Python programming exercises

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1 Simple functions

Define the following **functions** in Python.

1.1 Average of two numbers

Given two numbers a and b, evaluate their average

$$avg(a, b) = \frac{a + b}{2}$$

1.2 Average of three numbers

Given three numbers a, b, c, evaluate their average.

1.3 Square

Given a number a, evaluate its square a^2.

1.4 Power

Given a number a and an exponent b, evaluate a^b.

1.5 Multiplicative inverse

Given a number a, evaluate its multiplicative inverse $\frac{1}{a}$.

1.6 Quadratic function

Given three coefficients a, b, c and a value x, evaluate the function

$$f(x) = ax^2 + bx + c$$

1.7 Quadratic function of inverse

Given three coefficients a, b, c and a value x, evaluate the function

$$f(x) = a\left(\frac{1}{x}\right)^2 + b\frac{1}{x} + c$$

Hint: use the functions defined in 1.5 and 1.6.

1.8 2x2 matrix determinant

Given a matrix a with two rows and two columns, represented as a list of lists (e.g. `a = [ [a1, a2], [a3, a4] ]`), evaluate its determinant.

1.9 Even

Given a number a, evaluate if it is even.

1.10 Multiple of 3

Given a number a, evaluate if it is a multiple of 3.

1.11 Multiple of x

Given two numbers a and x, evaluate if a is a multiple of x.

1.12 Cases

Given a number a, evaluate its square if it is odd, otherwise divide it by 2

$$f(a) = \begin{cases} a^2 & \text{if } x \text{ is odd} \\ \frac{a}{2} & \text{otherwise} \end{cases}$$

1.13 Base complement

Given a character a representing a DNA base (e.g. A, T, C, G), evaluate its complement.

$$f(a) = \begin{cases} \text{T} & \text{if } a = \text{A} \\ \text{A} & \text{if } a = \text{T} \\ \text{G} & \text{if } a = \text{C} \\ \text{C} & \text{if } a = \text{G} \end{cases}$$

1.14 Complement, again

Given a character a and a complement mapping b, evaluate the complement of a.

$$f(a, b) = b[a]$$

2 Looping functions

Define the following functions in Python, usually by using a `for` loop.

2.1 Squares

Given a list of numbers l, evaluate their squares:

$$result_i = l_i^2 \quad \forall i \in l$$

2.2 Quadratic function

Given three coefficiels a, b, c and a list L, evaluate the quadratic function for every value of L.

Hint: exploit the function defined in 1.6

2.3 Size of a list

Given a list of numbers l, count the number of elements it contains.

Please notice that you cannot use the built-in function `len`, neither the function `range`.

Hint: you should evaluate the following function:

$$size(l) = \sum_{i \in l} 1$$

2.4 Average

Given a list of numbers l, evaluate their average

$$avg(l) = \sum_{i \in l} \frac{i}{size(l)}$$

2.5 Average, again

Given a list of numbers l, evaluate their average. You should evaluate the list size at the same time (e.g. without using *len* or the previously defined function *size*).

$$avg(l) = \sum_{i \in l} i \cdot \left(\sum_{i \in l} 1 \right)^{-1}$$

2.6 Factorial

Given a number n, evaluate its factorial $n!$

$$fact(n) = 1 \cdot 2 \cdots (n-1) \cdot n = \prod_{i=1}^{n} i$$

2.7 Binomial coefficient

Given two numbers n and k, evaluate the binomial coefficient:

$$\binom{n}{k} = \frac{n!}{k! \cdot (n-k)!}$$

Hint: you could use the factorial function defined in 2.6.

2.8 Complement

Given a string representing a DNA sequence, evaluate its complement.

Hint: you could use the function defined in 1.13.

2.9 Reverse complement

Given a string representing a DNA sequence, evaluate its reverse complement.

Hint: you could use the function defined in 1.13.

2.10 Powers

Given two lists of numbers a and b, evaluate powers using elements of a as base and the corresponding elements of b as exponent:

$$result_i = a_i^{b_i}$$

Hint: you may use the function defined in 1.4.

2.11 Weighted average

Given two lists of numbers a and b, the first representing values, the second representing weights, evaluate the weighted average

$$wavg(a,b) = \left(\sum_{i=1}^{n} b_i\right)^{-1} \sum_{i=1}^{n} a_i b_i$$

2.12 Covariance

Given two lists of numbers a and b, evaluate the covariance of the two datasets.

$$cov(a,b) = \frac{1}{n} \sum_{i=1}^{n} (a_i - avg(a)) \cdot (b_i - avg(b))$$

2.13 Root mean square deviation, simple

Given two vectors of data v and w, evaluate their root mean squadre deviation

$$RMSD(v, w) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(v_i - w_i)^2}$$

2.14 Root mean square deviation, 3D

Given two vectors of data v and w, evaluate their root mean squadre deviation. Each data point is a 3D point represented by a tuple $v_i = (v_i^x, v_i^y, v_i^z)$

2.15 Dot product

Given two vectors v and w, evaluate their dot product

$$dot(v, w) = \sum_{i=1}^{n} v_i w_i$$

2.16 Strand matching

Given two strings a and b representing two DNA sequences, evaluate if they are paired strands.

E.g. $a_i = \text{complement}(b_i)$

Hint: you could use the function defined in 1.13.

2.17 Matrix transpose

Given a matrix a, represented as a list of lists, evaluate its transpose.

2.18 Matrix product

Given two matrices a and b, represented as list of lists, evaluate their product

$$result_{i,j} = \sum_{k=0}^{n} a_{i,k} b_{k,j}$$

2.19 Substitution matrix

Given two aligned sequences stored in a file (one sequence per line), evaluate the log-odd score for each substitution.

$$s(i, j) = log\left(\frac{p_{i \to j}}{p_i p_j}\right)$$