Technical University of Denmark

Course name	Introduction to programming and data processing
Course number	02631, 02692, 02694, 02633
Aids allowed	All Aids
Exam duration	2 hours
Weighting	All exercises have equal weight

Contents

Submission details

You must hand in your solution electronically:

1. You can upload your solutions individually on CodeJudge (`dtu.codejudge.net/prog-f16/assignment`) under *Afleveringer/Exam*. When you hand in a solution on CodeJudge, the test example given in the assignment description will be run on your solution. If your solution passes this single test, it will appear as *Submitted*. This means that your solution passes on this single test example. You can upload to CodeJudge as many times as you like during the exam.

2. You must upload your solutions on CampusNet. Each assignment must be uploaded as one separate .py file, given the same name as the function in the assignment:

   (a) `eseries.py`
   (b) `alphaToPhone.py`
   (c) `genderGuess.py`
   (d) `birthday.py`
   (e) `matrixSearch.py`

   The files must be handed in separately (*not* as a zip-file) and must have these exact filenames.

After the exam, your solutions will be automatically evaluated on CodeJudge on a range of different tests, to check that they work correctly in general. The assessment of you solution is based only on how many of the automated tests it passes.

- Make sure that your code follows the specifications exactly.
- Each solution shall not contain any additional code beyond the specified function.
- Remember, you can check if your solutions follow the specifications by uploading them to CodeJudge.
- Note that all vectors and matrices used as input or output must be numpy arrays.

Assignment A Exponential series expansion

The exponential function e^x can be approximated by the following power series:

$$f(x) = \sum_{i=0}^{N-1} \frac{x^i}{i!}$$

where $i!$ denotes the factorial of i, and N is the number of terms.

Problem definition

Create a function named `eseries` that takes as input x and N, and evaluates the above expression.

Solution template

```
def eseries(x, N):
  #insert your code
  return f
```

Input

`x`	x-value to evaluate the approximation (decimal number).
`N`	Number of terms (positive whole number).

Output

`f`	The approximation of the exponential function at x (decimal number).

Example

Consider evaluating $f(x)$ at $x = 1.23$ with $N = 5$ terms. The terms can be computed as (here shown with five decimals)

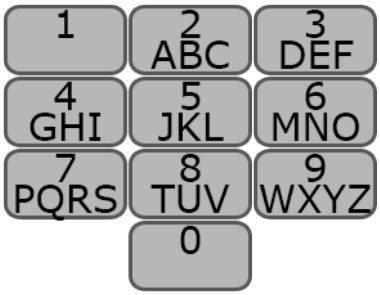
$i = 0$	$i = 1$	$i = 2$	$i = 3$	$i = 4$
1.00000	1.23000	0.75645	0.31014	0.09537

The sum can then computed as 3.39196 which is the final result.

A

Assignment B Alpha to phone number

On a phone keypad, each letter of the alphabet is assigned to one of the digits 2-9. This makes it possible to write alpha-numeric phone numbers using a mix of letters and digits (by replacing digits in the phone number by the corresponding letters).



Problem definition

Create a function named `alphaToPhone` that takes as input an alpha-numeric (letters and digits) phone number as a string, and returns the corresponding numeric (only digits) phone number as a string. You may assume that all letters in the input are given as upper case.

Solution template

```
def alphaToPhone(alpha):
  #insert your code
  return phone
```

Input

`alpha` Alpha-numeric phone number (string containing letters and digits).

Output

`phone` Numeric phone number (string containing only digits).

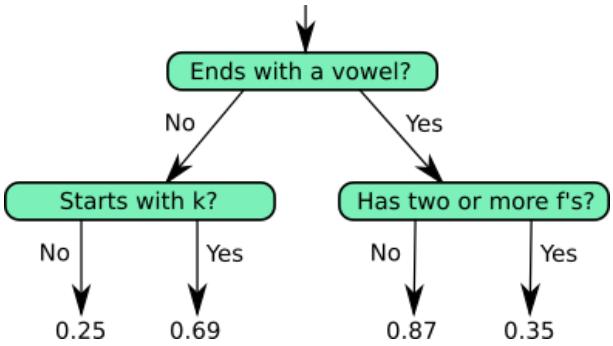
Example

Consider the alpha-numeric phone number `4525DTU1`. Converted to a numeric phone number, it should be `45253881`.

B

Assignment C Guess the gender

You are given a simple "decision tree" below that aims at predicting the gender of a person given his or her name.



The four numbers indicated at the possible outcomes are the probability that the given name is female.

Problem definition

Create a function named `genderGuess` that takes as input a name as a string and computes the probablity that the name is female based on the decision tree above. You may assume that the input name consists only of lower case letters `a`–`z`. As vowels we consider the letters `a`, `e`, `i`, `o`, `u`, and `y`.

Solution template

```
def genderGuess(name):
  #insert your code
  return pFemale
```

Input	
`name`	Name (string).

Output	
`pFemale`	Probability that name is female (decimal number).

Example

Consider the name `affonso`. We start at the top of the decision tree. Since the name ends with a vowel, `o`, we go down to the right in the decision tree. Next, since the name contains two or more `f`'s, we go down to the right again. The final result, which can be read off by the arrow, is that the probability of a female name is 0.35.

C

Assignment D Birthday problem

The socalled "birthday problem" consists of calculating the probability that at two (or more) people within a population of n people have the same birthday. This probability can be computed as:

$$P(n) = 1 - \exp\left(\ln\Gamma(k+1) - \ln\Gamma(k-n+1) - n\log(k)\right)$$

where $\log(\cdot)$ and $\exp(\cdot)$ are the natural logarithm and exponential function, and $\ln\Gamma(\cdot)$ is the socalled log-gamma function which is implemented in Python as the function `math.lgamma`. The number k is the number of days in a year, which we will set to $k = 365$, and we can assume that $2 \geq n \geq k$.

Problem definition

Create a function named `birthday` that takes as input the size of the population, n, and returns the probability $P(n)$ that two (or more) people within the population have the same birthday.

Solution template

```
def birthday(n):
  #insert your code
  return P
```

Input	
`n`	The number of people in the population (positive whole number).

Output	
`P`	The probability that two (or more) persons have the same birthday (decimal number).

Example

Consider at population of size $n = 23$. The probability can be computed as follows (show with for decimals):

$$\begin{aligned} P(23) &= 1 - \exp\left(\ln\Gamma(365+1) - \ln\Gamma(365-23+1) - 23\log(365)\right) && (1)\\ &= 1 - \exp(1792.3316 - 1657.3419 - 135.6976) && (2)\\ &= 0.5073 && (3) \end{aligned}$$

D

Assignment E Matrix search

You are given a matrix of whole numbers, where both the rows and the columns are sorted in increasing order. For example, the matrix could look as follows:

$$\begin{bmatrix} 1 & 2 & 6 & 10 \\ 3 & 7 & 7 & 13 \\ 7 & 9 & 11 & 14 \end{bmatrix}.$$

Let us denote the matrix A, its dimensions $M \times N$, and its elements $a_{i,j}$. The following algorithm is an efficient way of finding out if and where a specific number, x, occurs in the matrix:

1. Start at the top right corner of the matrix, $i = 1$, $j = N$.
2. Examine the number $a_{i,j}$:
   (a) If $a_{i,j} = x$ you are done. Return the result $[i, j]$.
   (b) Else, if $a_{i,j} > x$ go one step to the left, $j \leftarrow j - 1$.
   (c) Else, if $a_{i,j} < x$ go one step down, $i \leftarrow i + 1$.
3. If you are within the matrix, i.e. $i \leq M$ and $j > 0$, repeat from 2. Otherwise, return the result $[0, 0]$.

Problem definition

Create a function named `matrixSearch` that takes as input a matrix A as described above and a number x to search for in the matrix. The function must return a vector of the coordinates $[i, j]$ of the first occurence of x as found by the algorithm above. If x does not occur in the matrix, the function must return the vector $[0, 0]$.

Solution template

```
def matrixSearch(A, x):
  #insert your code
  return index
```

Input

`A`	Row and column sorted matrix ($M \times N$) with whole numbers.
`x`	Number to search for (whole number).

Output

`index`	Row and column coordinates of the found number (vector of length 2). Return $[0, 0]$ if the number does not occur in the matrix.

Example

Consider the matrix shown above where $M = 3$ and $N = 4$, and let us look for the number $x = 7$. We start at the top right corner at $a_{1,4} = 10$. Since $10 > x$ we move left to $a_{1,3} = 6$. Since $6 < x$ we move down to $a_{2,3} = 7$. Since this is equal to x, we return the result $[2, 3]$.

E