Problem Set 1: Fundamentals of Programming

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Exercise 1. Lists and indexing (20 points). Given the list

```
l1 = [2, 5, 6, 4, 5 ,9, 3, 2, 2]
```

a. Extract and print the first 3 elements of the list ([2,5,6]). Extract and print the last 2 elements. Remember that in Python the first element is indexed by 0 and so on.

b. Replace the 3rd element in the list for number 4. Replace the 7th element in the list for number 7. Print the new list.

c. Replace the number 9 for 8 using *list.index()*.

d. Replace number 9 for number 8 using *NumPy argmax*.

Exercise 2. Arrays and matrix operations (20 points). Given the list from the previous exercise

```
l1 = [2, 5, 6, 4, 5 ,9, 3, 2, 2]
```

a. Convert the list into a 3×3 matrix (2-d array). The outcome should be the matrix
$$A = \begin{bmatrix} 2 & 5 & 6 \\ 4 & 5 & 9 \\ 3 & 2 & 2 \end{bmatrix}$$

b. Find the maximum of the matrix A. Find the index of the maximum.

c. Transpose the matrix$A$.

d. Squared the matrix (i.e. AA'). Raise to the power all the elements in matrix A.

e. Compute the eigenvalues of matrix A.

f. Multiply matrix A by a matrix of zeros (f1), by the identity matrix (f2),and by a matrix of ones (f3).

g. Create an even grid from 0 to 9 with 9 elements. Convert the grid into a 3x3 matrix called B. Multiply matrix A by matrix B.

Exercise 3. for loop (10 points). Write a code to iterate the first 10 numbers and in each iteration, print the sum of the current and previous number.

Exercise 4. Conditional statements and operations (20 points). Given the list from exercise 1

```
l1 = [2, 5, 6, 4, 5 ,9, 3, 2, 2]
```

a. Create a new list that contains only the elements in list l1 that are smaller than 5.

b. Create a new list that contains only the elements in list l1 bigger or equal than 3 and smaller than 7.

c. Given matrix A from exercise 2, write a code that checks whether 5 belongs to A.

d. Create a new matrix B that is equal to matrix A but where numbers below 4 are replaced by zeroz.

e. Write a code that counts the number of zeros in matrix B.

Exercise 5. CES production function and comparative statistics (30 points). The Constant Elasticity of Substitution production function is a commonly used production function that takes the following form

$$Y = F(K, L) = A\left(\alpha K^{\frac{\sigma-1}{\sigma}} + (1-\alpha)L^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

Where K and L are the capital and labor factors. A represents the total factor productivity, α is the capital's share, and σ is the constant elasticity of substitution between the two production factors. A, α, σ are strictly positive. It can be shown (using L'Hôpital's rule) that when $\sigma \to 1$ the CES production function boils down to a Cobb-Douglas production function

$$Y = F(K, L) = AK^{\alpha}L^{1-\alpha}$$

a. Create a function that given the arguments K, L, A, α, σ, returns output Y. You can have inside the function an if statement for when $\sigma = 1$ the output Y comes from Cobb-Douglass production function, else from the CES function.

   From now on work with the following parameterization: $A = 1.5, \alpha = 0.33$.

b. **Cobb-Douglass production function**. First consider the Cobb-Douglass case with $\sigma = 1$. Compute output Y for an even-spaced grid of K, $G_k = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$, and a fixed $L = 3$. Plot the resuls—make an x-y plot with the grid of K in the x and output Y in the axis y.

c. From b recompute output Y for the 3 cases $\alpha = 0.25, \alpha = 0.5, \alpha = 0.75$. Make an $x - y$ plot with the 3 production functions in the same graph.

d. **CES production function.** Redo exercise b but for $\sigma = 0.33$.

e. Keeping $\alpha = 0.33$, plot output Y vs the grid of capital for the cases of $\sigma = 0.25, \sigma = 0.5, \sigma = 1, \sigma = 2, \sigma = 4$.

f. How does output Y changes along K for the different σ specifications? Can you provide the economic interpretation? **Hint:** σ captures the relative degree of substitutability/complementarity between the two inputs K, L.