**Mathematical methods in Macroeconomics - Problem Set 1**

IES FSV UK

Notes:

Homework is due to **23rd November, 13:45.** You can bring had-written part to the lecture (or upload pdf to Moodle), upload ONE Python notebook via Moodle.

1. Consider equation , where *y(t)* is a function and *a,b,c,d* are coefficients

* 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*
* *Example: Josef Stráský - first name:* ***J****; surname:* ***S*** --> *a* = 3; *b* = -1; *c* = -4; *d* = 2;

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| first name | surname | A | B | C | D | E | F | G | H | I | J | K | L | M |
| **a** | **c** | -2 | -1 | 1 | 2 | 3 | -2 | -1 | 1 | 2 | 3 | -2 | -1 | 1 |
| **b** | **d** | -2 | -2 | -2 | -2 | -2 | -1 | -1 | -1 | -1 | -1 | 1 | 1 | 4 |
| first name | surname | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| **a** | **c** | 2 | 3 | -2 | -1 | 1 | -4 | 3 | -2 | -1 | 1 | 2 | 3 | 4 |
| **b** | **d** | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |

* Find equilibria of your personalized differential equation.
* Draw direction field (by hand is fine) and discuss stability of equilibria.
* Draw phase diagram (either by hand or using Python) and discuss stability of equilibria using phase diagram.

*Note: if your coefficients give especially strange equation and results then choose another combination.*

1. Find general solution of following equations (by manual calculation – no software needed), then use initial conditions and find specific solution for given initial conditions.
2. *y(0) = 0; y(1) = e;*
3. *y(0) = 4; y´(0) = 4;*

BONUS: In exercise (b) find another **initial condition** such that the specific solution is converging, but not constant.

3) Python functions

Prepare a function **optimize()** with the following parameters:

* **start** - single float, the start of the interval
* **end** - single float, end of the interval
* **step** - single float, the incremental step of the sequence
* **fun** - function to be optimized

Your function should construct a sequence of numbers from **start** to **end** with the increment of size **step**, then find the function’s maximum value and where it was found, in other words:

**x** and **fun(x)** s. t. **fun(x)** = max **fun(x)** for **x ∊** **{**start, start+step, start+2\*step, … , stop**}**

E.g.

***parameters:*** start = -1, stop = 1, step = 0.1, fun = cos

***output:*** (0, 1) -  maximum is at position 0 with value of 1

*Note: don’t use the build-in / package functions* ***max()*** *and* ***argmax()***

4) Python data wrangling

Prepare a single python notebook with following steps

* Read the data from oecd\_covid\_cases.csv
* Choose data for one country
* Prepare your data
  + Summarize the variable values, prepare nice plots
  + Comment your results extensively– what can you observe in your data, what are the consequences – show that you understand the dataset.
  + Utilize meaningful data transformations
    - Think about what are the model expectation?
* Malthusian population growth model
  + Describe the theoretical framework (how it should work)
  + Fit the model to the data
  + Comment on the model fit – is the model meeting assumptions, what do the residuals look like, what are the problems (and where)?
* Prepare the interactive plot
  + For a selected data range:
  + Fit the model to the selection and print against the actual values
  + Present the formula (with parameters), R0 and R^2 values

*Note 1: Please comment all your steps extensively, using both code comments (# comment) and markdown cells, it helps us understand that you understand what you are doing.*

*Note 2: Do not blindly copy code from seminar. This exercise serves to make you get used to work in python, not in the art of copy-pasting. Large chunks of code directly from seminar will yield negative points (except for the update function for interactive plot).*