

**MMM - Problem Set 2**  
 IES FSV UK  
 Winter Semester 2021/2022

Notes:

Homework is due to **18<sup>th</sup> November 13:00**, submit your solution via Moodle. You can also bring the hand-written part to the lecture.

- 1) Find complete solution (without any software) of these difference equations and discuss stability of equilibrium:

a)  $y_{n+1} + 0.8y_n = 5$

b)  $y_{n+2} - 4y_{n+1} + 8y_n = -5$

2) Consider the cobweb model from the lecture

- Find out the first letter of your surname (English alphabet)
- Find appropriate values of coefficients  $a, b, c, d$
- *Example: Stráský – surname: S -->  $a = 4; b = 1; c = 4; d = 0.4$ ;*

surname	A	B	C	D	E	F	G	H	I	J	K	L	M
<b>a</b>	1	2	3	4	5	1	2	3	4	5	1	2	3
<b>b</b>	0.2	0.3	0.4	0.5	0.8	1	1.2	0.2	0.3	0.4	0.5	0.8	1
<b>c</b>	1	1	1	1	1	2	2	2	2	2	3	3	3
<b>d</b>	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.5	0.3	0.3	0.5	0.5
Surname	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
<b>A</b>	4	5	1	2	3	4	5	1	2	3	4	5	1
<b>B</b>	0.2	0.3	0.4	0.5	0.8	1	1.2	0.2	0.3	0.4	0.5	0.8	1
<b>C</b>	3	3	4	4	4	4	4	5	5	5	5	5	6
<b>D</b>	1	1	1	1	1	0.4	1	1.2	1.2	1.2	1.2	1.2	1.2

- **Write down your personal equation. Find equilibrium.**
- Solve your personal difference equation quantitatively. (Find sequence  $p_t$ .)
- Draw **phase diagram** (of the difference equation): **hand-written and Python.**

4) Consider following systems of differential equations.

$$\dot{x}(t) = a \cdot x(t) + b \cdot y(t) + e$$

$$\dot{y}(t) = c \cdot x(t) + d \cdot y(t) + f$$

- Find out the first letter of your first name and the first letter of your surname (English alphabet)
- Find appropriate values of coefficients  $a, b, c, d, e, f$

Example: Josef Stráský – surname: **S**, first name: **J**; -->  $a = -3; b = 3; c = -1; d = 1; e = -3; f = 2$

surname	first name	A	B	C	D	E	F	G	H	I	J	K	L	M
<b>A</b>	<b>d</b>	-3	-2	-1	1	2	3	-3	-2	-1	1	2	3	-3
<b>B</b>	<b>e</b>	2	2	2	-2	-2	-2	3	3	3	-3	-3	-3	1
<b>C</b>	<b>f</b>	1	1	1	1	1	1	2	2	2	2	2	2	3
surname	first name	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
<b>A</b>	<b>d</b>	-2	-1	1	2	3	-3	-2	-1	1	2	3	-3	-2
<b>B</b>	<b>e</b>	1	1	-1	-1	-1	3	3	3	3	3	3	1	1
<b>C</b>	<b>f</b>	3	3	3	3	3	-1	-1	-1	-1	-1	-1	-2	-2

Consider your personal system of differential equations and without any software:

- Find **fixed point, equilibrium lines**, **draw phase diagram by hand** and explain in detail how you got it.
- **Draw phase in Python including arrows.**
- Find **eigenvalues** of the system. Classify fixed point.
- *If you get “strange” system (for instance, parallel equilibrium lines do not intersect), rename yourself (for the purpose of this problem set).*