Unassessed Coursework 1

DUE @ 4 pm on Wednesday, 26/02/2025, Week 4

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Key Learning: Coursework about Python basics, solving equations with Python, and Pandas basics

1 COURSEWORK INSTRUCTIONS:

How to answer the questions?

- For each question write a Python script using the naming convention: `question1.py` for question 1 and so forth. **Make sure that your files run without errors!**
- Make short comments in your Python script that explain what you are doing: e.g. `while a > tol # while loop ends when 'a' smaller` etc.
- **Each question and subquestion asks you to write code!** Add all code pieces you have created to the Python script that corresponds to the question you are answering.
- Write a short report (**up to about 6 pages A4 including pictures, code snippets, and code output**) alongside the Python scripts in which you briefly answer the questions. In this document, you should include:
  - the output of your code (e.g. as a screenshot of the output printed in the iPython console of Spyder or by using in Latex the 'lstlisting'-environment) that is useful and relevant to answer the corresponding question,
  - the figures you have created,
  - short explanations about what Python functions and packages you use to address the question: e.g. 'I used numpy to create a 3x3 matrix and then I used the build-in functions ... to do this or that!
  - Optional: you can also add code snippets you would like to discuss in order to explain your approach to write your code (this might be useful in case you couldn't get your code properly running)

How to submit your answers?

The submission must happen via the corresponding folder that you find in the Assessment tap on 'SurreyLearn'. The submission must include:

- 1 report (pdf) including code output, explanations, and figures (see explanation above).
- 6 **(executable)** Python scripts named 'question1.py' for Q1 and 'question2.py' for Q2 and so forth (you can use the #%% command in Spyder to separate your code into cells).

2 QUESTIONS

Question 1: Defining matrices and performing operations

1. Define a four by four matrix A and find its transpose, trace, determinant and inverse.
2. For the cyclic matrix

$$C = \begin{pmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix}$$

find the smallest value of n such that $C^n = I$, where I is the 3 by 3 identity matrix.

Question 2: Solving Matrix-vector systems

Find the solution of the following systems of linear equations. Check your answer for each by evaluating $A\mathbf{x} - \mathbf{b}$, where $\mathbf{x}$ is the unknowns and $\mathbf{b}$ is the right hand side.

1. System of equations:

$$4x - 5y + 2z = 7$$
$$8x + 5y - 4z = 10$$
$$3x - 2y + z = 5$$

Question 3: Solving iteration problems

1. For the iteration

$$x_{n+1} = 4x_n(1 - x_n), \quad x_0 = 0.1,$$

how many iterations are required for convergence with `tol` $= 10^{-2}, 10^{-3}, 10^{-4}$ and 10^{-5}? Do you think that this iteration will converge as $n \to \infty$? (To help understand this iteration, plot the first 100 iterates of the map by plotting the points (n, x_n), $n = 0, \ldots, 100$.))

Question 4: Solving equations

1. Show that the function $f(x) = \sin^2(x) - \sin(2x) - 1$ changes sign between $x = -1$ and $x = 0$. Find a solution of the equation $f(x) = 0$ between $x = -1$ and $x = 0$ (Hint: use the .brentq() function of scipy.optimize)

Question 5:

Explore the training dataset!

1. Calculate the standard correlation coefficient matrix of the housing data set.
2. Assume your quantity of interest is the `median_income`. Provide the correlation coefficient with respect to this attribute and sort them in ascending order.

Question 6:

In the lecture notes, we defined the following attribute combinations:

```
housing["rooms_per_household"] = housing["total_rooms"]/housing["households"]
housing["bedrooms_per_room"] = housing["total_bedrooms"]/housing["total_rooms"]
housing["population_per_household"] = housing["population"]/housing["households"]
```

1. Plot the scatter matrix using the following attributes:
   `rooms_per_household`, `bedrooms_per_room`,
   `population_per_household`, `median_income`
   `median_house_value`.
   Plot also a scatter plot for the attributes `median_house_value` over `rooms_per_household`.
2. As comparison, print out the standard correlation coefficients relative to `median_house_value` (sort them as you like). Discuss: (i) is the negative correlation of `bedrooms_per_room` to `median_house_value` visible in the scatter matrix; and (ii) do we see a positive correlation of `median_house_value` and `rooms_per_household`? What problem could impact our capability to infer from the picture such correlation?