Programming assignment No. 1

General hints and rules:

- Although the submission of this assignment is not mandatory, you are advised and encouraged to submit your solution, as you can earn bonus points (to be added to your final exam score).
- The solutions can be submitted until Monday, May 13th, 2024, 11.30 am to tilmann.haertl@uni-konstanz.de. Late submissions will not be considered.
- We recommend to use the programming language Python* for the following programming problems. The solutions should be handed in form of a code file. Answers to questions requiring text (e.g. for interpretations) should be given as comments in the code.
- Name your code file with the assignment number and your student number (not your name). Example: For programming assignment 1 (PA1) and if your student number is 007007, call the file PA1_007007.py
- Policy with regard to academic dishonesty: Students who wish to work together on assignment material may do so. Please indicate the student numbers of all fellow students that have worked in your group. **Each student must submit her or his individual code/solution file**.
- Write your code general enough such that it can be easily reused. Document your code.
- Avoid loops as much as possible and use matrix language techniques whenever possible.

Tasks:

1) Download the time series for quarterly seasonally adjusted German real GDP from the FRED database of the St. Louis Fed and save it as a *.csv file (`https://fred.stlouisfed.org/series/CLVMNACSCAB1GQDE`). Load the data into Python and provide a time series plot of the raw series.

2) Write a function that performs some standard transformations (i.e. log, first differences of logs, first differences, seasonal differences, seasonal differences of logs) on a user-specified time series. Using the GDP data from 1), create plots for the quarterly and yearly growth rates of real GDP.

3) Write a function that computes for any time series input the sample autocorrelations up to some user-specified lag h. Program a plot of the sample autocorrelations for the quarterly and the yearly growth rate of German real GDP. Compare the plots and explain.

4) Create a function to implement the Hodrick-Prescott(HP)-filter for the log of real German GDP (*Hint: Results from problem set 1 may be useful*). Provide a plot of the cyclical component from the HP-filter.

*A download link for Python can be found on ILIAS. There is also a link to a Python documentation.

5) Create a function that generates artificial data of an MA(1) process using the data generating process

$$y_t = \varepsilon_t + \theta \varepsilon_{t-1} \tag{1}$$

for $t = 2, \ldots, T$, where ε_t is a normally distributed white noise process with mean 0 and variance $\sigma^2 = 1$. The function should take as an input the parameter θ, the time series length T and should return a vector of observations on y_t.

Generate two time series for $\theta = 0.3$ and $\theta = -0.5$ with $T = 500$ observations according to equation (1) and compute the sample autocorrelation and sample partial autocorrelation functions for both time series. Compare your results with the expected patterns of the theoretical ACFs and PACFs of the processes.