; **end do**

$$a1 := 93$$

$$a2 := 45$$

$$[93, 45]$$

$$\{[4183.989130, 0.01086956522]\}$$

$$a1 := 44$$

$$a2 := 100$$

$$[44, 100]$$

$$\{[4398.976744, 0.02325581395]\}$$

$$a1 := 38$$

$$a2 := 69$$

$$[38, 69]$$

$$\{[2620.972973, 0.02702702703]\}$$

$$a1 := 27$$

$$a2 := 96$$

$$[27, 96]$$

$$\{[2590.961538, 0.03846153846]\}$$

$$a1 := 17$$

$$a2 := 90$$

$$[17, 90]$$

$$\{[1528.937500, 0.06250000000]\}$$

$$a1 := 34$$

$$a2 := 18$$

$$[34, 18]$$

$$\{[610.9696970, 0.03030303030]\}$$

$$a1 := 52$$

$$a2 := 56$$

$$[52, 56]$$

$$\{[2910.980392, 0.01960784314]\}$$

$$a1 := 43$$

$$a2 := 83$$

$$[43, 83]$$

$$\{[3567.976190, 0.02380952381]\}$$

$$a1 := 25$$

$$a2 := 90$$

$$[25, 90]$$

$$\{[2248.958333, 0.04166666667]\}$$

$$a1 := 93$$

$$a2 := 60$$

$$[93, 60]$$

$$\{[5578.989130, 0.01086956522]\}$$

$$a1 := 93$$

$$a2 := 14$$

$$[93, 14]$$

$$\{[1300.989130, 0.01086956522]\}$$

$$a1 := 50$$

$$a2 := 47$$

$$[50, 47]$$

$$\{[2348.979592, 0.02040816327]\}$$

$$a1 := 8$$

$$a2 := 46$$

$$[8, 46]$$

$$\{[366.8571429, 0.1428571429]\}$$

$$a1 := 44$$

$$a2 := 9$$

$$[44, 9]$$

$$\{[394.9767442, 0.02325581395]\}$$

$$a1 := 77$$

$$a2 := 59$$

$$[77, 59]$$

$$\{[4541.986842, 0.01315789474]\}$$

$$a1 := 16$$

$$a2 := 1$$

$$[16, 1]$$

$$\{[14.93333333, 0.06666666667]\}$$

$$a1 := 70$$

$$a2 := 77$$

$$[70, 77]$$

$$\{[5388.985507, 0.01449275362]\}$$

$$a1 := 39$$

$$a2 := 92$$

$$[39, 92]$$

$$\{[3586.973684, 0.02631578947]\}$$

$$a1 := 71$$

$$a2 := 67$$

$$[71, 67]$$

$$\{[4755.985714, 0.01428571429]\}$$

$$a1 := 78$$

$$a2 := 51$$

$$[78, 51]$$

$$\{[3976.987013,\ 0.01298701299]\} \quad \textbf{(5)}$$

```
> SIRSdemo(1000, 400, 1, 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=*, 1

*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 , 400, *infected individuals, 0 removed and hence*, 600, *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, [999.6693512, 0.04464970605]], [9.99, [999.6721666, 0.04424784393]], [10.00, [999.6749582, 0.04384959883]], [10.01, [999.6777263, 0.04345493819]]]

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

the long-term behavior is

[[9.98, [998.8686058, 0.2679278925]], [9.99, [998.8764375, 0.2660514879]], [10.00, [998.8842153, 0.2641882307]], [10.01, [998.8919395, 0.2623380288]]]

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

the long-term behavior is

[[9.98, [995.5661036, 1.464972088]], [9.99, [995.5885005, 1.457614750]], [10.00, [995.6107835, 1.450294524]], [10.01, [995.6329532, 1.443011223]]]

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

the long-term behavior is

[[9.98, [982.9907292, 6.871557578]], [9.99, [983.0448236, 6.850124744]], [10.00, [983.0987363, 6.828761355]], [10.01, [983.1524679, 6.807467168]]]

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

the long-term behavior is

[[9.98, [944.9550913, 25.07830676]], [9.99, [945.0414764, 25.04080455]], [10.00, [945.1276722, 25.00337789]], [10.01, [945.2136792, 24.96602657]]]

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

the long-term behavior is

[[9.98, [866.8575732, 64.57449614]], [9.99, [866.9275067, 64.54449698]], [10.00, [866.9972772, 64.51456141]], [10.01, [867.0668854, 64.48468924]]]

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

the long-term behavior is

[[9.98, [764.2055840, 117.1693099]], [9.99, [764.2277964, 117.1616555]], [10.00, [764.2499053, 117.1540354]], [10.01, [764.2719113, 117.1464495]]]

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

the long-term behavior is

[[9.98, [667.4467215, 166.2827762]], [9.99, [667.4446531, 166.2847218]], [10.00, [667.4425717, 166.2866623]], [10.01, [667.4404774, 166.2885977]]]

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

the long-term behavior is

[[9.98, [588.7326192, 205.7837146]], [9.99, [588.7278789, 205.7854544]], [10.00, [588.7231678, 205.7871777]], [10.01, [588.7184858, 205.7888844]]]

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

the long-term behavior is

[[9.98, [526.3391708, 236.9273141]], [9.99, [526.3371276, 236.9274194]], [10.00, [526.3351118, 236.9275155]], [10.01, [526.3331234, 236.9276024]]]

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

the long-term behavior is

[[9.98, [476.0755911, 261.9954214]], [9.99, [476.0755589, 261.9947893]], [10.00, [476.0755398, 261.9941570]], [10.01, [476.0755336, 261.9935246]]]

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

the long-term behavior is

[[9.98, [434.6820669, 282.6567829]], [9.99, [434.6827642, 282.6561293]], [10.00, [434.6834631, 282.6554802]], [10.01, [434.6841635, 282.6548356]]]

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

the long-term behavior is

[[9.98, [399.9447066, 300.0130619]], [9.99, [399.9454130, 300.0126472]], [10.00, [399.9461153, 300.0122378]], [10.01, [399.9468135, 300.0118336]]]

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

the long-term behavior is

[[9.98, [370.3498315, 314.8101124]], [9.99, [370.3503056, 314.8099378]], [10.00, [370.3507743, 314.8097672]], [10.01, [370.3512378, 314.8096006]]]

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

the long-term behavior is

[[9.98, [344.8255549, 327.5761726]], [9.99, [344.8257953, 327.5761533]], [10.00, [344.8260313, 327.5761363]], [10.01, [344.8262630, 327.5761215]]]

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

the long-term behavior is

[[9.98, [322.5856476, 338.7004341]], [9.99, [322.5857299, 338.7004867]], [10.00, [322.5858094, 338.7005401]], [10.01, [322.5858863, 338.7005943]]]

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

the long-term behavior is

[[9.98, [303.0363872, 348.4783244]], [9.99, [303.0363869, 348.4783944]], [10.00, [303.0363852, 348.4784644]], [10.01, [303.0363821, 348.4785344]]]

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

the long-term behavior is

[[9.98, [285.7191728, 357.1389626]], [9.99, [285.7191408, 357.1390237]], [10.00, [285.7191083, 357.1390844]], [10.01, [285.7190753, 357.1391447]]]

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

the long-term behavior is

[[9.98, [270.2735369, 364.8628645]], [9.99, [270.2735002, 364.8629086]], [10.00, [270.2734634, 364.8629522]], [10.01, [270.2734267, 364.8629953]]]

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

the long-term behavior is

$[[9.98, [256.4121907, 371.7940209]], [9.99, [256.4121603, 371.7940490]], [10.00, [256.4121301, 371.7940766]], [10.01, [256.4121001, 371.7941037]]]$ **(6)**

> **for** *i* **from** 1 **to** 10 **do** *HWgE*(100, 1000); **end do**

0.5290000000

0.5700000000

Error, (in HWgE) cannot determine if this expression is true or false: abs(FAIL[1]-1) < .1e-2 or abs(FAIL[2]-1) < .1e-2 or abs(FAIL[1]-FAIL[2]) < .1e-2 |L18.txt:16|

> **for** *i* **to** 10 **do**
>
> *HWgE*(100, 1000);
>
> **end do**

0.5480000000

Error, (in HWgE) cannot determine if this expression is true or false: abs(FAIL[1]-1) < .1e-2 or abs(FAIL[2]-1) < .1e-2 or abs(FAIL[1]-FAIL[2]) < .1e-2 |L18.txt:16|

> *# Yes, the answers are similar*