

- > #OK to post Homework
 - #Shreya Ghosh, 12-6-2021, Assignment 26
 - > **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 Zeilberger)

*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());*

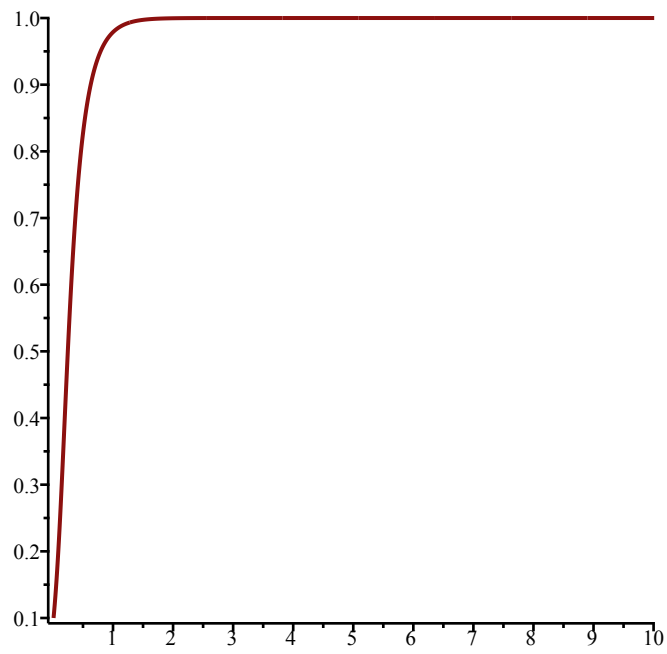
For help with any of them type: Help(ProcedureName);

For a list of the functions continuous-time dynamical systems (some famous) type: HelpCDM());

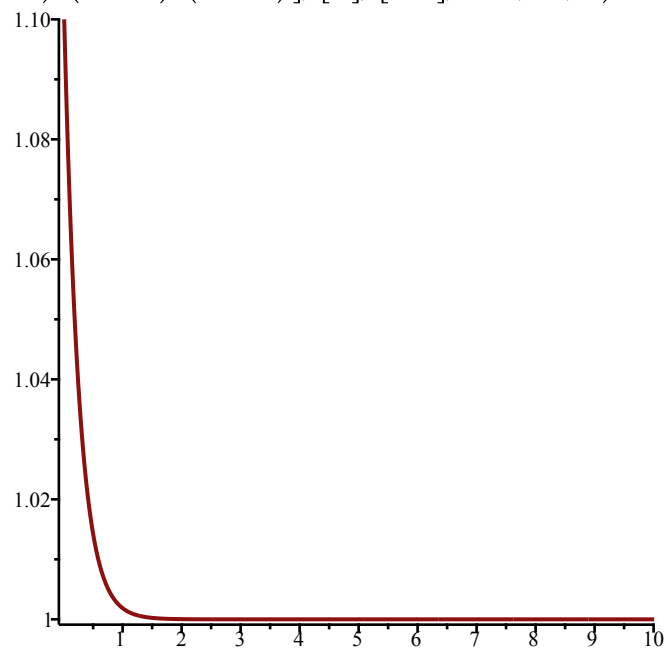
For help with any of them type: Help(ProcedureName);

(1)

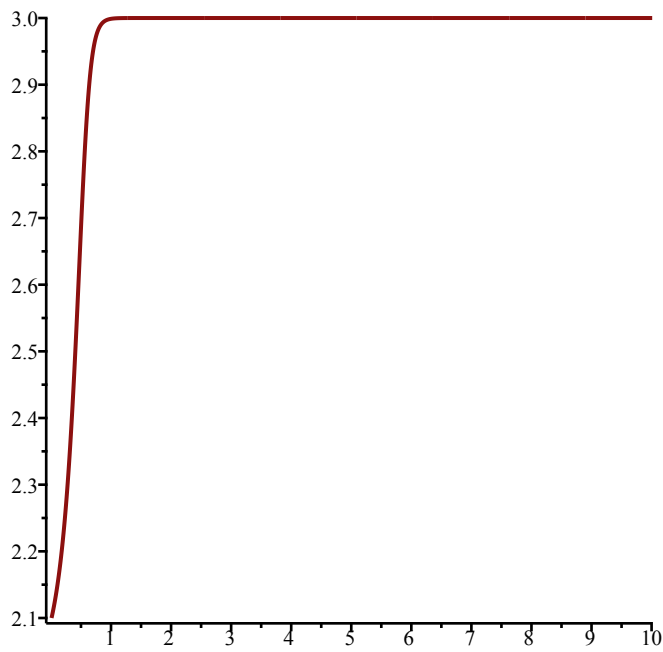
- > #14ii)
- > *TimeSeries* ([$2 \cdot x \cdot (1 - x) \cdot (2 - x) \cdot (3 - x)$], [x], [0.1], 0.01, 10, 1)



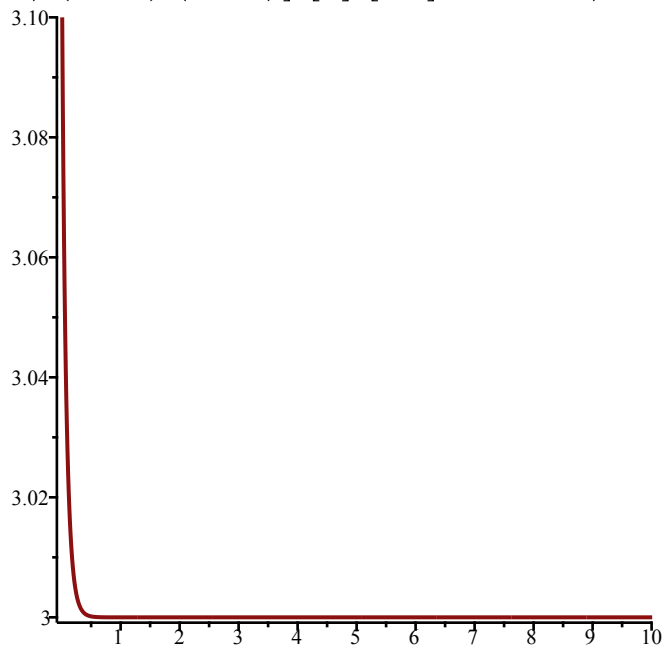
> *TimeSeries* ([$2 \cdot x \cdot (1 - x) \cdot (2 - x) \cdot (3 - x)$], [x], [1.1], 0.01, 10, 1)



> *TimeSeries* ([$2 \cdot x \cdot (1 - x) \cdot (2 - x) \cdot (3 - x)$], [x], [2.1], 0.01, 10, 1)



> `TimeSeries([2·x·(1-x)·(2-x)·(3-x)], [x], [3.1], 0.01, 10, 1)`



> *#There seems to be stability at x=1 and x=3*

>

> #15)

> `Orb([x3 + 2·y, x2 + 5·y], [x, y], [1, 3], 0, 3)`
[[1, 3], [7, 16], [375, 129], [52734633, 141270]]

(2)

>

> #16)

> $F := \left[\frac{2 + x + y}{2 + 2 \cdot x + 2 \cdot y}, \frac{2 + x + y}{1 + 2 \cdot x + 2 \cdot y} \right]$

(3)

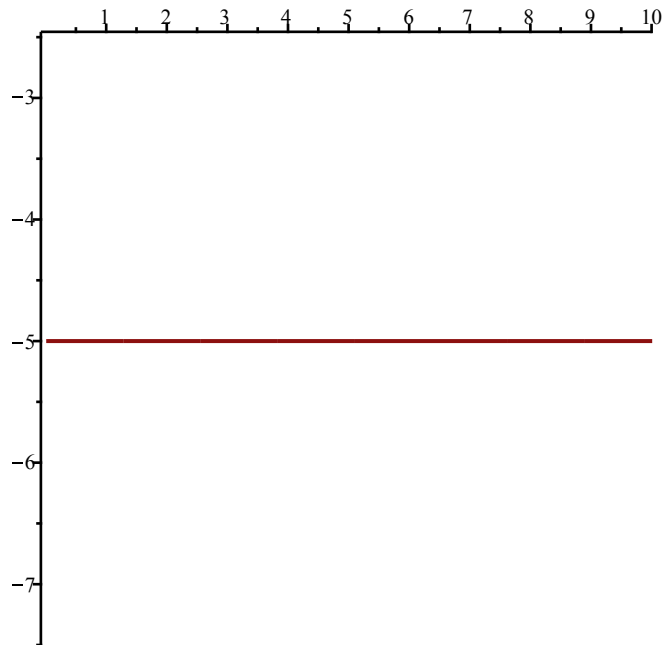
$$F := \left[\frac{2 + x + y}{2 + 2x + 2y}, \frac{2 + x + y}{1 + 2x + 2y} \right] \quad (3)$$

> *SFP*(*F*, [*x*, *y*])
 {[0.6953496364, 0.8641637014]} (4)

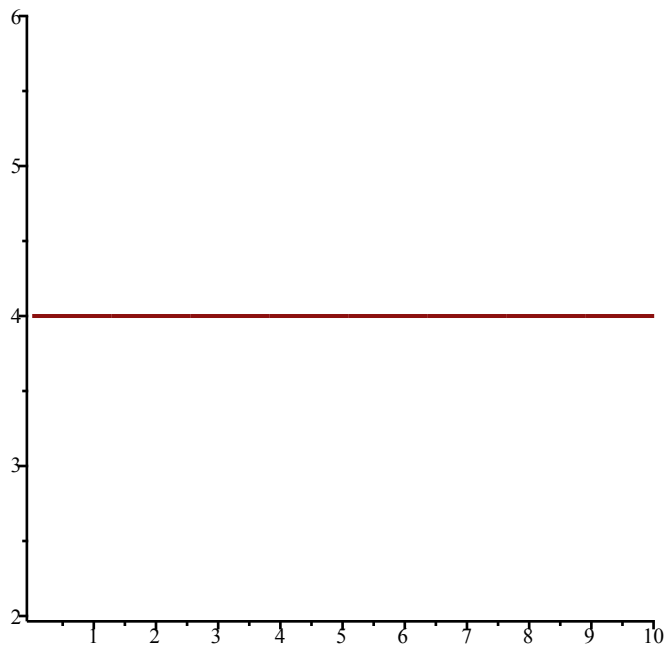
> *Orb*(*F*, [*x*, *y*], [0.5, 0.4], 1000, 1000)[1]
 [0.6953496364, 0.8641637013] (5)

>
 #17)

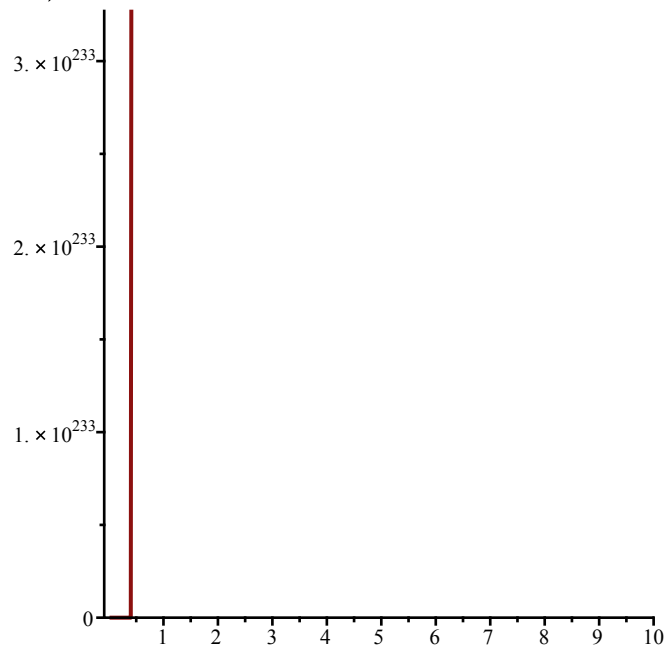
> *TimeSeries*([(1 - 2·*x* - 3·*y*)·(2 - 2·*x* - 3·*y*), (3 - *x* - 2·*y*)·(1 - *x* - 2·*y*)], [*x*, *y*], [-5, 4], 0.01, 10, 1)



> *TimeSeries*([(1 - 2·*x* - 3·*y*)·(2 - 2·*x* - 3·*y*), (3 - *x* - 2·*y*)·(1 - *x* - 2·*y*)], [*x*, *y*], [-5, 4], 0.01, 10, 2)

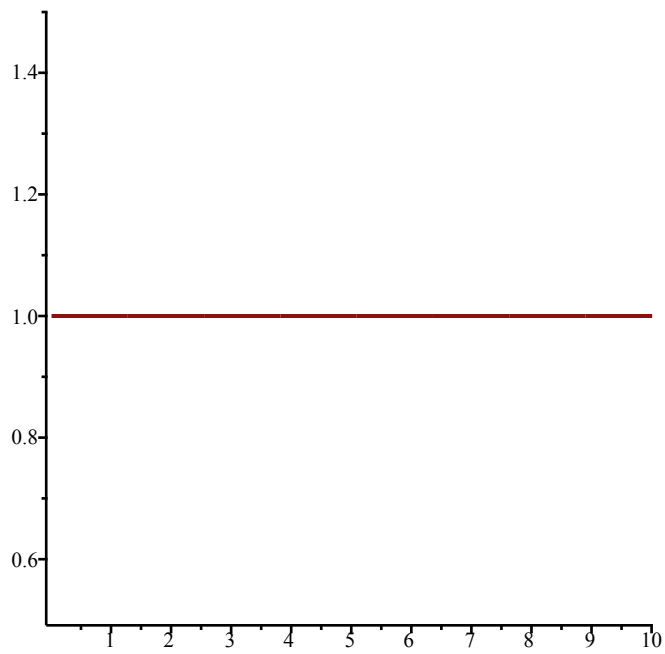


> *TimeSeries* ([(1 - 2 · x - 3 · y) · (2 - 2 · x - 3 · y), (3 - x - 2 · y) · (1 - x - 2 · y)], [x, y], [-4.9, 4.1], 0.01, 10, 1)

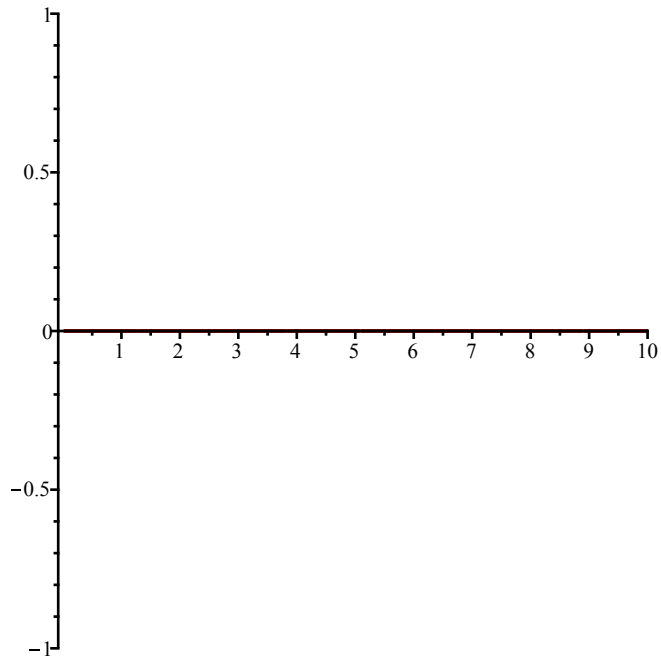


> #[-5,4] is unstable

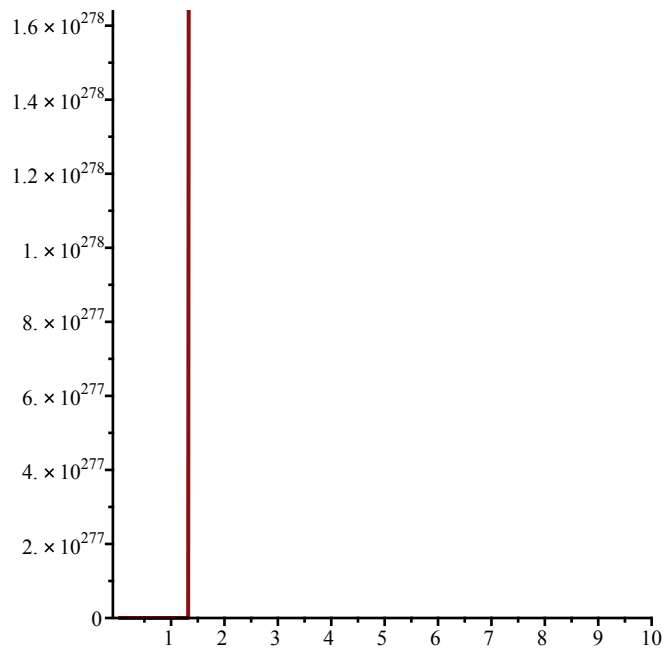
> *TimeSeries* ([(1 - 2 · x - 3 · y) · (2 - 2 · x - 3 · y), (3 - x - 2 · y) · (1 - x - 2 · y)], [x, y], [1, 0], 0.01, 10, 1)



> *TimeSeries*([(1 - 2 · x - 3 · y) · (2 - 2 · x - 3 · y), (3 - x - 2 · y) · (1 - x - 2 · y)], [x, y], [1, 0], 0.01, 10, 2)



> *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, 10, 1)



$\Rightarrow \#[1,0]$ is unstable

HW 26

14. i) $x'(t) = 2x(t)(1-x(t))(2-x(t))(3-x(t))$

$$f(x) = 2x(1-x)(2-x)(3-x)$$

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

$$x = 0, x = 1, x = 2, x = 3$$

ii) In Maple

iii) $f(x) = (2x - 2x^2)(2-x)(3-x)$

$$= (4x - 2x^2 - 4x^2 + 2x^3)(3-x)$$

$$= 12x - 4x^2 - 18x^2 + 6x^3 + 6x^3 - 2x^4$$

$$f(x) = 12x - 22x^2 + 12x^3 - 2x^4$$

$$f'(x) = 12 - 44x + 36x^2 - 8x^3$$

$$f'(0) = 12 \Rightarrow \text{unstable} \quad (12 > 0)$$

$$f'(1) = -4 \Rightarrow \text{stable} \quad (-4 < 0)$$

$$f'(2) = 4 \Rightarrow \text{unstable} \quad (4 > 0)$$

$$f'(3) = -12 \Rightarrow \text{stable} \quad (-12 < 0)$$

15. $x(n) = x(n-1)^3 + 2y(n-1)$, $y(n) = x(n-1)^2 + 5y(n-1)$, $x(0) = 1$, $y(0) = 3$

$$x(1) = x(0)^3 + 2y(0) = 1^3 + 2(3) = 7 \quad y(1) = x(0)^2 + 5y(0) = 1^2 + 5(3) = 16$$

$$x(2) = x(1)^3 + 2y(1) = 7^3 + 2(16) = 375 \quad y(2) = x(1)^2 + 5y(1) = 7^2 + 5(16) = 129$$

$$x(3) = x(2)^3 + 2y(2) = 375^3 + 2(129) = 52734633 \quad y(3) = x(2)^2 + 5y(2) = 141270$$

$$[[1, 3], [7, 16], [375, 129], [52734633, 141270]]$$

16. In Maple

17. In Maple