UNIVERSITY OF LIVERPOOL

CMIT Summer Research Internship 2023: Python Basics 1

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Contents

The word: Natural VS Programming Languages

Natural Language

- English: nouns, verbs, adjectives, preps....
- Function differently in the sentence
- Similarly for programming languages

Programming Language

- Python Language: int, float, complex, strings, boolean,
- list, tuple, dictionary...

Definitions

- int: integers,e.g. 0,1,-2,...
- float: float numbers, or just simply: decimal numbers
- 1.5, 3.14, etc.
- complex: complex numbers, e.g. 1+4j
- string: ordinary words, used with ""

For example,...

Libraries

- math: basic math functions, sin, cos, log, etc
- `https://docs.python.org/3/library/math.html`
- numpy: numeric python. matrix, vector operations
- matplotlib: plotting graphs
- Imread: read images, translate into data, etc.

Sphere Calculation

Find surface area of sphere, given the volume.

- $V = \frac{4}{3}\pi r^3$
- calculate r first
- $r = \left(\frac{3V}{4\pi}\right)^{\frac{1}{3}}$
- find surface area with formula
- $A = 4\pi r^2$

Look at the script now!

Quadratic Equations

How the "if" works?

- 3 cases depending on $\Delta = b^2 - 4ac$
- how to compute with 3 inputs?
- any restrictions on a?
- $\frac{-b \pm \sqrt{\Delta}}{2a}$

Look at the script now!

if—elif—else

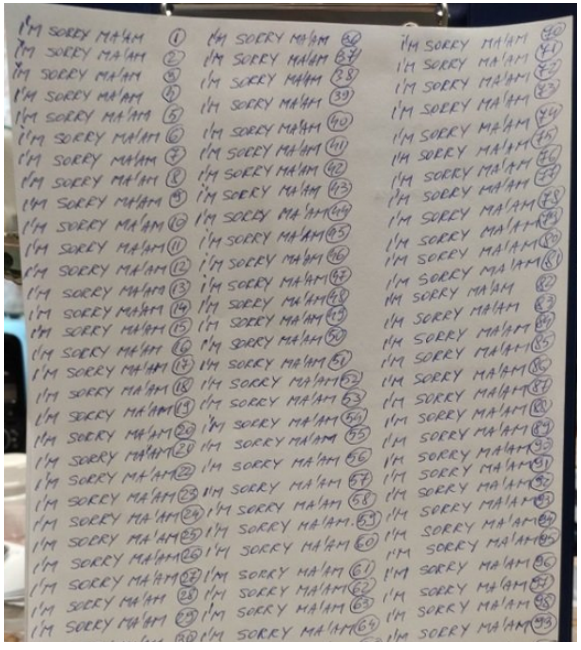
- "if" on its own: just for 2 cases
- "elif, else": use when at least 3 cases
- "elif": after the first "if", until the final one
- "else": the final case, mutually exclusive to all other cases.

The use of if, elif and else is not unique. In fact, different codes can do the same work. Just like English, famous= well known!

for loop

- do the same task for a specific number of times
- people cannot get bored but python cannot
- need to use range(n) to specify how many times
- be careful: just like the floor numbers in UK,
- the first number is 0 not 1.

for loop examples



- write "I am sorry" 100 times!

for loop examples

Perfect squares chart

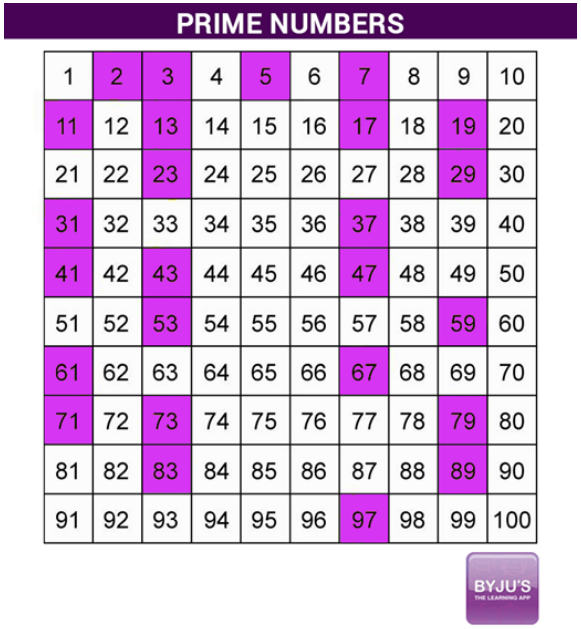
X	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	2	4	6	8	10	12	14	16	18	20
3	3	6	9	12	15	18	21	24	27	30
4	4	8	12	16	20	24	28	32	36	40
5	5	10	15	20	25	30	35	40	45	50
6	6	12	18	24	30	36	42	48	54	60
7	7	14	21	28	35	42	49	56	63	70
8	8	16	24	32	40	48	56	64	72	80
9	9	18	27	36	45	54	63	72	81	90
10	10	20	30	40	50	60	70	80	90	100

- Now take it seriously!
- How many perfect square numbers below 1000?
- $\sqrt{1000} = 31.622776601683793\cdots \sim 31$
- Let's verify by counting!

while loop

- We do not know how many times we need to run it!
- for example
- While I have not done it, I do it! No matter how many times.
- Once the condition is met, stop it!

while loop examples



- Let's find the nth prime number!

numpy and matplotlib

- Analytic method is quite limited
- Numerics gives wonderful approximation
- numpy: numerical python. solves problems numerically.
- matplotlob: visualisation, graph plotting, human readable.

Plot of Cycloid

- $x = r(t - \sin(t))$
- $y = r(1 - \cos(t))$
- $t \in [0, 2\pi]$

Elliptic Integral

- Originates from finding the elliptic perimeter
- No analytic formula available
- Only possibly evaluated by numerical approximation

Elliptic Integral

- The key part of the integral
- $K(k) = \int_0^{\frac{\pi}{2}} \frac{d\theta}{\sqrt{1-k^2 \sin^2(\theta)}}$
- Focus on a spacial case: $k = \frac{1}{2}$
- $K(\frac{1}{2}) = \int_0^{\frac{\pi}{2}} \frac{2d\theta}{\sqrt{4-\sin^2(\theta)}}$

Draw a circle iteratively

- np.matmul(Rotation,point)
- rotational matrix
- $R(\theta) \equiv \begin{pmatrix} \cos(\theta) & -\sin(\theta) \\ \\ \sin(\theta) & \cos(\theta) \end{pmatrix}$
- $\mathbf{X} \equiv \begin{pmatrix} 1 \\ 0 \end{pmatrix}$
- the circle
- $\{\mathbf{X}, R\mathbf{X}, R^2\mathbf{X}, \cdots ,, R^N\mathbf{X}\}$