> #OK to post homework
#Shreya Ghosh, 11-15-2021, Assignment 20

> **read** "/Users/shreyaghosh/Documents/DMB.txt"

*First Written: Nov. 2021*

*This is DMB.txt, A Maple package to explore Dynamical models in Biology (both discrete and continuous)*
*accompanying the class Dynamical Models in Biology, Rutgers University. Taught by Dr. Z. (Doron Zeilbeger)*

*The most current version is available on WWW at:*
*http://sites.math.rutgers.edu/~zeilberg/tokhniot/DMB.txt .*
*Please report all bugs to: DoronZeil at gmail dot com .*

*For general help, and a list of the MAIN functions,*
*type "Help();". For specific help type "Help(procedure_name);"*

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*For a list of the supporting functions type: Help1();*
*For help with any of them type: Help(ProcedureName);*

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*For a list of the functions that give examples of Discrete-time dynamical systems (some famous), type: HelpDDM();*
*For help with any of them type: Help(ProcedureName);*

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*For a list of the functions continuous-time dynamical systems (some famous) type: HelpCDM();*
*For help with any of them type: Help(ProcedureName);*

------------------------------ **(1)**

> #1 i (beta = 0.3 $\frac{\text{nu}}{1000}$).
$F := SIRS(s, i, 0.0006, 5, 2, 1000)$

$$F := [-0.0006\, s\, i + 5000 - 5\, s - 5\, i,\ 0.0006\, s\, i - 2\, i] \quad \textbf{(2)}$$

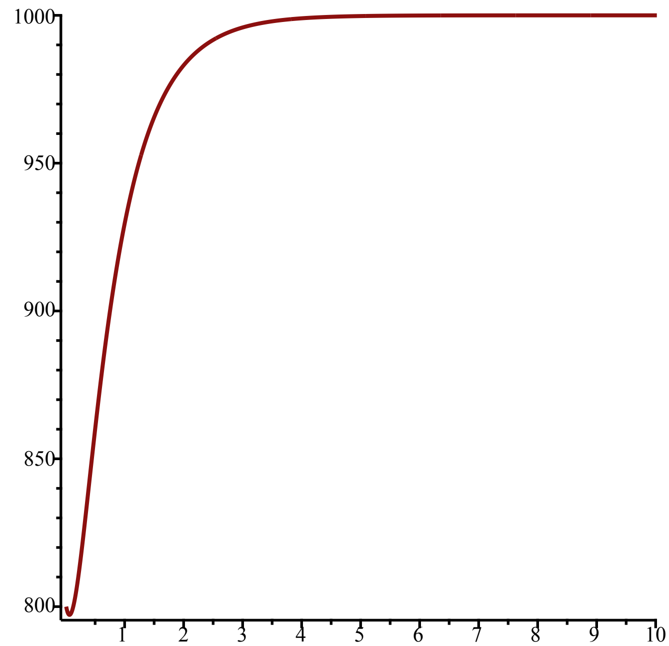
> $EquP(F, [s, i])$

$$\{[1000., 0.], [3333.333333, -1666.666667]\} \quad \textbf{(3)}$$

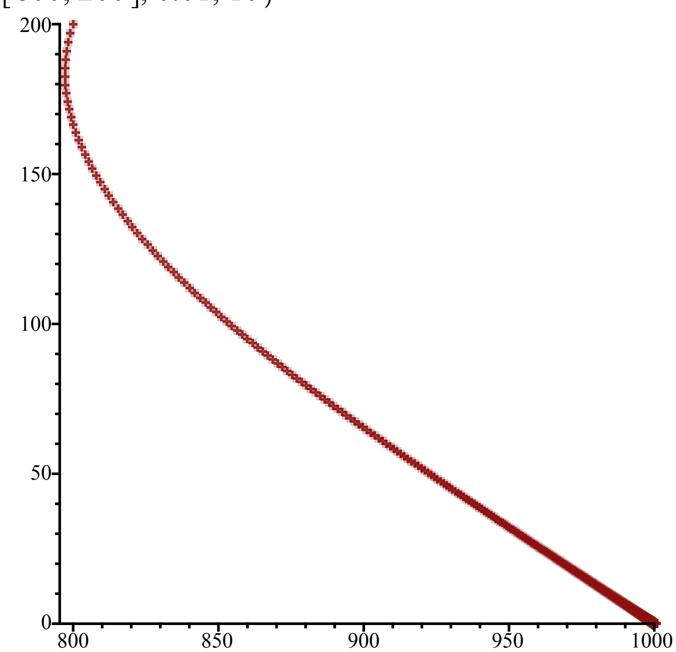
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \quad \textbf{(4)}$$

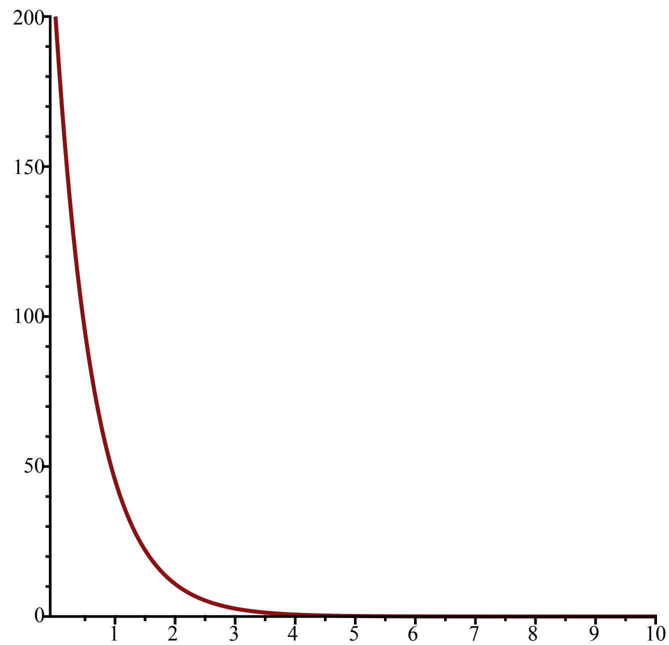
> *TimeSeries*(*F*, [*s*, *i*], [800, 200], 0.01, 10, 1)




> *PhaseDiag*(*F*, [*s*, *i*], [800, 200], 0.01, 10)




> *TimeSeries*([0.0006 *s* *i* − 2 *i*, -0.0006 *s* *i* + 5000 − 5 *s* − 5 *i*], [*i*, *s*], [200, 800], 0.01, 10, 1)




>

> #1 i (beta=0.9 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0018, 5, 2, 1000)$

$$F := [-0.0018\, s\, i + 5000 - 5\, s - 5\, i,\ 0.0018\, s\, i - 2\, i] \qquad \textbf{(5)}$$

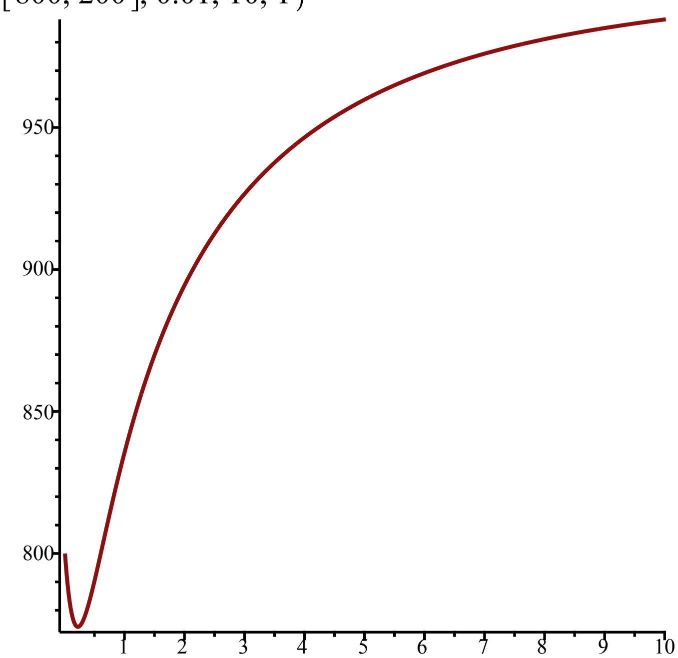
> $EquP(F, [s, i])$

$$\{[1000., 0.], [1111.111111, -79.36507937]\} \qquad \textbf{(6)}$$

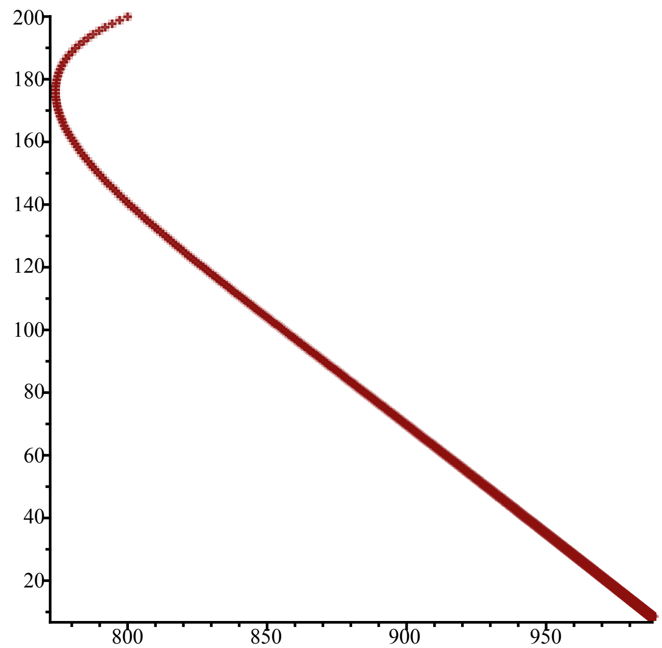
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \qquad \textbf{(7)}$$

> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> #1 i (beta=0.9 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0018, 5, 2, 1000)$

$$F := [-0.0018\, s\, i + 5000 - 5\, s - 5\, i,\ 0.0018\, s\, i - 2\, i] \quad \textbf{(8)}$$

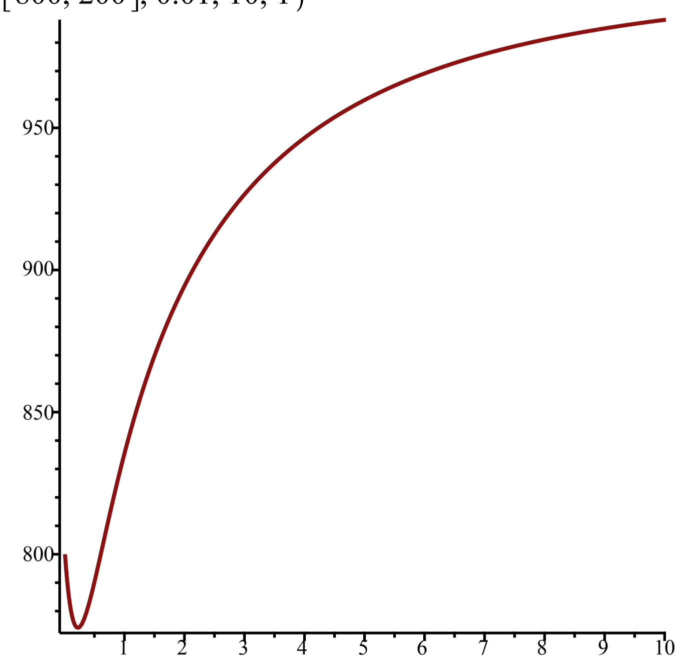
> $EquP(F, [s, i])$

$$\{[1000., 0.], [1111.111111, -79.36507937]\} \quad \textbf{(9)}$$

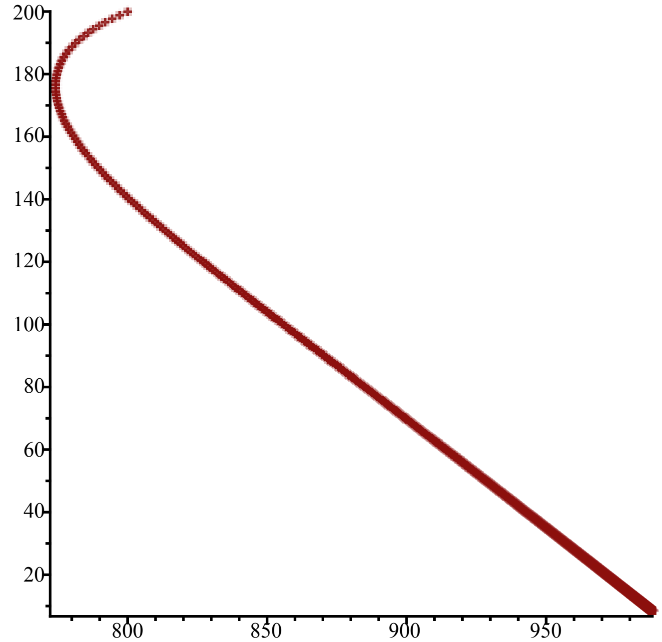
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \quad \textbf{(10)}$$

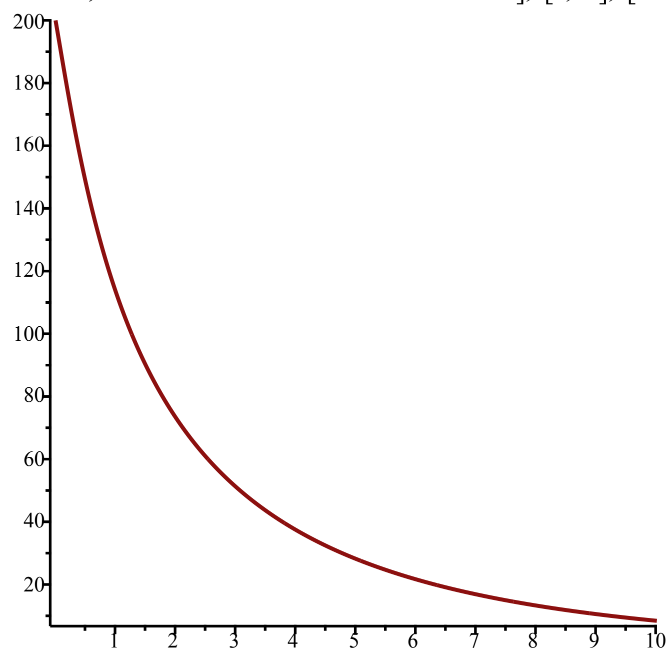
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> $TimeSeries([0.0018\, s\, i - 2\, i, -0.0018\, s\, i + 5000 - 5\, s - 5\, i], [i, s], [200, 800], 0.01, 10, 1)$




> #1i (beta = 3.9 $\frac{\text{nu}}{1000}$)

> $F := SIRS(s, i, 0.0078, 5, 2, 1000)$

$$F := [-0.0078\, s\, i + 5000 - 5\, s - 5\, i, 0.0078\, s\, i - 2\, i] \quad \textbf{(11)}$$

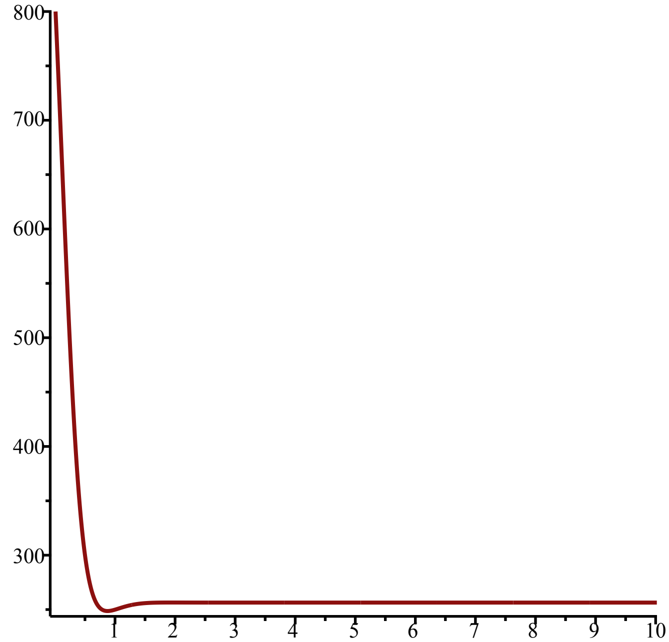
> $EquP(F, [s, i])$

$$\{[256.4102564, 531.1355311], [1000., 0.]\} \quad \textbf{(12)}$$

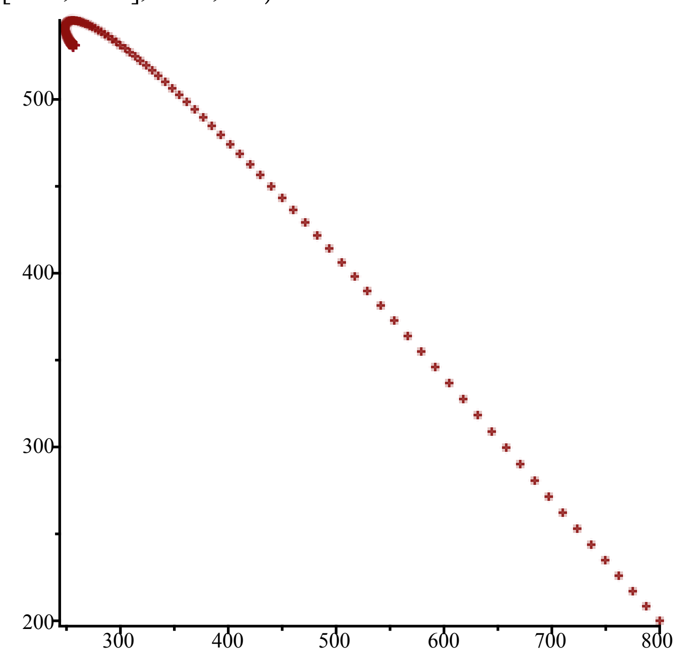
> $SEquP(F, [s, i])$

$$\{[256.4102564, 531.1355311]\} \quad \textbf{(13)}$$

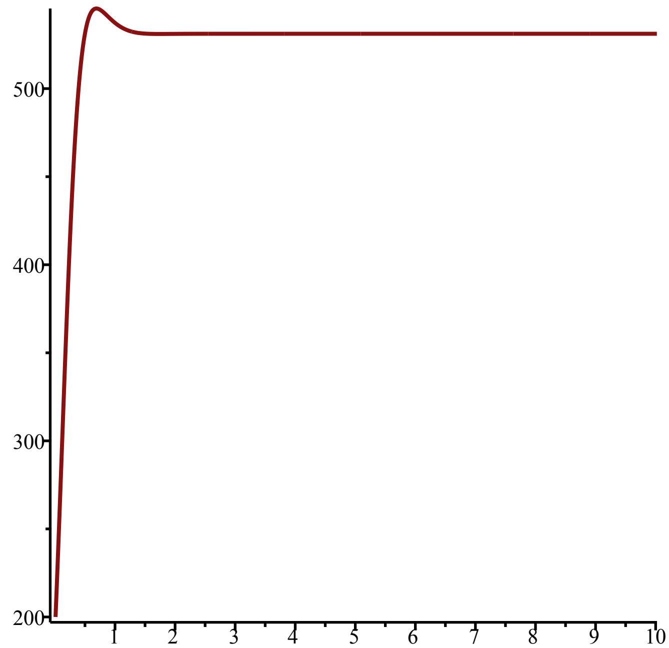
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> *PhaseDiag*(*F*, [*s*, *i*], [800, 200], 0.01, 10)




> *TimeSeries*([0.0078 *s* *i* − 2 *i*, -0.0078 *s* *i* + 5000 − 5 *s* − 5 *i*], [*i*, *s*], [200, 800], 0.01, 10, 1)




> #1ii(beta = 0.3 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0009, 6, 3, 1000)$

$$F := [-0.0009\, s\, i + 6000 - 6\, s - 6\, i, 0.0009\, s\, i - 3\, i] \quad (14)$$

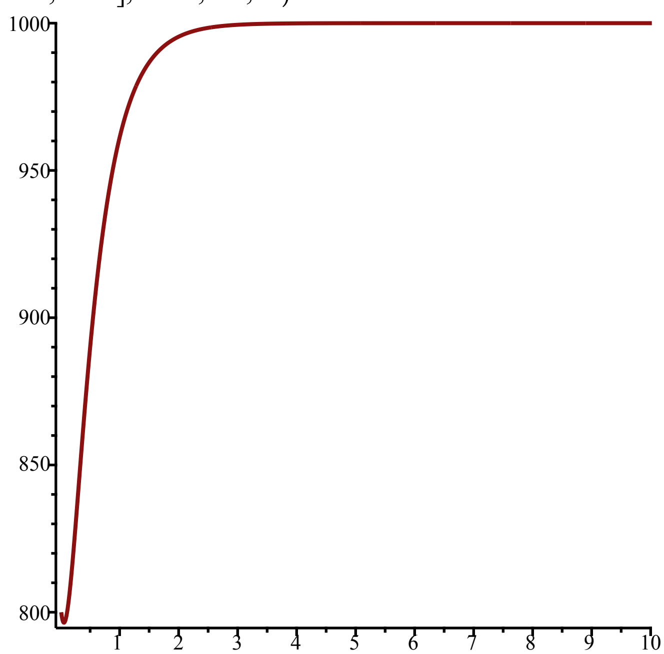
> $EquP(F, [s, i])$

$$\{[1000., 0.], [3333.333333, -1555.555556]\} \quad (15)$$

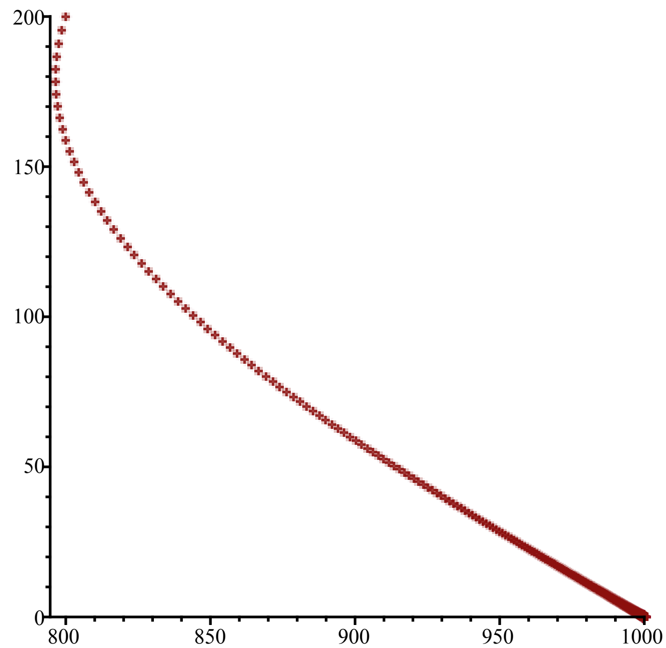
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \quad (16)$$

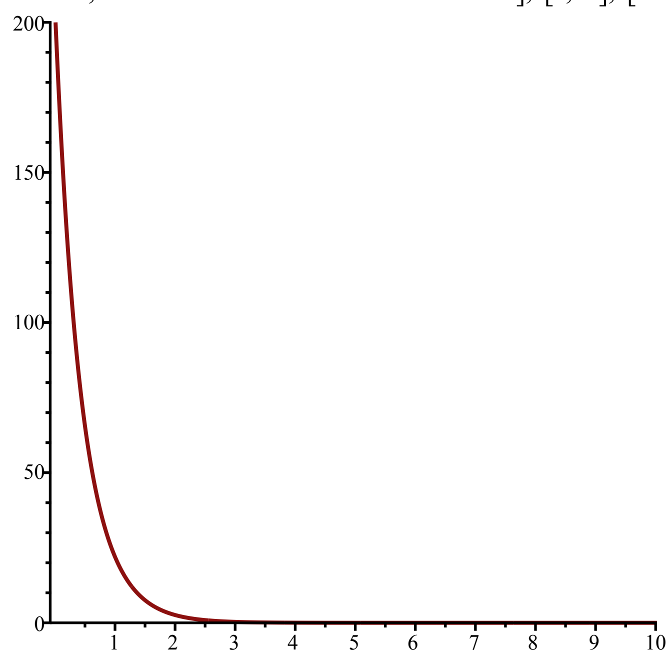
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> $TimeSeries([0.0009\, s\, i - 3\, i, -0.0009\, s\, i + 6000 - 6\, s - 6\, i], [i, s], [200, 800], 0.01, 10, 1)$




> #1ii(beta = 0.9 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0027, 6, 3, 1000)$

$$F := [-0.0027\, s\, i + 6000 - 6\, s - 6\, i, 0.0027\, s\, i - 3\, i] \quad \textbf{(17)}$$

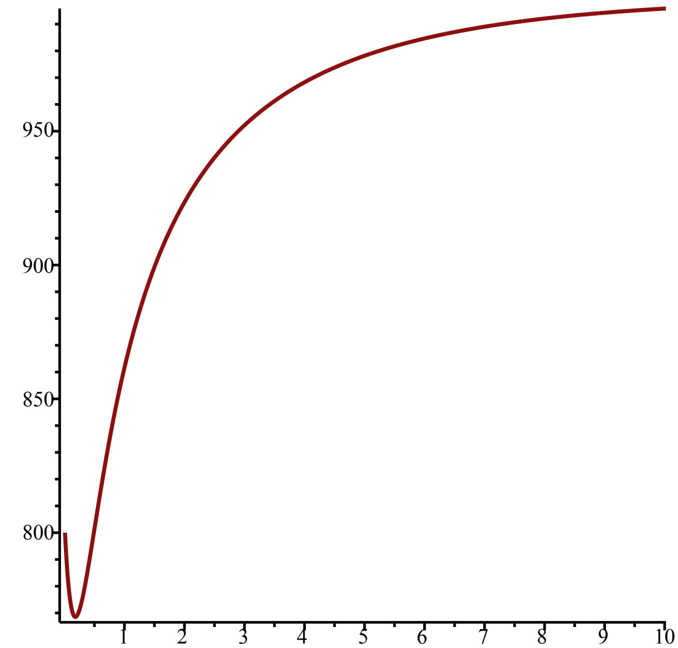
> $EquP(F, [s, i])$

$$\{[1000., 0.], [1111.111111, -74.07407407]\} \quad \textbf{(18)}$$

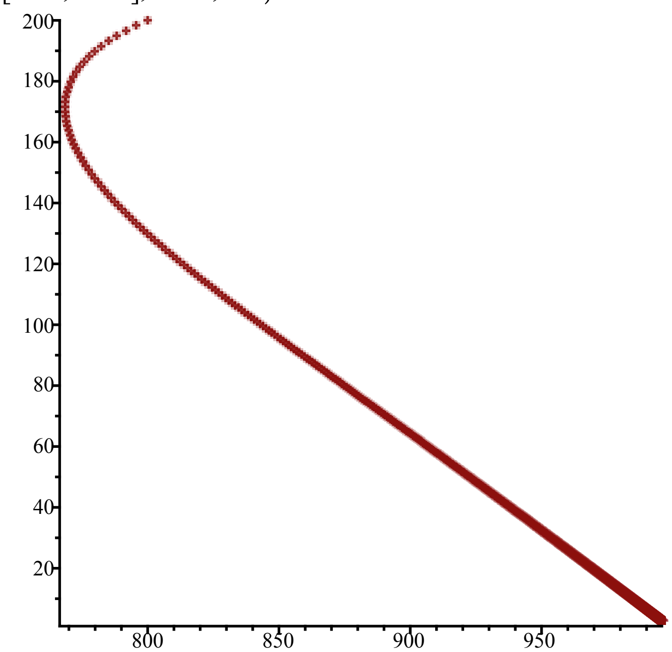
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \quad \textbf{(19)}$$

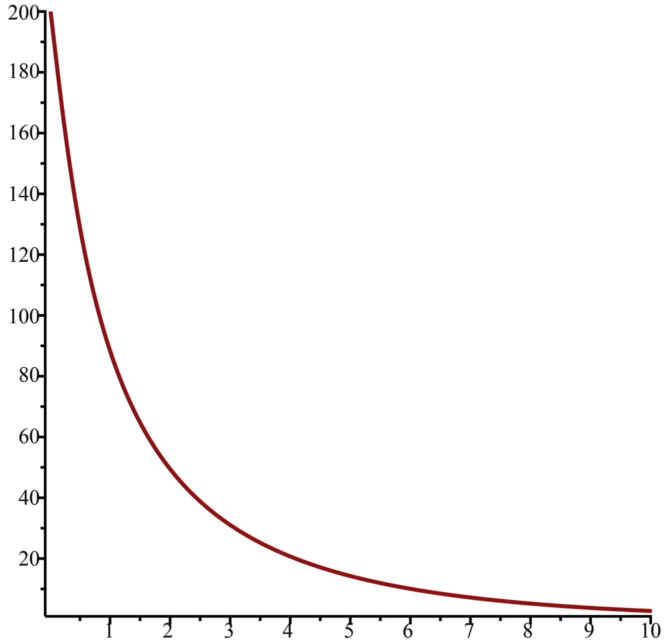
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> $TimeSeries([0.0027\,s\,i - 3\,i, -0.0027\,s\,i + 6000 - 6\,s - 6\,i], [i, s], [200, 800], 0.01, 10, 1)$




> #1ii (beta = 3.9 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0117, 6, 3, 1000)$

$$F := [-0.0117\, s\, i + 6000 - 6\, s - 6\, i, 0.0117\, s\, i - 3\, i] \quad \textbf{(20)}$$

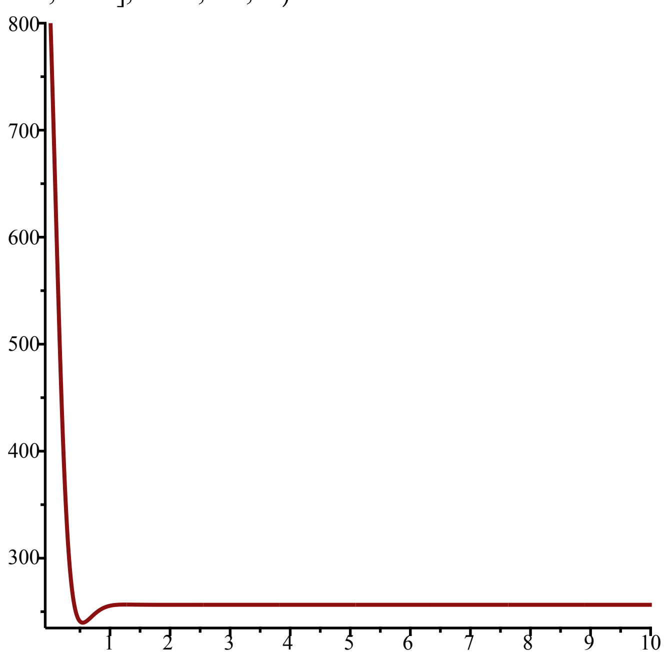
> $EquP(F, [s, i])$

$$\{[256.4102564, 495.7264957], [1000., 0.]\} \quad \textbf{(21)}$$

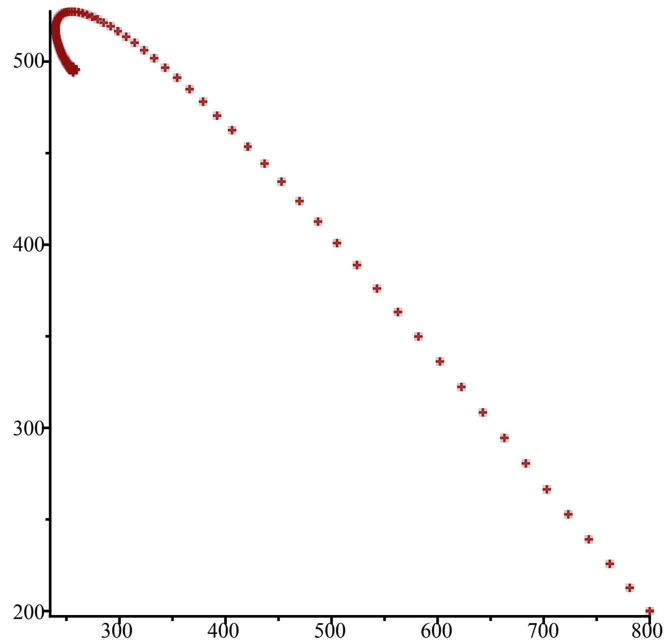
> $SEquP(F, [s, i])$

$$\{[256.4102564, 495.7264957]\} \quad \textbf{(22)}$$

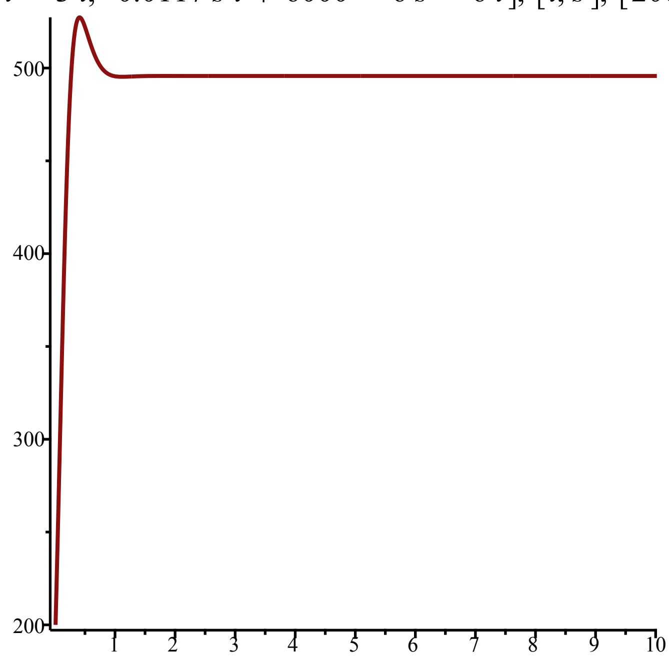
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> $TimeSeries([0.0117\, s\, i - 3\, i, -0.0117\, s\, i + 6000 - 6\, s - 6\, i], [i, s], [200, 800], 0.01, 10, 1)$




> #1iii (beta = 0.3 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0012, 1, 4, 1000)$

$$F := [-0.0012\, s\, i + 1000 - s - i, 0.0012\, s\, i - 4\, i] \quad (23)$$

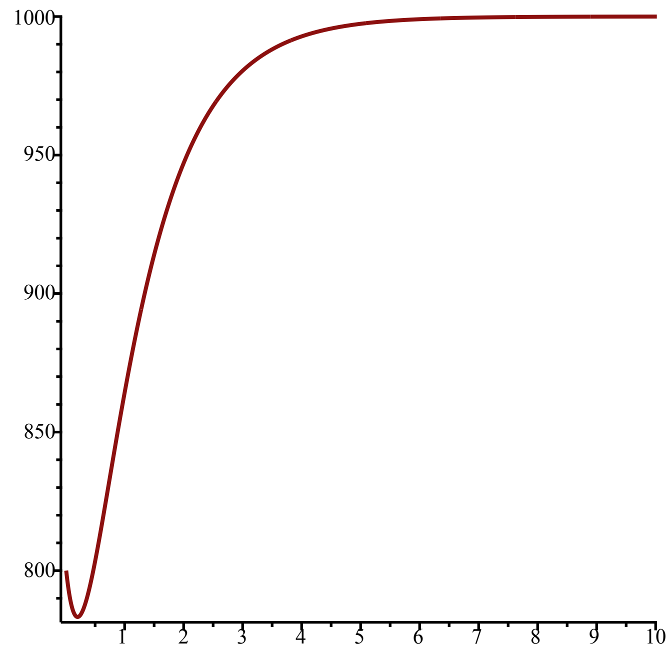
> $EquP(F, [s, i])$

$$\{[1000., 0.], [3333.333333, -466.6666667]\} \quad (24)$$

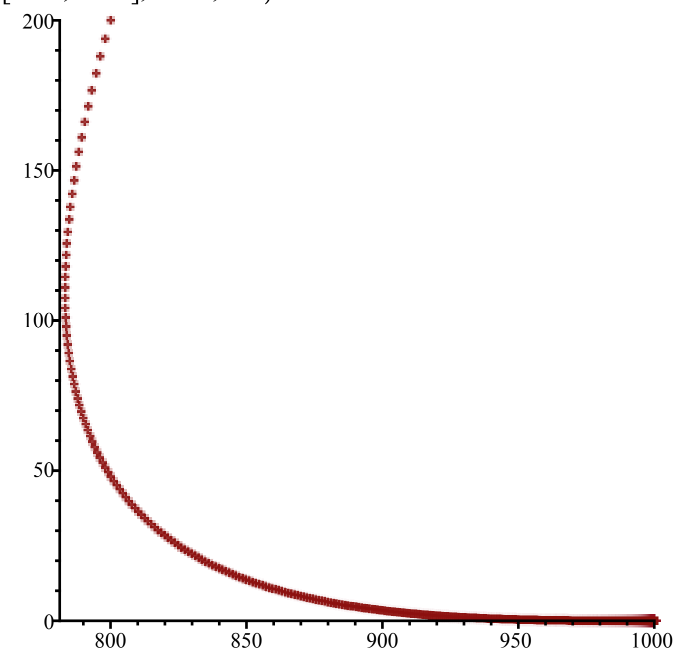
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \quad (25)$$

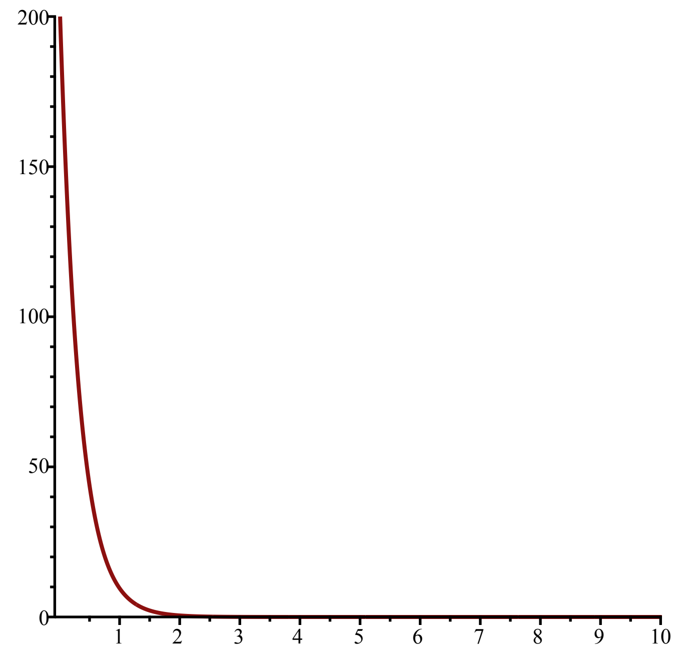
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> $TimeSeries([0.0012\, s\, i - 4\, i, -0.0012\, s\, i + 1000 - s - i], [i, s], [200, 800], 0.01, 10, 1)$




> $\#1iii(beta = 0.9\ \frac{\text{nu}}{1000}).$

> $F := SIRS(s, i, 0.0036, 1, 4, 1000)$

$$F := [-0.0036\, s\, i + 1000 - s - i,\ 0.0036\, s\, i - 4\, i] \quad \textbf{(26)}$$

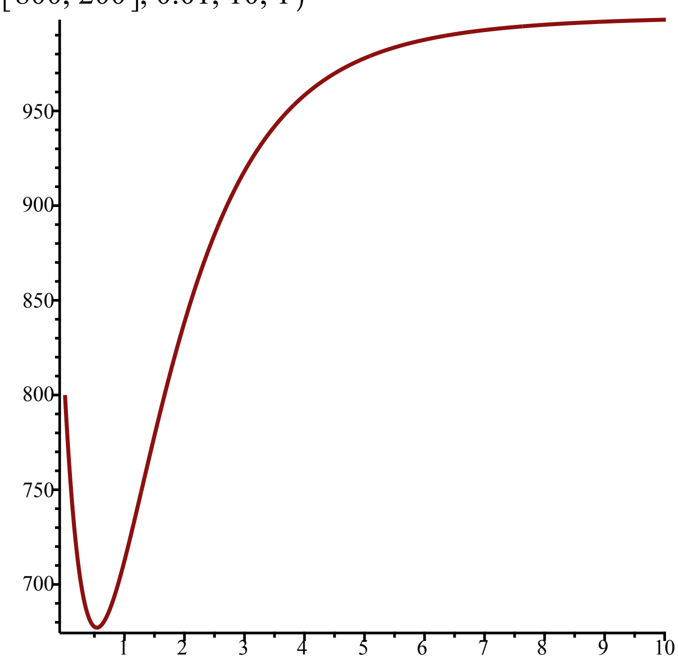
> $EquP(F, [s, i])$

$$\{[1000., 0.], [1111.111111, -22.22222222]\} \quad \textbf{(27)}$$

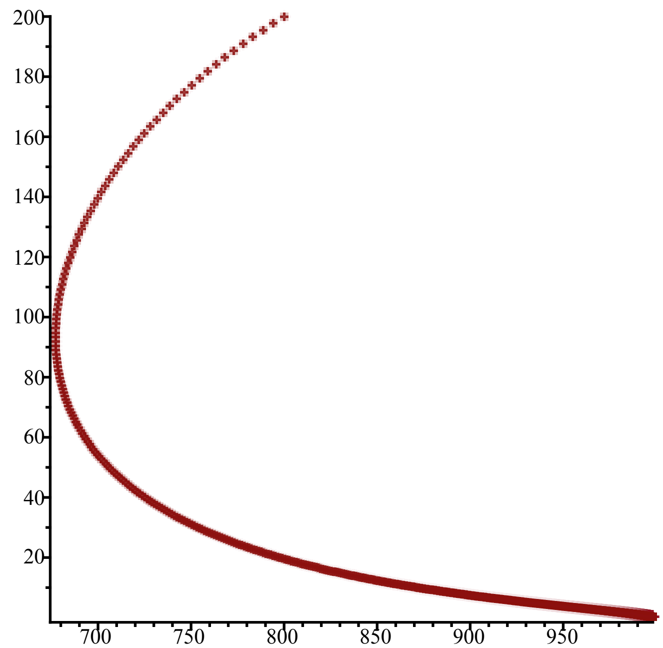
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \quad \textbf{(28)}$$

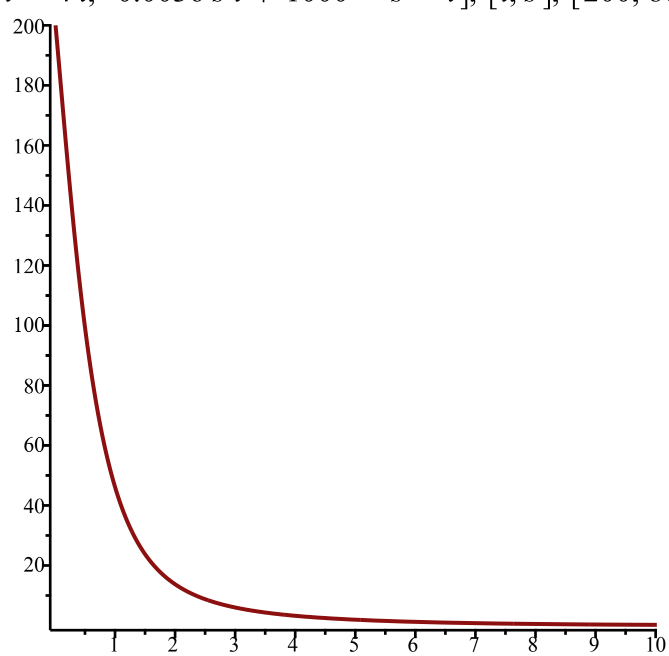
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> *TimeSeries*([0.0036 *s i* − 4 *i*, -0.0036 *s i* + 1000 − *s* − *i*], [*i*, *s*], [200, 800], 0.01, 10, 1)




> #1iii(beta = 3.9 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0156, 1, 4, 1000)$

$$F := [-0.0156\, s\, i + 1000 - s - i,\ 0.0156\, s\, i - 4\, i] \quad \textbf{(29)}$$

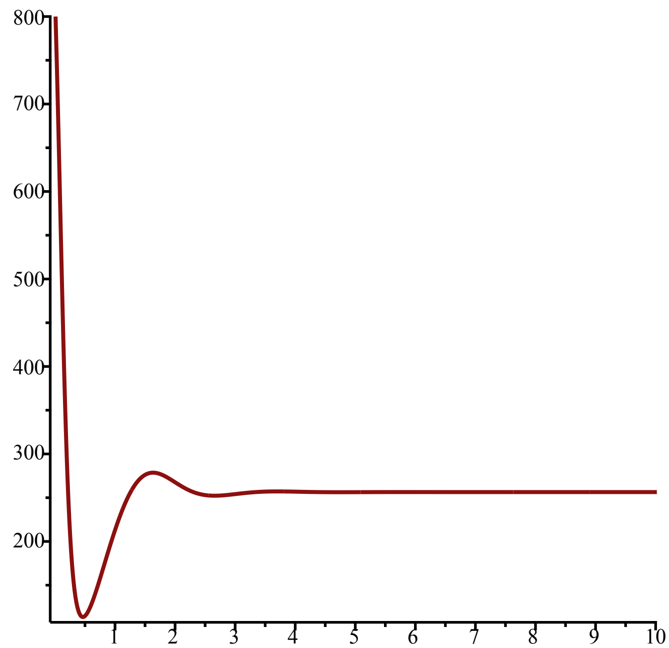
> $EquP(F, [s, i])$

$$\{[256.4102564, 148.7179487], [1000., 0.]\} \quad \textbf{(30)}$$

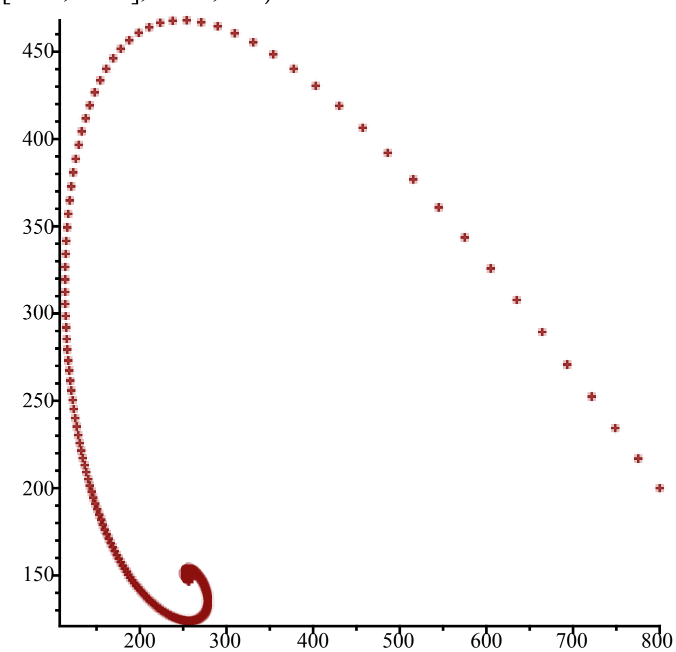
> $SEquP(F, [s, i])$

$$\{[256.4102564, 148.7179487]\} \quad \textbf{(31)}$$

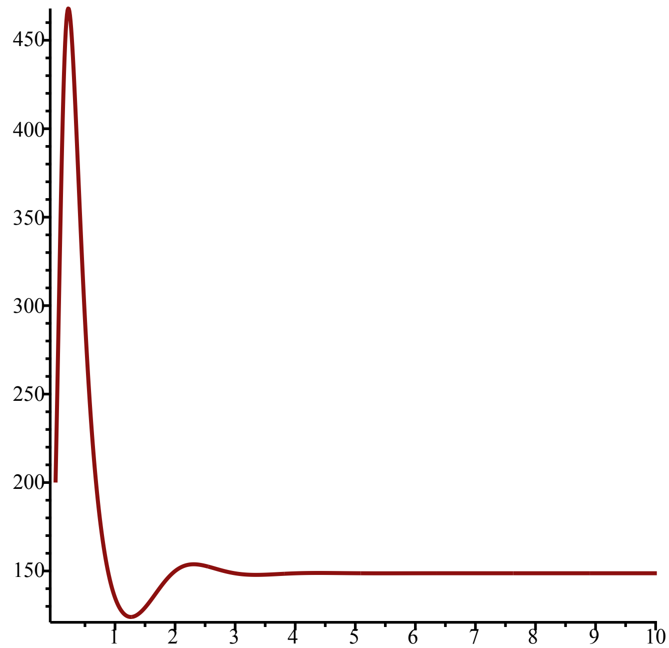
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> $TimeSeries([0.0156\, s\, i - 4\, i, -0.0156\, s\, i + 1000 - s - i], [i, s], [200, 800], 0.01, 10, 1)$




> #1iv(beta = 0.3 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0021, 10, 7, 1000)$

$$F := [-0.0021\, s\, i + 10000 - 10\, s - 10\, i,\ 0.0021\, s\, i - 7\, i] \quad \textbf{(32)}$$

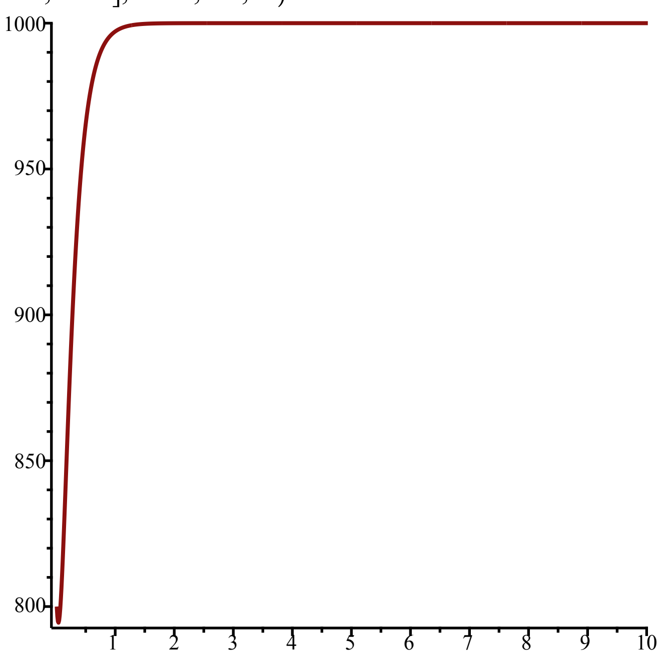
> $EquP(F, [s, i])$

$$\{[1000., 0.], [3333.333333, -1372.549020]\} \quad \textbf{(33)}$$

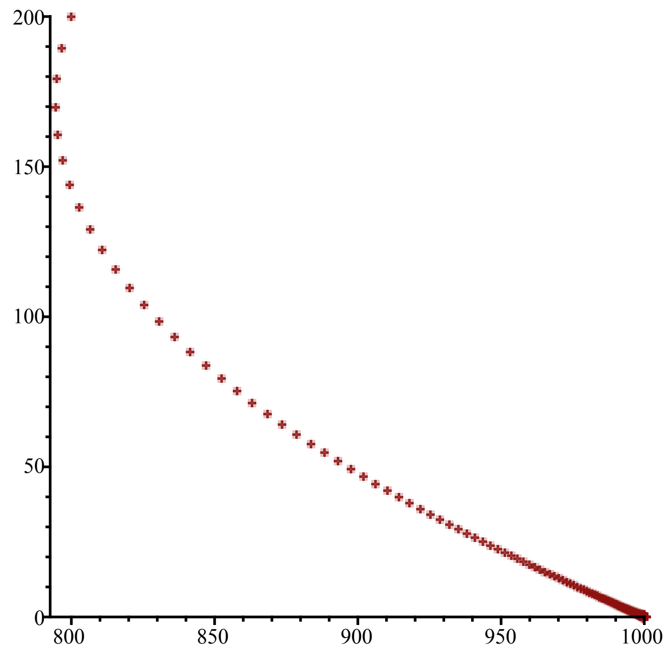
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \quad \textbf{(34)}$$

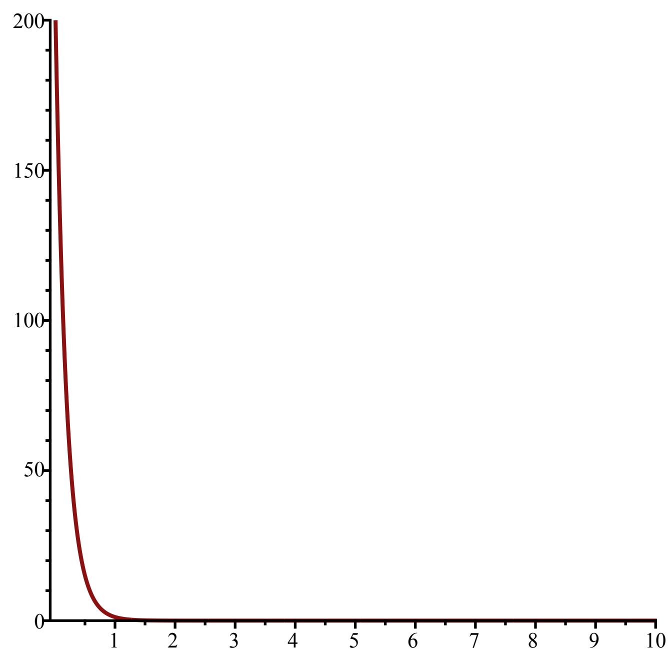
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> $TimeSeries([0.0021\, s\, i - 7\, i,\ -0.0021\, s\, i + 10000 - 10\, s - 10\, i], [i, s], [200, 800], 0.01, 10, 1)$




> #1iv(beta = 0.9 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0063, 10, 7, 1000)$

$$F := [-0.0063\, s\, i + 10000 - 10\, s - 10\, i,\ 0.0063\, s\, i - 7\, i] \quad \textbf{(35)}$$

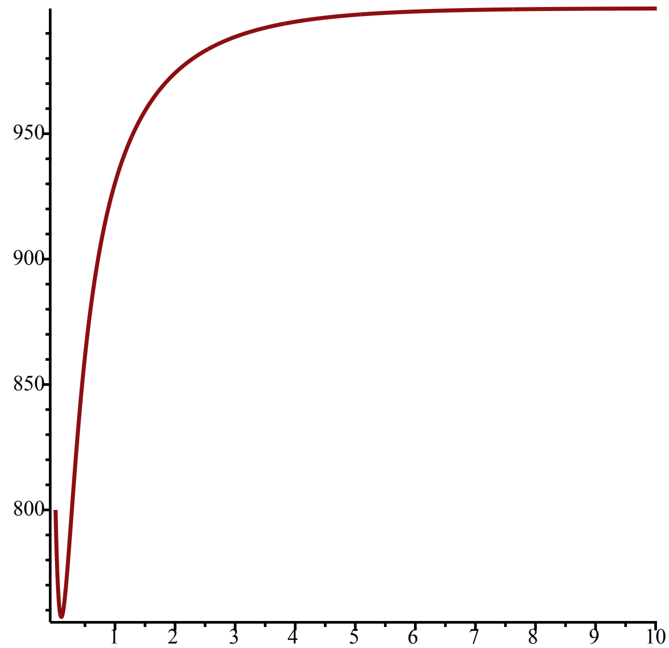
> $EquP(F, [s, i])$

$$\{[1000., 0.], [1111.111111, -65.35947712]\} \quad \textbf{(36)}$$

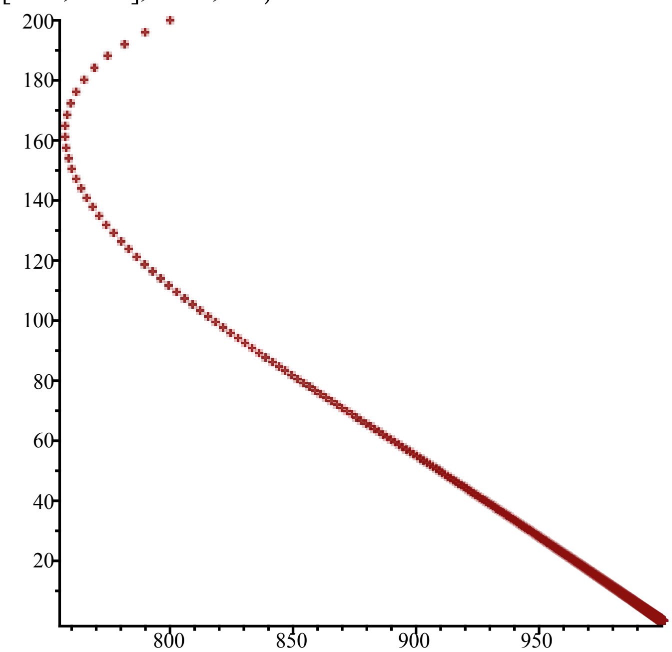
> $SEquP(F, [s, i])$

$$\{[1000., 0.]\} \quad \textbf{(37)}$$

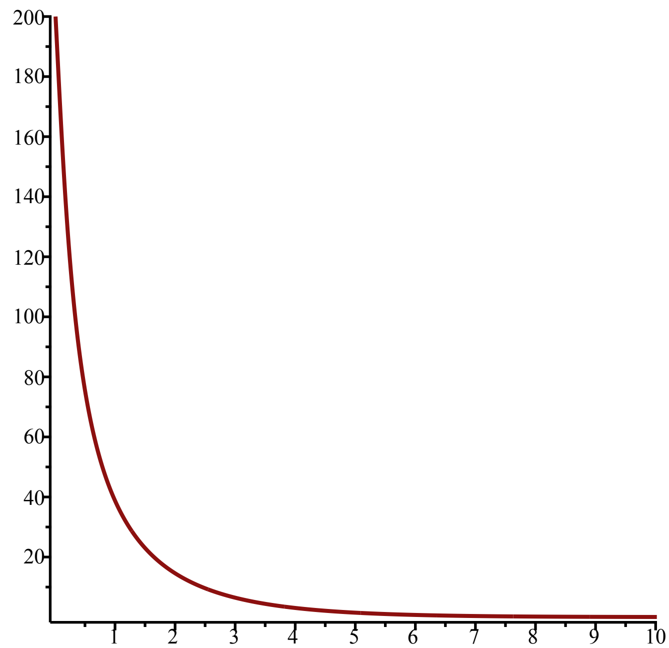
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> $TimeSeries([0.0063\, s\, i - 7\, i, -0.0063\, s\, i + 10000 - 10\, s - 10\, i], [i, s], [200, 800], 0.01, 10, 1)$




> #1iv (beta = 3.9 $\frac{\text{nu}}{1000}$).

> $F := SIRS(s, i, 0.0273, 10, 7, 1000)$

$$F := [-0.0273\, s\, i + 10000 - 10\, s - 10\, i, 0.0273\, s\, i - 7\, i] \quad (38)$$

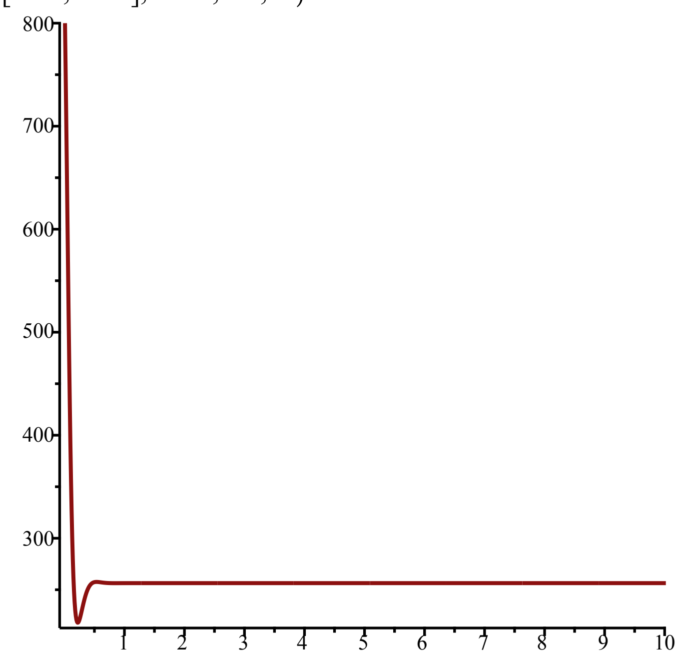
> $EquP(F, [s, i])$

$$\{[256.4102564, 437.4057315], [1000., 0.]\} \quad (39)$$

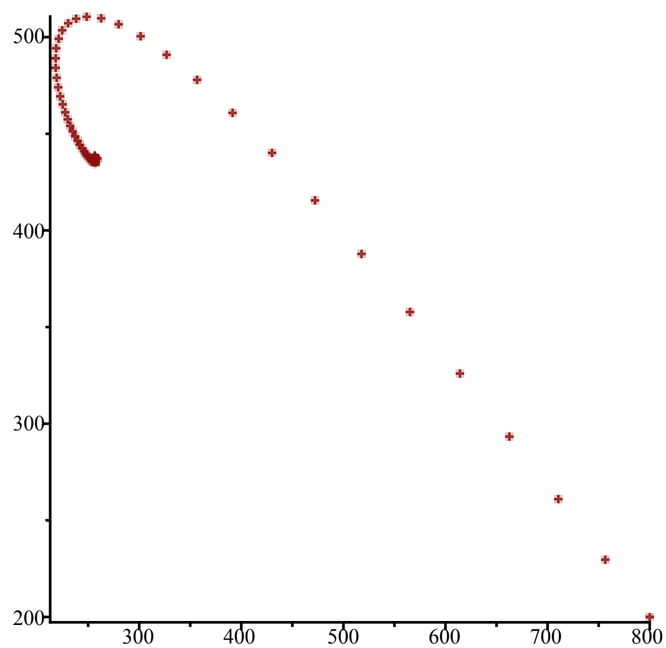
> $SEquP(F, [s, i])$

$$\{[256.4102564, 437.4057315]\} \quad (40)$$

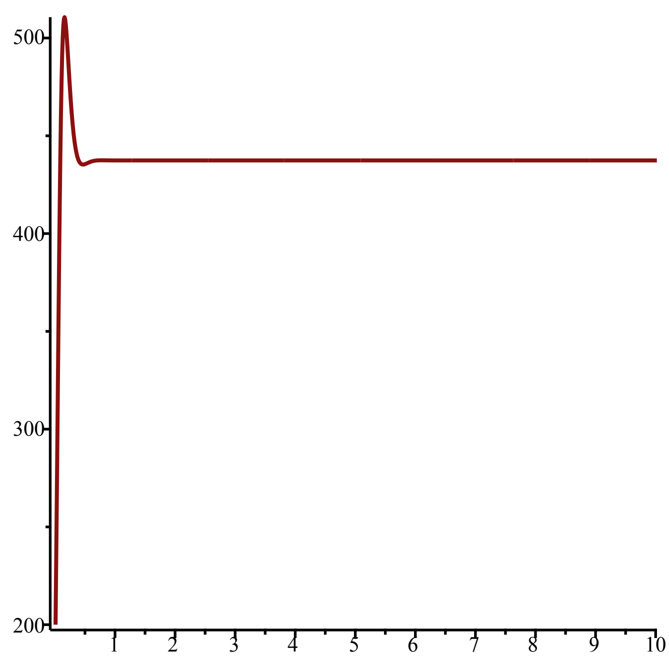
> $TimeSeries(F, [s, i], [800, 200], 0.01, 10, 1)$




> $PhaseDiag(F, [s, i], [800, 200], 0.01, 10)$




> *TimeSeries*$([0.0273\, s\, i - 7\, i, -0.0273\, s\, i + 10000 - 10\, s - 10\, i], [i, s], [200, 800], 0.01, 10, 1)$




> #2.
> $F := \mathit{RandNice}([x, y], 3)$

$$F := [(3 - 3\,x - y)\,(2 - x - y), (2 - 2\,x - 3\,y)\,(3 - 2\,x - 2\,y)] \quad \textbf{(41)}$$

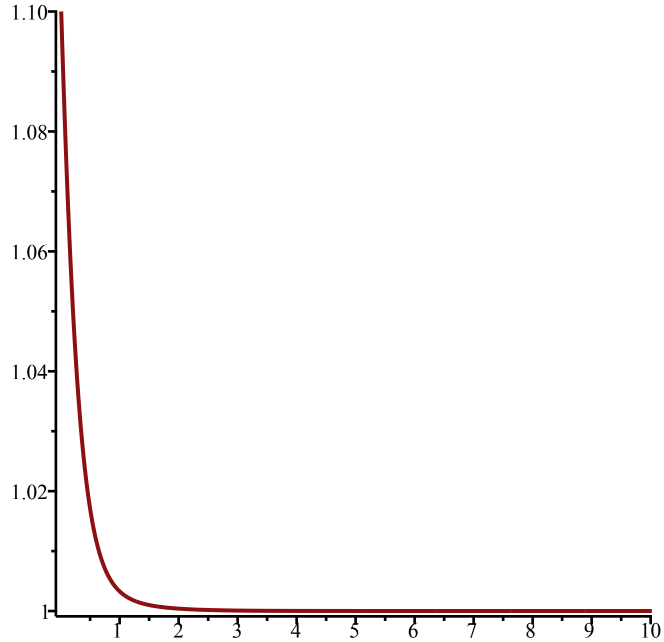
> $\mathit{EquP}(F, [x, y])$

$$\left\{[1, 0], [4, -2], \left[\frac{3}{4}, \frac{3}{4}\right]\right\} \quad \textbf{(42)}$$

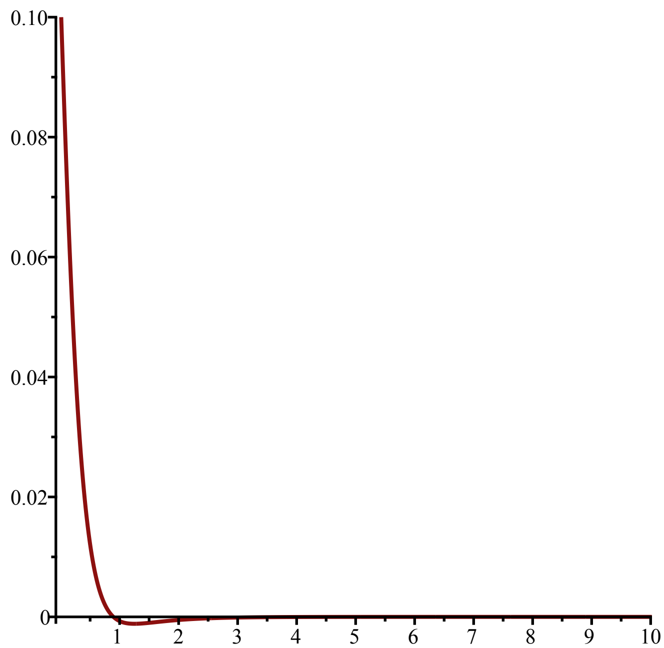
> $\mathit{SEquP}(F, [x, y])$

$$\{[1., 0.]\} \quad \textbf{(43)}$$

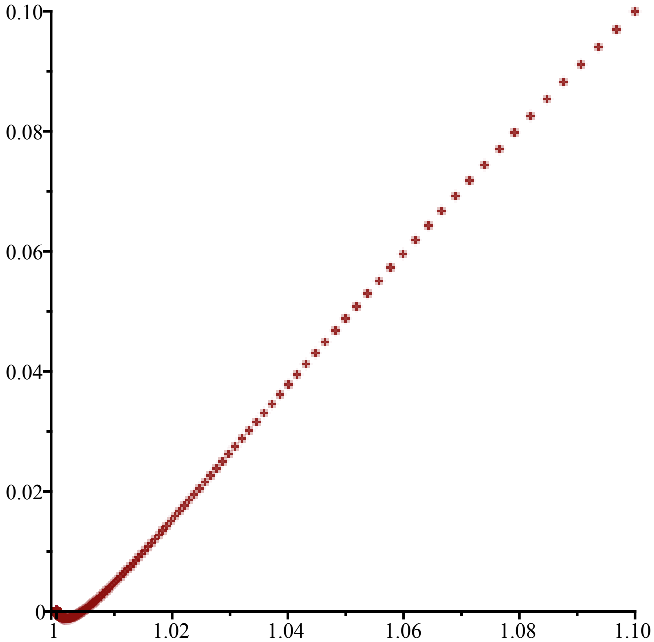
> $\mathit{TimeSeries}(F, [x, y], [1.1, 0.1], 0.01, 10, 1)$




> $TimeSeries([(2-2x-3y)(3-2x-2y), (3-3x-y)(2-x-y)], [y, x], [0.1, 1.1], 0.01, 10, 1)$




> $PhaseDiag(F, [x, y], [1.1, 0.1], 0.01, 10)$




> $F := RandNice([x, y], 3)$

$$F := [(2-3x-2y)(3-2x-y), (1-x-3y)(1-3x-2y)] \quad \textbf{(44)}$$

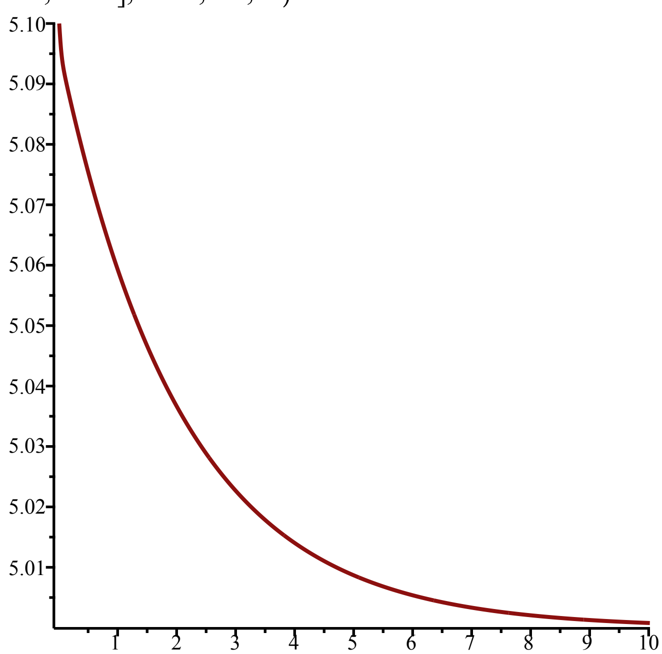
> $EquP(F, [x, y])$

$$\left\{[5, -7], \left[\frac{4}{7}, \frac{1}{7}\right], \left[\frac{8}{5}, -\frac{1}{5}\right]\right\} \quad \textbf{(45)}$$

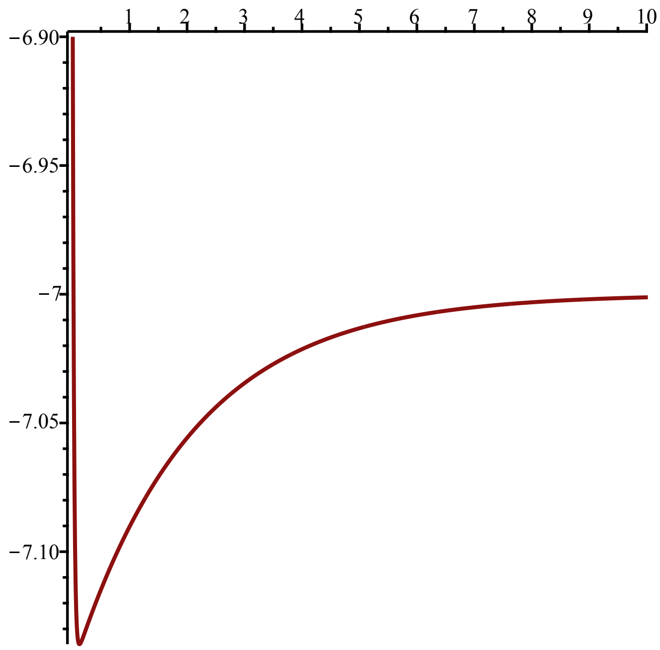
> $SEquP(F, [x, y])$

$$\{[5., -7.]\} \quad \textbf{(46)}$$

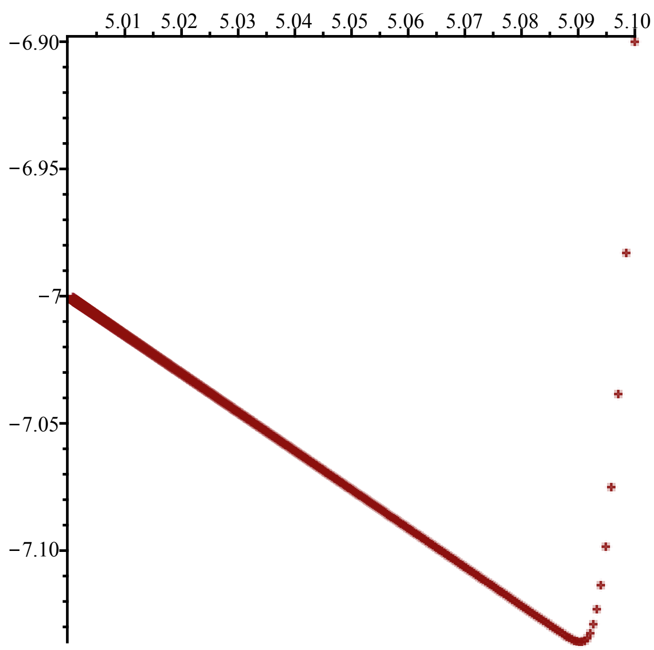
> $TimeSeries(F, [x, y], [5.1, -6.9], 0.01, 10, 1)$




> $TimeSeries([(1-x-3y)(1-3x-2y), (2-3x-2y)(3-2x-y)], [y, x], [-6.9, 5.1], 0.01, 10, 1)$




> $PhaseDiag(F, [x, y], [5.1, -6.9], 0.01, 10)$




> $F := RandNice([x, y], 3)$

$$F := [(3 - x - 2y)(1 - 3x - y), (3 - x - y)(2 - 2x - 3y)] \quad \textbf{(47)}$$

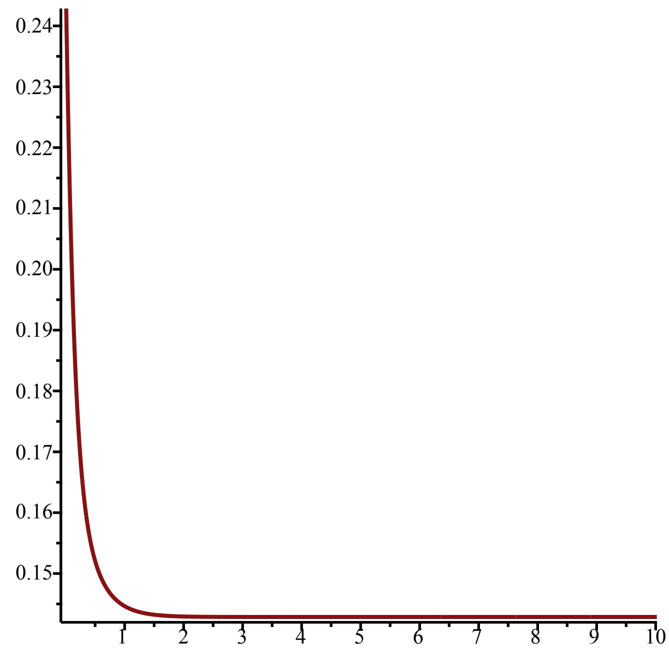
> $EquP(F, [x, y])$

$$\left\{[-5, 4], [-1, 4], [3, 0], \left[\frac{1}{7}, \frac{4}{7}\right]\right\} \quad \textbf{(48)}$$

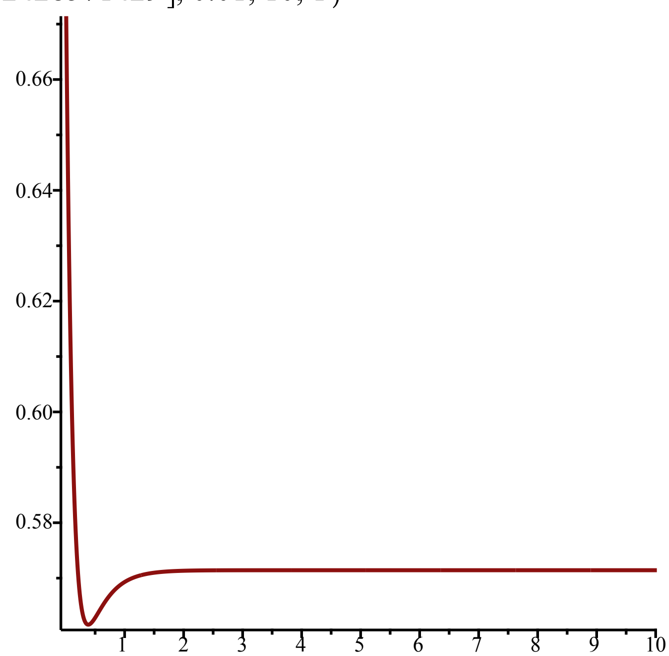
> $SEquP(F, [x, y])$

$$\{[0.1428571429, 0.5714285714]\} \quad \textbf{(49)}$$

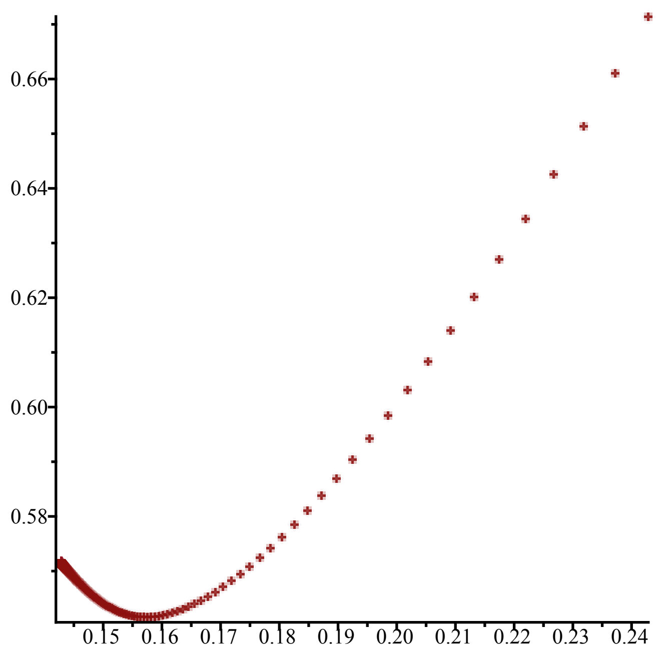
> $TimeSeries(F, [x, y], [0.2428571429, 0.6714285714], 0.01, 10, 1)$




> $TimeSeries([(3-x-y)\ (2-2x-3y), (3-x-2y)\ (1-3x-y)], [y, x],$
> $[0.6714285714, 0.2428571429], 0.01, 10, 1)$




> $PhaseDiag(F, [x, y], [0.2428571429, 0.6714285714], 0.01, 10)$




> *#3.*

> $evalf\left(Orbk\left(4, z, \frac{3+z[2]+z[3]+z[4]}{1+z[1]+z[3]}, [1, 1, 1, 1], 1000, 1010\right)\right)$

> *#Orbk taking a long time to compute*

> $ToSys\left(4, z, \frac{3+z[2]+z[3]+z[4]}{1+z[1]+z[3]}\right)$

$$\left[\frac{3+z_2+z_3+z_4}{1+z_1+z_3}, z_1, z_2, z_3\right], [z_1, z_2, z_3, z_4] \quad \textbf{(50)}$$

> $SFP\left(\left[\frac{3+z_2+z_3+z_4}{1+z_1+z_3}, z_1, z_2, z_3\right], [z_1, z_2, z_3, z_4]\right)$

$$\{[1.822875656, 1.822875656, 1.822875656, 1.822875656]\} \quad \textbf{(51)}$$

>