Computer Programming

Second year physics

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WHAT IS PROGRAMMING?

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- A computer is a Machin that stores pieces of information.
- A computer also moves, arranges, and controls that information (or data).
- A **program** is a detailed set of instruction that tells a computer what to do with that data.

Week 1

Why python

- Python is an easy to learn freely available, high level, objective oriented programming language (invented by **Guido Van Rossum** and released in 1991).
- Python is an interactive language. This means we don't need to compile and then run the code but execute each line as you type it.
- Python runs on Windows, Mac and Linux. This means that you will be able to download and install Python on any of PC or laptop.
- Python is a general purpose language. As you become more familiar with python, you will admire to how well it is designed.
- Powerful. Because it is well designed , it is easier to transfer your idea into cod.
- Portability. Because python is for free, your code can run everywhere.

- Python is a special programming language that includes the functionality required by programmers to write all types of code.

- Python contain a library of functions capable for different tasks.

Major uses of Python

- **Web and internet development**
- **HTML (hypertext markup language) and XML (extensible markup language)**
- **E-mail processing**
- **Scientific and numeric**
- **Scipy**
- **Panda**
- **Ipython**
- **Education:** is a superb language for teaching programming, both at the introductory level and in more advanced courses.
- **Software development**

- **ForecastWatch.com**

The software used to make the comparisons (between thousands of forecasters against actual climate to find their accuracy) is written in pure Python because it comes with standard libraries useful in collecting, parsing, and storing data from online sources.

- **Frequentis**

A software product that is used for air traffic control in many airports. This particular tool provides updates on the weather and runway conditions to air traffic controllers.

- **Corel**

PaintShop Pro is a product that many people have used over the years to grab screenshots, modify their pictures, draw new images, and perform a lot of other graphics-oriented tasks.

- **Honeywell**

Documenting large systems is expensive and error prone. Honeywell uses Python to perform automated testing of applications, but it also uses Python to control a cooperative environment between applications used to generate documentation for the applications

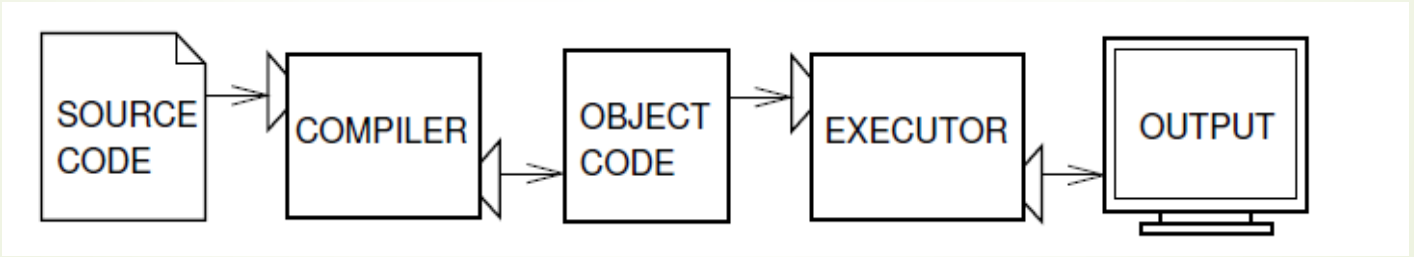
- **United space Alliance**

This company provides major support to NASA (National Aeronautics and Space Administration) for various projects, such as the space shuttle. Python was chosen over languages such as Java and C++ because it provides dynamic typing and pseudo-code–like syntax and it has an interpreter.

Installation of Python

- You need to install a proper version of Python that is suit your level in prpgramming. If you already have installed python in your laptop then make sure it works properly. To do this go to **command prompt** then wrote **python.** If everything is okay you should get information about the version that you installed. However, if your computer tell you the **name python is unknown** that means you didn't specify the needed path.
- Try to install python packages numpy, scipy, and matplotlib which are suitable for installed python.
- We generally write a computer program using a high-level language. A high-level language is one which is understandable by us humans. It contains words and phrases from the English (or other) language. But a computer does not understand high-level language. It only understands program written in 0's and 1's in binary, called the machine code. A program written in high-level language is called a source code. We need to convert the source code into machine code and this is accomplished by compilers and interpreters. **Hence, a compiler or an interpreter is a program that converts program written in high-level language into machine code understood by the computer**

An interpreter reads a high-level program and executes it, meaning that it does what the program says. It processes the program a little at a time, alternately reading lines and performing computations



A compiler reads the program and translates it completely before the program starts running

Interpreter	Compiler
Translates program one statement at a time.	Scans the entire program and translates it as a whole into machine code.
It takes less amount of time to analyze the source code but the overall execution time is slower.	It takes large amount of time to analyze the source code but the overall execution time is comparatively faster.
No intermediate object code is generated, hence are memory efficient.	Generates intermediate object code which further requires linking, hence requires more memory.
Continues translating the program until the first error is met, in which case it stops. Hence debugging is easy.	It generates the error message only after scanning the whole program. Hence debugging is comparatively hard.
Programming language like Python, Ruby use interpreters.	Programming language like C, C++ use compilers.

Week 2

Python programming

- The course starts with the basics of computing method and scientific knowledge and cover more advanced topics and numerical methods.
- Python is a special programming language that includes the functionality required by programmers to write all types of code.
- Python contain a library of functions capable for different tasks.
- a library is a collection of “books” that perform specific tasks and extend your programs functionality. In python a library is a collection of modules
- a module is a file, like a book in the library, that contains functions you can import into your program.
- IDLE : Integrated development and learning environments

Python packages

Numpy (Numeric python) package provides basic routines for manipulating large arrays and matrices of numeric data. It contains array functionality, linear algebra, Fourier transform, and random number capabilities.

Example 1:

```
from numpy import*
Print pi, e
3.14, 2.71
```

Example 2:

```
from numpy import*
print arange(0.0, 1.0, 0.1)
[ 0.  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  0.9]
```

Example 3:

```
import numpy as np
x= np.array([2.4, -1.5, 3.0, 8.8])
print x
[2.4 -1.5  3.0  8.8]
print x[0]   ……..2.4, print x[1]…..-1,5
```


2- Scipy(Scientific python) Open-source Python software for mathematics, science, and engineering. This contains a large number of packages which can perform some fairly complex analysis. The additional benefit of basing SciPy on Python is that this also makes a powerful programming language available for use in developing sophisticated programs and specialized applications.

SciPy is organized into subpackages covering different scientific computing domains.

These are summarized in the following table:

Subpackage	Description
cluster	Clustering algorithms
constants	Physical and mathematical constants
fftpack	Fast Fourier Transform routines
integrate	Integration and ordinary differential equation solvers
interpolate	Interpolation and smoothing splines
io	Input and Output
linalg	Linear algebra
ndimage	N-dimensional image processing
odr	Orthogonal distance regression
optimize	Optimization and root-finding routines
signal	Signal processing
sparse	Sparse matrices and associated routines
spatial	Spatial data structures and algorithms
special	Special functions
stats	Statistical distributions and functions

from Scipy import linalg, optimize

.....

3- Matplotlib : Python 2D plotting library. It tries to make easy things easy and hard things possible. This provides a straightforward way to generate and save plots, histograms, power spectra, bar charts, errorcharts, scatterplots, etc., with just a few lines of code.

Syntax summary we will provide a syntax summary that lists all of the functions and computational methods that are introduced in each lecture. This is available in the python math package, and the same functions (with additional features) are available in NumPy. We will be using the NumPy versions

Function	Syntax	Alternative Syntax
Addition	x + y	add(x,y)
Subtraction	x - y	subtract(x,y)
Multiplication	x * y	multiply(x,y)

Division	x / y	divide(x,y)
Remainder	x % y	remainder(x,y)
Test of equality	x == y	
Tests of inequality	x > y; x < y	x >= y; x <= y
Modulus	abs()	
Power	x**y	pow(x,y)
Scientific notation	2.5*10**7	2.5e7
Square root	sqrt(x)	
Log_e	log(x)	
Log_{10}	log10(x)	
Exponential	exp(x)	e**x
Sine	sin(x)	
Cosine	cos(x)	
Tangent	tan(x)	
Inverse Sine	arcsin(x)	

Inverse Cosine	arccos(x)	
Inverse Tangent	arctan(x)	
Hyperbolic Sine	sinh(x)	
Hyperbolic Cosine	cosh(x)	
Hyperbolic Tangent	tanh(x)	
Inverse Hyperbolic Sine	arcsinh(x)	
Inverse Hyperbolic Cosine	arccosh(x)	
Inverse Hyperbolic Tangent	arctanh(x)	
Convert angle from degrees to radians	deg2rad(x)	radians(x)
Convert angle form radians to degrees	rad2deg(x)	degrees(x)

Dealing with variable

When setting a variable to be a function of another variable, be careful that the one you are changing comes first:

x = y/2 sets the value of x to be half the value of y. y/2 = x will not work -- it gives the error ***SyntaxError: can't assign to operator***

Note: ***lambda*** cannot be used as a variable name, it is reserved for a specific purpose in python

Function	Syntax	Alternative Syntax
Define variable as integer	x = 5	x = int(5)
Define variable as float	x = 5.0	x = float(5)
Display value of variable	print(x)	print x
Increment variable	x = x + 1	

Addition:

4+5 → add(4,5) don't forget to import numpy!

Subtraction:

6-2 → subtract(6,2)

Multiplication:

7*9 → multiply(7,9)

Division:

7/3 or divide(7,3) did the division gives what you expected? no why?

Use remainder function → remainder(7,3) !

- As we have seen, Python will by default treat whole numbers as integers. In order to have the computer work with decimals (floating point numbers), you have to tell Python to store it as a float (floating point number) rather than an int (integer or whole number).

Example

divide(7.0,3.0) = 2.33 ⟶ ***The easiest way to simply put a decimal point after every number you want treated as a float such as 3., 7., 10.***

The equal sign = is used to assign a value to a variable. Afterwards, no result is displayed before the next interactive prompt

Example

```
>>>width= 20
>>>height= 5*9
>>>Width *height
900
```

- If a variable is not “defined” (assigned a value), trying to use it will give you an error → Trace back (most recent call last):

  File “<stdin>”, line 1, in <module>

  Name error: name ‘…’ is not defined

Other operations

1- ***abs() function*** can return the absolute value of the number

abs(-7.3) return a value of 7.3

2- **Powers** There are two way to raise a number a to the power n, use ** or the function **pow()**

7**2 or pow(7,2) these should be give the same answer 49.

9**(1.0/2) or 9**0.5 should be equivalent to pow(9,1./2)

Exercise: Try 9** ½ , 9** (1/2) and , 9** 1./2 what is the difference check?

Very small numbers or large numbers are often written in scientific notation, for example 4.5×10^6. In Python you can do this in two ways

4.5*10**6 or using 4.5E6

3- Roots in python we have a specific function ***sqrt()*** that describes the square root and the answer will be in float.

Example :

sqrt(9)

3.0

4- Exponentials You can calculate exponentials using the powers method described above, as a value for e is already stored in Python. There is also the built in function

exp().

Example

e**3 or exp(3) performs the same function.

5-Trigonometric: Python can handle trigonometry in much the same way as your calculator. **Note** that by default, it works in radians

Example **sin(60)** dose not give you the value that you expect. However, pi is already defined so one can use

Sin(pi/3) instead of sin(60) ….the same is true for other trigonometric functions.

- To convert an angle from degrees to radians, use:

  radians(60) or **deg2rad**(60)

How python performs order of calculation

An essential point to remember, especially when performing large calculations, is the order in which Python will do each operation. For each line of calculation, Python will operate in the following order

1- **Brackets**. 2- **Indices**. 3- **Division and Multiplication**. 4-**Addition and subtraction**

Division and multiplication are of the same level, so in the absence of brackets they will be performed in the order they are read (i.e. left to right) and the same for addition and subtraction.

Remember that if all values are entered as integers, calculations involving division may give incorrect answers. The easiest way to avoid this is to get into the habit of entering numbers as floats by adding a decimal point where necessary as we have done in the examples throughout this worksheet.

Variable incrementing

Incrementing a variable means increasing the value by a step. You can increment the variable x by 1 by typing

```
>>>Print x
>>>x=x+1
>>>Print x
```

x=x+1 command sometime bother people who have not done programming before. Mathematically it is clearly nonsense whilst for a computer it makes sense: the variable x will subsequently be defined as having the current value of the variable x plus 1. This is used often in coding systems that change over time.

Example

A ball is dropped under the earth gravity with zero initial velocity so its speeds up. IF the variable t represent the time and the constant g is an acceleration. Write a program to find the speed, v, of the ball after one second.

>>>t=1.0

>>>g=9.8

>>>v_o =0

>>> v= v_o + g*t

>>> print v

If we increment the time by one second , and make the old final velocity be the new initial velocity, and recalculate for the speed after 2 seconds

>>>t=t+1

>>>v=v_o

>>> v= v_o + g*t

>>>print v

Exercise

a) Calculate $7 \div 2$. Do this both as an integer and a float calculation and note the difference.

b) Calculate the remainder.

c) Define the variable x=55, y= 70, and n=3 then test:

$x+y$

y/x

$x^3 - y^n$

$\sqrt{y}$

y^3. Check this gives the same result as y x y x y

e^{-2n+1} , $\ln(2x)$, $\log_{10}(6y)$

Treating x and y as angles in degrees convert them to radians and calculate the following:

$\sin(x)$

$\cos^2(5y)$

$\cos^2(x)+\sin^2(x)$