Python pour la physique

Version 1

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1 Exercices

1.1 Mathematical functions

Mathematical functions can be imported from the `math` module. Python uses standards name for mostly all functions : `sin`, `cos`, `tan`, `log`, `exp`, `sqrt`. The inverse trigonometric functions are `acos`, `asin`, `atan`. The `pi` constant can also be imported from the `math` module.

You can import all the content of the math module using the `import` statement

```
from math import *
```

To get familiar with the python terminal answer the following questions

- Is the `log` function the decimal one or the natural one ? How to choose the base ?
- Calculate $\sqrt{2}$. How many digits are displayed ?
- Calculate $\arccos\left(\frac{\sqrt{2}}{2}\right)$ et compare with the expected value

1.2 Calcul of VAT

The VAT rate is 19.6 %.

- Create a function that calculates the price with taxes from the price without
- Well, the VAT rate has change and is now 20 %. Modify the function so that the VAT rate is an optional parameter with a default value set by a global constant.

1.3 Docstring

Write the documentation string (docstring) of the following function

```
from math import pi

def volume_cone(r,h):
    return pi*r**2*h/3
```

1.4 Heron's formula

The Heron's formula is used to calculate the area of a triangle using the length of the three sides.

$$A = \sqrt{s(s-a)(s-b)(s-c)}$$

where

$$s = \frac{1}{2}(a+b+c)$$

- write the function that calculate the area of a triangle using the Heron's formula
- What happens when the triangle does not exist (for example $a = 100$, $b = 1$ and $c = 1$?

1.5 Derivative

The derivative of a function can be calculated using the following limit :

$$\lim_{\epsilon \to 0} \frac{f(x+\epsilon) - f(x)}{\epsilon}$$

An approximation of the derivative is obtained using a suffitiently small value of $epsilon$

- By choosing $\epsilon = 10^{-6}$, calculate the derivative of sine for $x = 1$. Compare with the theoretial result.
- Compare the result with the one obtained using the formula :
$$\lim_{\epsilon \to 0} \frac{f(x+\epsilon) - f(x-\epsilon)}{2\epsilon}$$
- Write a function that take the **function** f as an argument and return the derivative of f as a **function**.

1.6 Floating point numbers

The number *x=1.0* is stored as a float on 64 bits (double precision, using the IEEE 754, http://en.wikipedia.org/wiki/IEEE_754 .

Answer the following questions :

- What is the result of (x+2E-20) - x ? Why ?
- What is the smallest number y such that x + y is not equal to x
- What is **exactly** the difference between (x+1E-15) and x ?
- For *epsilon<1* what is the order of magnitude of the relative difference between ((x+epsilon) - x) and epsilon ?

2 Loops

2.1 Sequence limit

Consider the following sequence

$$u_{n+1} = \frac{1}{1+u_n}$$

with

$$u_0 = 0$$

This sequence converges. The objective is to calculate its limit

- First calculate the `N` first elements (take `N=10`)
- Use a `while` loop that stops when the difference between two terms is less than ϵ. The calculation will be done with $\epsilon = 10^{-8}$
- Compare with the theoretical limit :

$$\frac{-1+\sqrt{5}}{2}$$

2.2 Series calculation

Calculate the `sin` function from its expansion :

$$\sin(x) = \sum_{n=0}^{\infty} \frac{(-1)^n x^{(2n+1)}}{(2n+1)!}$$

2.3 For loop

Print all the odd number below 100 that are multiple of 3 but not of 5

2.4 Prime number

Write a function that returns `True` if a number is prime and `False` else wise. We will test if a number is a prime number by succesfully testing if it can be divided by a number larger than 2 and smaller than $\sqrt{n}$

- Write the function
- Is 2011 a prime number ?
- During the 21st century, how many year numbers will be prime ?

3 List

3.1 simple list

In the Python console, create an empty list called py_list. Insert the number 2.7, 5.1 and 7 at the end of the list. Insert the number 4 at the begining of the list and the number 2.9 at the position 2. Supress the item number 2. Print the list and compare to your neighbour.

3.2 Research inside a list

- How to find the index of an item inside a list ? (use `help list`)
- Using a for loop, write your own function : from a list `l` and a value `x` the function will return the smallest `i` such that `l[i]==x`.

3.3 List of random number

The `random` package contains functions to generate random number. To obtain a number between 1 and 10 use

```python
from random import randint
print(randint(1,10))
```

We have two dices (with 6 faces). We consider the sum of the value of the two dices.

- Create a list containing n random realization.
- What is the number of 8 in the list.
- Using 100000 realization, estimate the probability to get 8 ?
- Same question with 4 dices (2 with 6 faces and 2 with 4 faces).

4 Strings

4.1 Unicode strings

There are 25 letters in the greek alphabet. In the unicode, they start from 945 to 969.

- Display all of them (use the chr function).
- Write a function that return the greek letter from its position in the greek alaphabet. For example, the function will return α if the argument is 1. Create an exception if necessary.

4.2 String and file

Take a large text file (for example Romeo and Juliet from Shakespeare http://www.gutenberg.org/files/47960/47960-0.txt).

- Print the distribution of the letter.
- How many words starts with an `e` or `E` ?

5 Module and package

We want to store physical constants in a package.

- Create a package `constants` with two modules : the first one called `fundamental` and the second called `atomic_mass`. They will be used as follow

```python
from constants.fundamental import mu_0, hbar, e, c
from constants.atomic_mass import rubidium_87
```

In case you don't know, in SI units, one has :

$$c = 299792458; e = 1.60217663 \times 10^{-19}; h = 6.62607015 \times 10^{-34}; \hbar = h/2\pi;$$
$$\mu_0 = 1.25663706212^{-6}; \epsilon_0 = 1/\mu_0 c^2; G = 6.67430 \times 10^{-11};$$

And for atomic masses :

$$M(^{87}\mathrm{Rb}) = 86.909180527 m_u; M(^{85}\mathrm{Rb}) = 86.909180527 m_u;$$

- Modify the `__init__.py` so that `from constants import mu_0, h, e` works.
- Create a setup.py, install it (using `pip install -e . --user`) and try to use it from a different directory