NOT OKAY TO POST!

Anusha Nagar, Homework 26, 12.05.2021

Assignment: "Do Right Now" Problems, pages 12-21

P14

(i) $x'(t) = 2x(t)\,(1-x(t))(2-x(t))(3-x(t))$

$F(x) = 2x(1-x)(2-x)(3-x) = 0$

Equilibrium solutions: $\{0, 1, 2, 3\}$

(ii) See attached maple code. 1 & 3 are stable because even if we move away from the point (ex. start @ 0.9 or 1.1 or 2.9 or 3.1), we end back up here. 0 & 2 are not stable as if we move a little away, we move towards the stable points 1 or 3. We end up w/ horizontal asymptotes @ 1 or 3 ⇒ meaning they are stable

(iii) $F'(x) = 2(1-x)(2-x)(3-x) - 2x(2-x)(3-x) - 2x(1-x)(3-x) - 2x(1-x)(2-x)$

$F'(0) = 2(1)(2)(3) = 12$ ⇒ not negative ⇒ unstable

$F'(1) = -2(1)(2) = -4$ ⇒ negative ⇒ stable

$F'(2) = -4(-1)(1) = 4$ ⇒ not negative ⇒ unstable

$F'(3) = -6(-2)(-1) = -12$ ⇒ negative ⇒ stable

$\{0, 2\}$ are unstable because $F'(x)$ is not negative. $\{1, 3\}$ are stable because $F'(x)$ is negative.

P15 $x(0) = 1,\ y(0) = 3$

$x(n) = x(n-1)^3 + 2y(n-1),\quad y(n) = x(n-1)^2 + 5y(n-1)^2$

$\{[1, 3], [7, 46], [435, 10629], [82334133, 5650679430]\}$

see maple code for orb results

Orb & hand calculations match up

P16 See Maple code

$$x(n) = \frac{2 + x(n-1) + y(n-1)}{2 + 2x(n-1) + 2y(n-1)},\quad y(n) = \frac{2 + x(n-1) + y(n-1)}{1 + 2x(n-1) + 2y(n-1)}$$

Results between SFP & Orb align

P17 See Maple code

Numerically can see that these are unstable

```
> #NOT okay to post
> #Anusha Nagar, Homework 26, 12.5.2021
>
>
> read "C://Users/an646/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);"

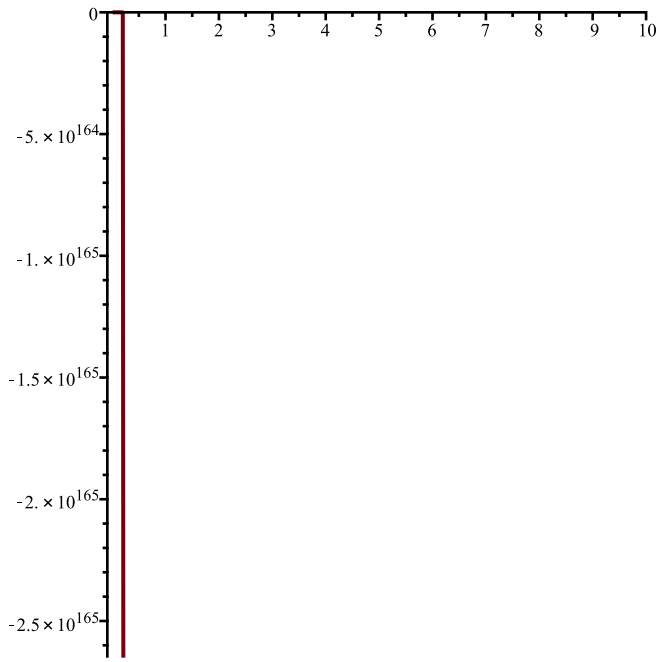
For a list of the supporting functions type: Help1();
For help with any of them type: Help(ProcedureName);

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);

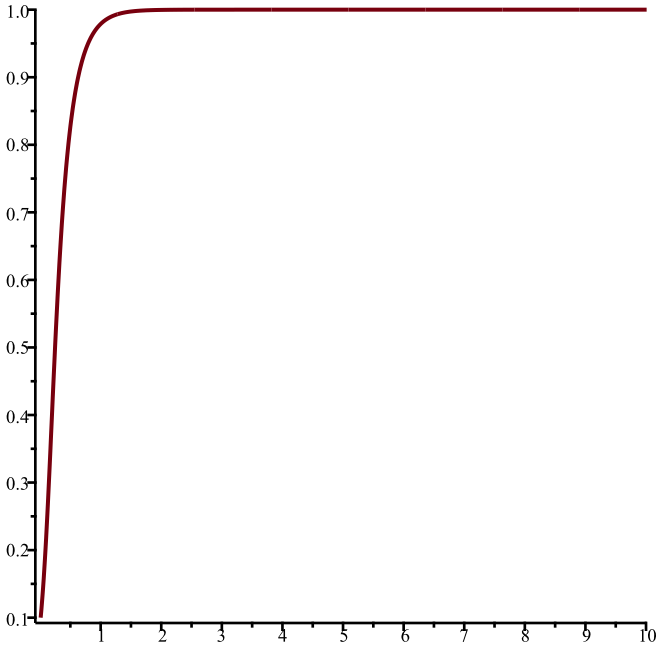
For a list of the functions continuous-time dynamical systems (some famous) type: HelpCDM();
For help with any of them type: Help(ProcedureName);

--- **(1)**

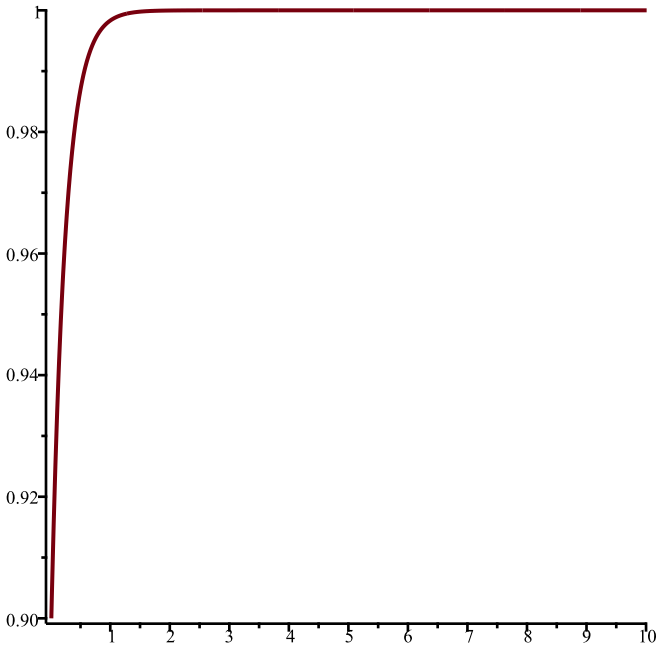
```
>
> #P14
> TimeSeries([2·x·(1 − x)·(2 − x)·(3 − x)], [x], [−0.1], 0.01, 10, 1);
```



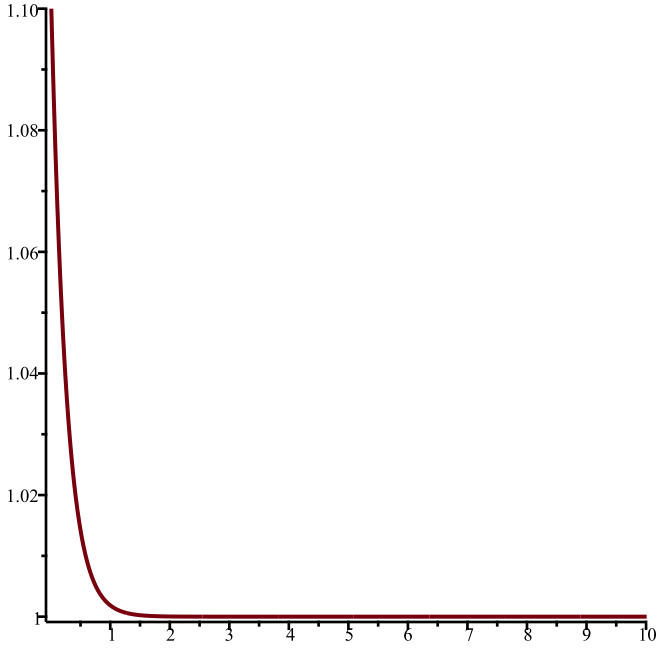

```
> TimeSeries([2·x·(1 − x)·(2 − x)·(3 − x)], [x], [0.1], 0.01, 10, 1);
```




```
> TimeSeries([2·x·(1 − x)·(2 − x)·(3 − x)], [x], [0.9], 0.01, 10, 1);
```

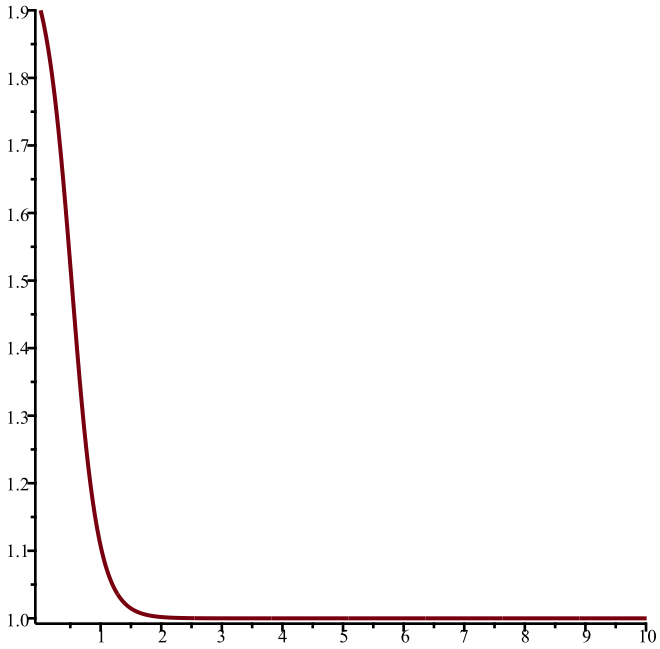


> *TimeSeries*([$2 \cdot x \cdot (1 - x) \cdot (2 - x) \cdot (3 - x)$], [x], [1.1], 0.01, 10, 1);

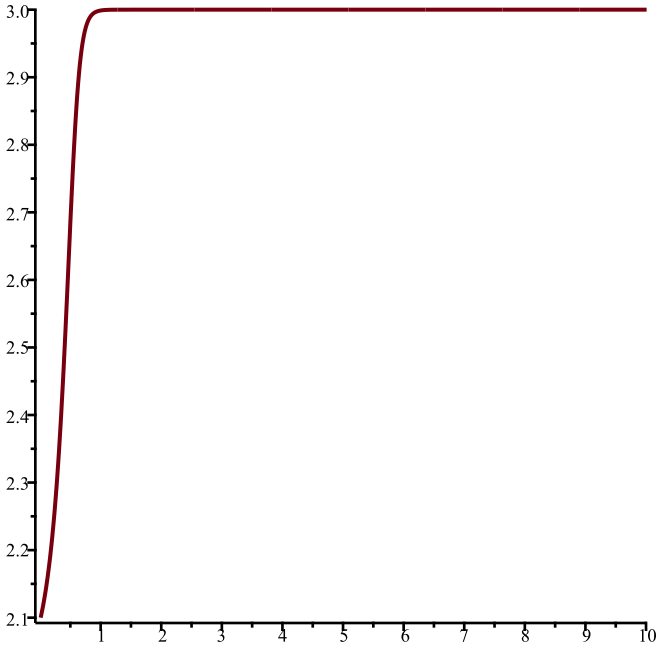


> *#0 seems unstable and 1 seems stable so far*

> *TimeSeries*([$2 \cdot x \cdot (1 - x) \cdot (2 - x) \cdot (3 - x)$], [x], [1.9], 0.01, 10, 1);

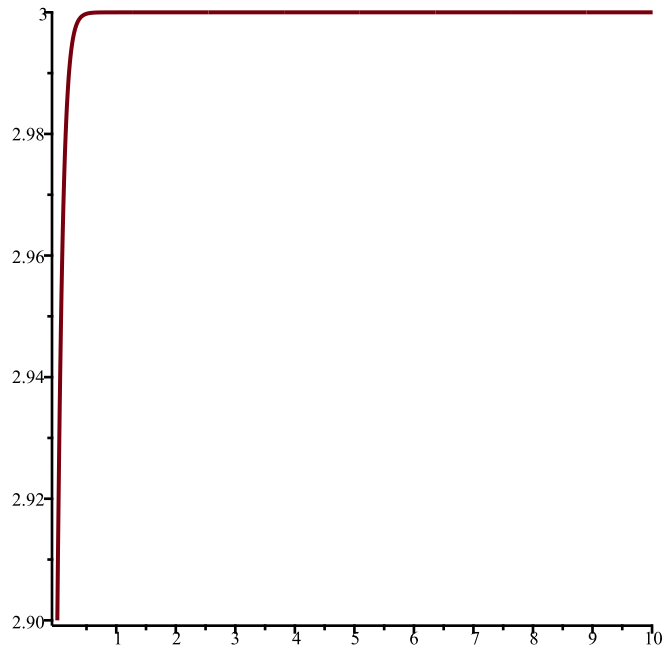


> *TimeSeries*([2·x·(1 − x)·(2 − x)·(3 − x)], [x], [2.1], 0.01, 10, 1);

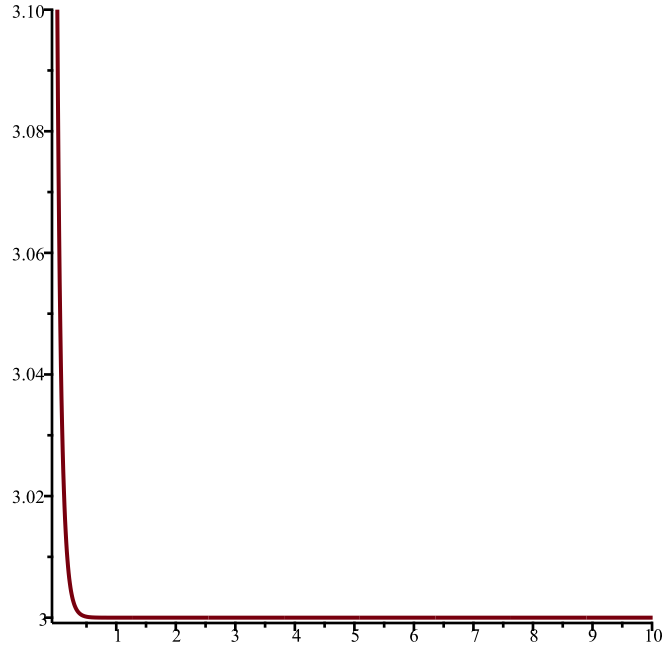


> *#2 seems unstable (goes to 1 or 3)*

> *TimeSeries*([2·x·(1 − x)·(2 − x)·(3 − x)], [x], [2.9], 0.01, 10, 1);



> $TimeSeries([2 \cdot x \cdot (1-x) \cdot (2-x) \cdot (3-x)], [x], [3.1], 0.01, 10, 1);$



> *#3 seems stable*

>

>

> *#P15*

>

> $Orb([x\cdot\cdot 3 + 2 \cdot y, x\cdot\cdot 2 + 5 \cdot y\cdot\cdot 2], [x, y], [1, 3], 0, 3);$

$$[[1, 3], [7, 46], [435, 10629], [82334133, 565067430]] \quad \textbf{(2)}$$

>

> *#P16*

```
> Help(SFP)
```

SFP(F,x): Given a transformation F in the list of variables finds all the STABLE fixed point of the transformation x->F(x), i.e. the set of solutions of the system {x[1]=F[1], ..., x[k]=F[k]}} that are stable. Try:

*SFP([5/2*x*(1-x)],[x]]);*

*SFP([[(1+x+y)/(2+3*x+y), (3+x+2*y)/(5+x+3*y)],[x,y]]);* **(3)**

```
> F := [ (2 + x + y)/(2 + 2·x + 2·y), (2 + x + y)/(1 + 2·x + 2·y) ]
```

$$F := \left[\frac{2 + x + y}{2 + 2\,x + 2\,y}, \frac{2 + x + y}{1 + 2\,x + 2\,y} \right] \quad \textbf{(4)}$$

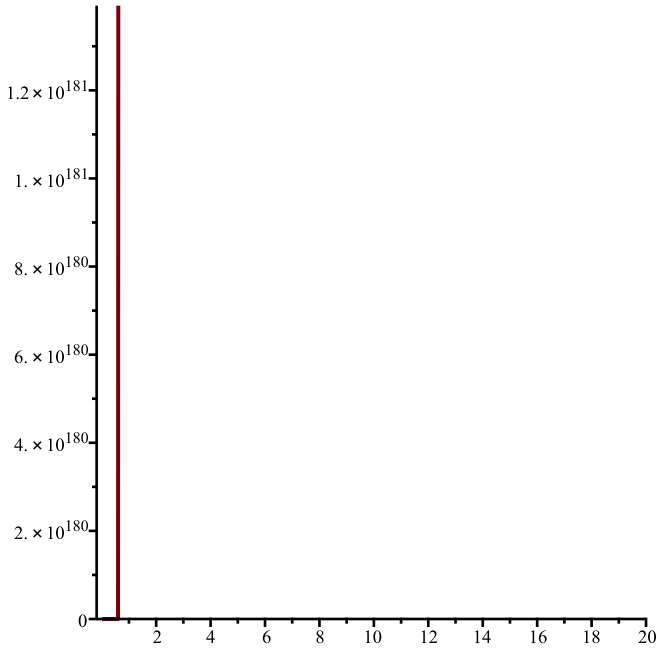
```
> SFP(F, [x, y])
```

$$\{[0.6953496364, 0.8641637014]\} \quad \textbf{(5)}$$

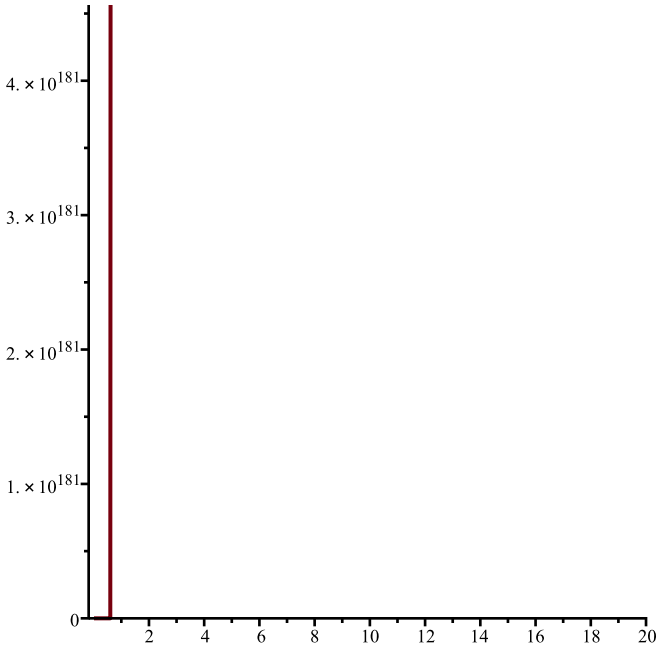
```
> #Matches up with what we were supposed to get
> Orb(F, [x, y], [0.5, 0.4], 1000, 1002);
```

$$[[0.6953496364, 0.8641637013], [0.6953496362, 0.8641637010], [0.6953496365, 0.8641637015]] \quad \textbf{(6)}$$

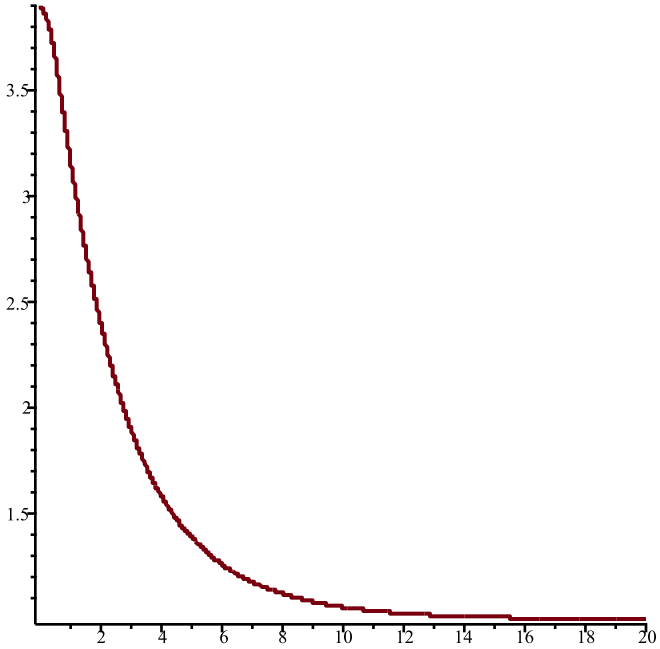
```
> #Aligns with Orb results as well
>
>
> #P17
> #Check whether [-5, 4], and [1,0] are stable
> TimeSeries([(1-2*x-3*y)*(2-2*x-3*y), (3-x-2*y)*(1-x-2*y)], [x, y], [-5.1, 4.1], 0.01, 20, 2);
```



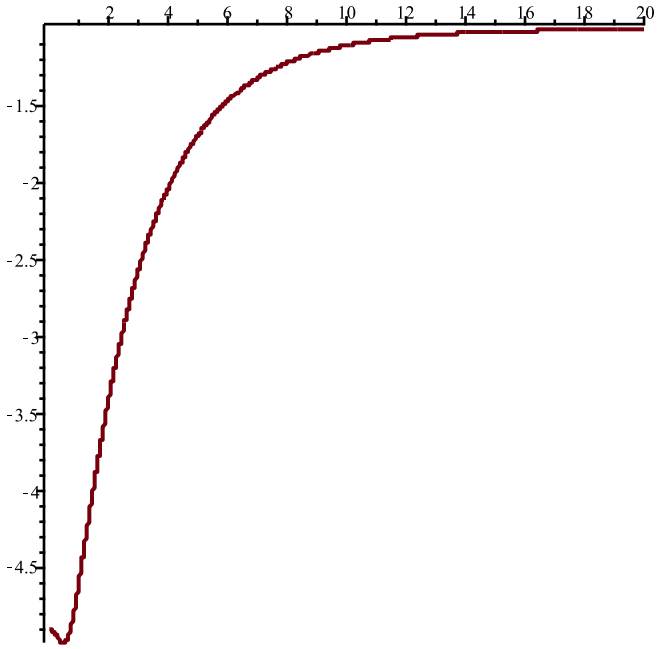

```
> TimeSeries([(1-2*x-3*y)*(2-2*x-3*y), (3-x-2*y)*(1-x-2*y)], [x, y], [-5.1, 4.1], 0.01, 20, 1);
```



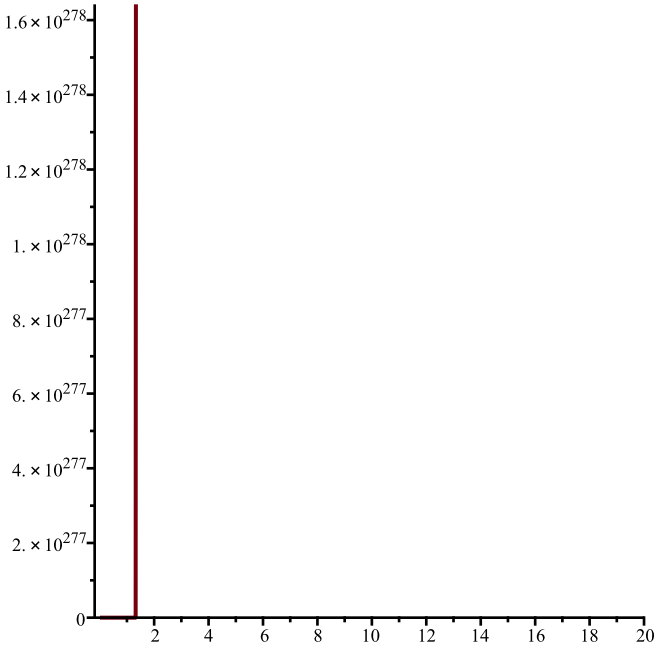

```
> TimeSeries([(1-2*x-3*y)*(2-2*x-3*y), (3-x-2*y)*(1-x-2*y)], [x, y], [-4.9, 3.9],
      0.01, 20, 2);
```



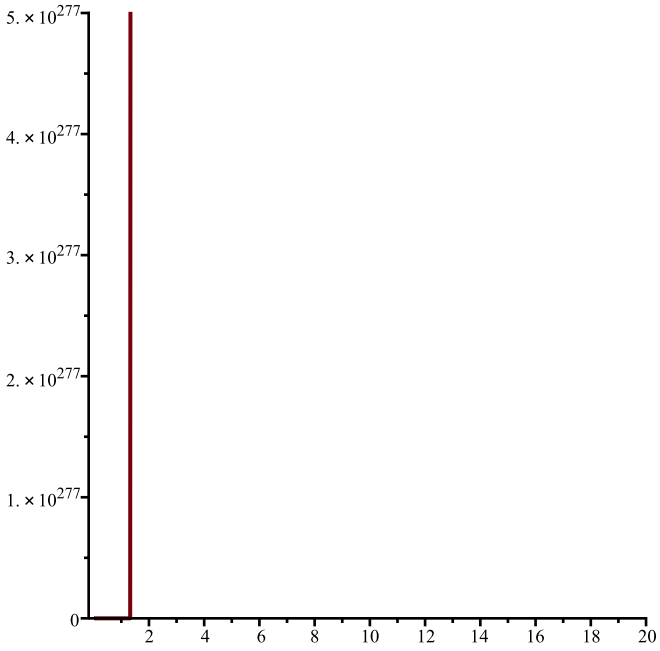

```
> TimeSeries([(1-2*x-3*y)*(2-2*x-3*y), (3-x-2*y)*(1-x-2*y)], [x, y], [-4.9, 3.9],
      0.01, 20, 1);
```



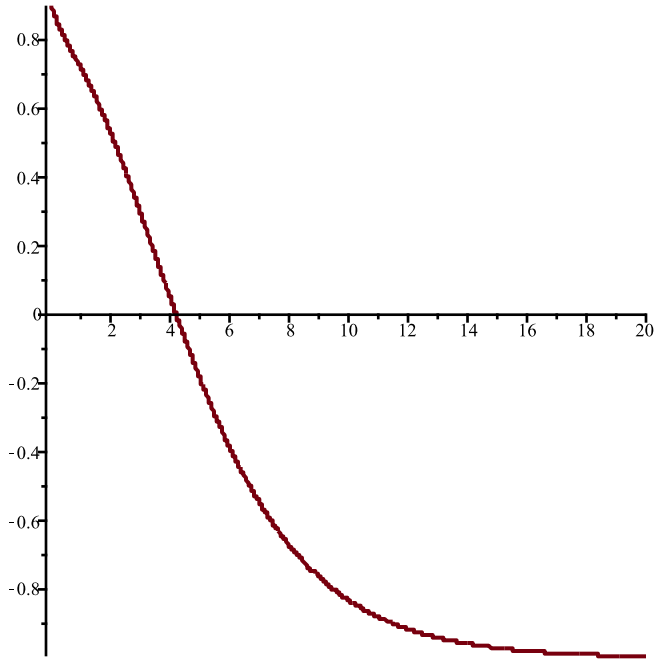

```
> #Horizontal asymptotes go to [-1,1], showing that [-5, 4] is not stable
> TimeSeries([(1 - 2*x - 3*y)*(2 - 2*x - 3*y), (3 - x - 2*y)*(1 - x - 2*y)], [x, y],
      [1.1, 0.1], 0.01, 20, 1);
```




```
> TimeSeries([(1 - 2*x - 3*y)*(2 - 2*x - 3*y), (3 - x - 2*y)*(1 - x - 2*y)], [x, y],
      [1.1, 0.1], 0.01, 20, 2);
```




```
> TimeSeries([(1 - 2*x - 3*y)*(2 - 2*x - 3*y), (3 - x - 2*y)*(1 - x - 2*y)], [x, y],
      [0.9, -0.1], 0.01, 20, 1)
```

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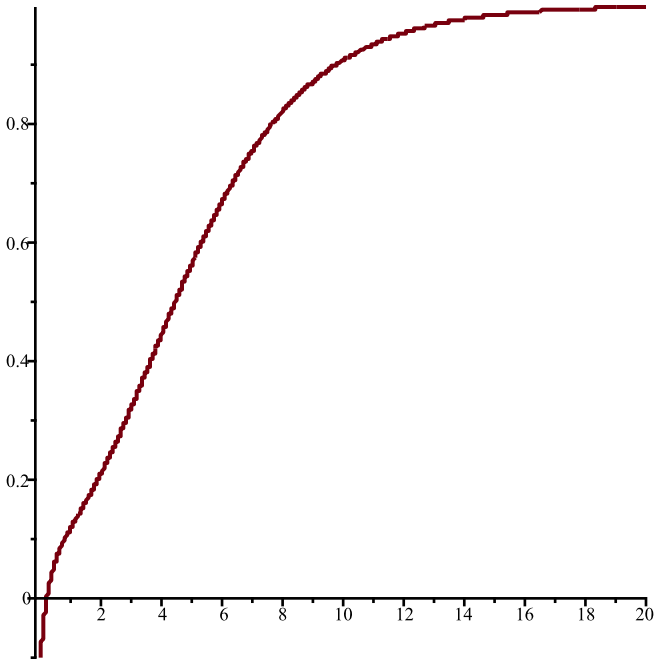
> TimeSeries([(1 - 2*x - 3*y)*(2 - 2*x - 3*y), (3 - x - 2*y)*(1 - x - 2*y)], [x, y],
      [0.9, -0.1], 0.01, 20, 2)
```



> *#[1,0] is also unstable because the horizontal asymptotes are still going to [-1, 1]*

>