Introduction to Programming with Python

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Note: modified from original LACC slides by Dr. Lucas Wanner, Prof. Mani Srivastava, Dr. Mark Gottscho, Dr. Bharathan Balaji, Wojciech Romaszkan, Aishwarya Sivaraman and Shuyang Liu

Slides taken from UCLA-LACC Intro module

Welcome to CE-Freshers-Bootcamp @ UCLA!

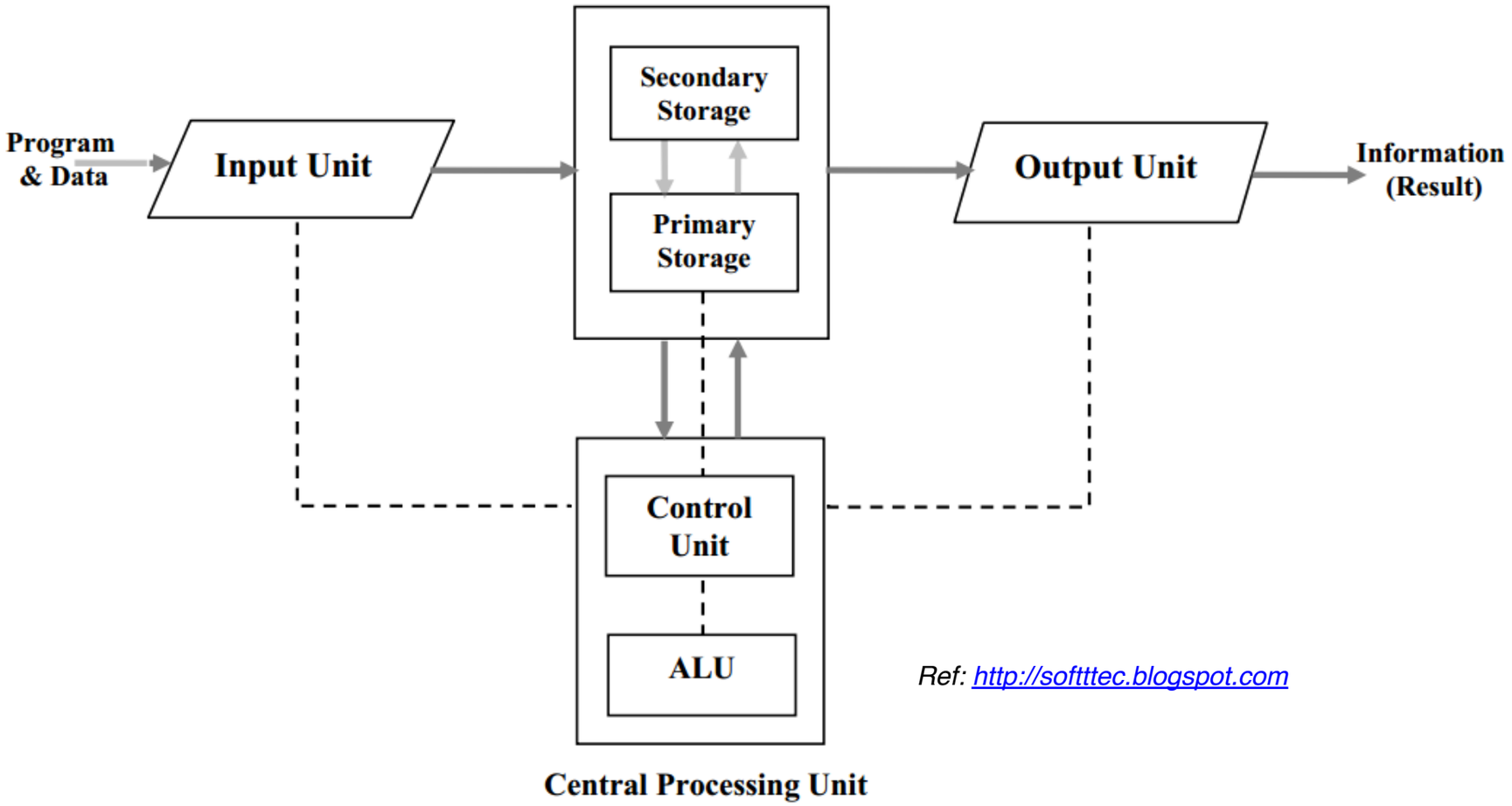
Introductions

- About you?

Introduction to Computers

- A computer is an electronic **programmable** machine that can process almost all kinds of data. Fundamentally, a computer is a "**calculating machine**".

- A computer performs **arithmetic** and **logical** operations.



Ref: http://softttec.blogspot.com

The Language of Computers

- A computer program is a **set of instructions** that dictates the steps required to perform a given task via some predefined **syntax** and **semantics**.

- A computer only understands 1s and 0s – **bits** (binary digits); 1 **byte** = 8 bits.

Decimal	Binary
1	0
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII
0	00000000	000	00	NUL	32	00100000	040	20	SP	64	01000000	100	40	@	96	01100000	140	60	`
1	00000001	001	01	SOH	33	00100001	041	21	!	65	01000001	101	41	A	97	01100001	141	61	a
2	00000010	002	02	STX	34	00100010	042	22	"	66	01000010	102	42	B	98	01100010	142	62	b
3	00000011	003	03	ETX	35	00100011	043	23	#	67	01000011	103	43	C	99	01100011	143	63	c
4	00000100	004	04	EOT	36	00100100	044	24	$	68	01000100	104	44	D	100	01100100	144	64	d
5	00000101	005	05	ENQ	37	00100101	045	25	%	69	01000101	105	45	E	101	01100101	145	65	e
6	00000110	006	06	ACK	38	00100110	046	26	&	70	01000110	106	46	F	102	01100110	146	66	f
7	00000111	007	07	BEL	39	00100111	047	27	'	71	01000111	107	47	G	103	01100111	147	67	g
8	00001000	010	08	BS	40	00101000	050	28	(	72	01001000	110	48	H	104	01101000	150	68	h
9	00001001	011	09	HT	41	00101001	051	29	)	73	01001001	111	49	I	105	01101001	151	69	i
10	00001010	012	0A	LF	42	00101010	052	2A	*	74	01001010	112	4A	J	106	01101010	152	6A	j
11	00001011	013	0B	VT	43	00101011	053	2B	+	75	01001011	113	4B	K	107	01101011	153	6B	k
12	00001100	014	0C	FF	44	00101100	054	2C	,	76	01001100	114	4C	L	108	01101100	154	6C	l
13	00001101	015	0D	CR	45	00101101	055	2D	-	77	01001101	115	4D	M	109	01101101	155	6D	m
14	00001110	016	0E	SO	46	00101110	056	2E	.	78	01001110	116	4E	N	110	01101110	156	6E	n
15	00001111	017	0F	SI	47	00101111	057	2F	/	79	01001111	117	4F	O	111	01101111	157	6F	o
16	00010000	020	10	DLE	48	00110000	060	30	0	80	01010000	120	50	P	112	01110000	160	70	p
17	00010001	021	11	DC1	49	00110001	061	31	1	81	01010001	121	51	Q	113	01110001	161	71	q
18	00010010	022	12	DC2	50	00110010	062	32	2	82	01010010	122	52	R	114	01110010	162	72	r
19	00010011	023	13	DC3	51	00110011	063	33	3	83	01010011	123	53	S	115	01110011	163	73	s
20	00010100	024	14	DC4	52	00110100	064	34	4	84	01010100	124	54	T	116	01110100	164	74	t
21	00010101	025	15	NAK	53	00110101	065	35	5	85	01010101	125	55	U	117	01110101	165	75	u
22	00010110	026	16	SYN	54	00110110	066	36	6	86	01010110	126	56	V	118	01110110	166	76	v
23	00010111	027	17	ETB	55	00110111	067	37	7	87	01010111	127	57	W	119	01110111	167	77	w
24	00011000	030	18	CAN	56	00111000	070	38	8	88	01011000	130	58	X	120	01111000	170	78	x
25	00011001	031	19	EM	57	00111001	071	39	9	89	01011001	131	59	Y	121	01111001	171	79	y
26	00011010	032	1A	SUB	58	00111010	072	3A	:	90	01011010	132	5A	Z	122	01111010	172	7A	z
27	00011011	033	1B	ESC	59	00111011	073	3B	;	91	01011011	133	5B	[	123	01111011	173	7B	{
28	00011100	034	1C	FS	60	00111100	074	3C	<	92	01011100	134	5C	\	124	01111100	174	7C	|
29	00011101	035	1D	GS	61	00111101	075	3D	=	93	01011101	135	5D	]	125	01111101	175	7D	}
30	00011110	036	1E	RS	62	00111110	076	3E	>	94	01011110	136	5E	^	126	01111110	176	7E	~
31	00011111	037	1F	US	63	00111111	077	3F	?	95	01011111	137	5F	_	127	01111111	177	7F	DEL

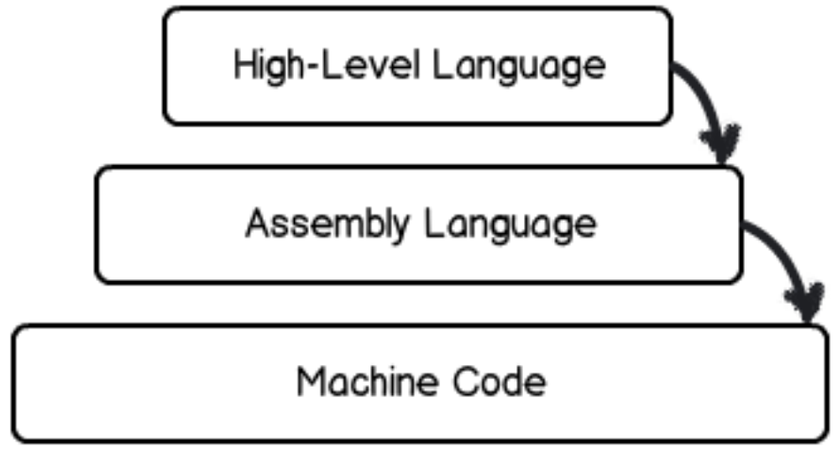
Ref: http://web.alfredstate.edu/faculty/weimandn/miscellaneous/ascii/ascii_index.html

Communicating with Computers

- Humans do not communicate in binary.

- We code in human-readable **programming languages**
  - Allow us to express programs in a way that is closer to natural languages
  - Provide libraries of commonly-used sub-tasks (functions)
  - **Translate high level code into machine code** through compilers or interpreters

- Given a language providing…
  - function definitions and calls, f(x)
  - a library function, print(“text”)
  - comparisons, x == y
  - assignments, x = y
  - conditional statements, if (condition) ... else …



Ref: http://shawnbiddle.com/js101/slides/class1.html#/6

Why do we choose Python?

- Relatively **simple syntax**.
- Relatively easy to **debug**.
- **Availability of open-source tools** and modules/libraries for eclectic applications with **large development community.**
- **Platform agnostic** (runs anywhere).
- **Broad application spectrum**, e.g. web applications / frameworks, standalone applications, video games, data science, artificial intelligence, machine learning, embedded systems etc.

Getting and Learning Python

- **Python Official Website: http://www.python.org**

- Virtual environments with prebuilt Python modules:
  - **Anaconda: https://www.anaconda.com/products/individual**
  - **Jupyter: https://jupyter.org/install**

- Standalone Python IDEs:
  - **Pycharm: https://www.jetbrains.com/pycharm/**
  - **Thonny: https://thonny.org**

- Browser-based Python IDEs:
  - **Google Colab: https://colab.research.google.com**
  - **Trinket: https://trinket.io/python**

- Tutorials (basic syntax and semantics):
  - **Official Tutorial: https://docs.python.org/3/tutorial/**
  - **Tutorial by Bucky Roberts: https://www.youtube.com/playlist?list=PL6gx4Cwl9DGAcbMi1sH6oAMk4JHw91mC_**
  - **Google: https://developers.google.com/edu/python/**

Python Basics: Variables, Types & Operators

- **What is a Variable?**
  A variable is a place in memory, which has a name, and where you can store a value (a number, phrase, etc.).

- **Assigning Values to Variables:**
  - Python variables are declared automatically when you assign a value to a variable.
  - The equal sign (=) is used to assign values to variables.

- **Values may be of different "types"**

```
In [1]: temperatureF = 78
```

- **Operators perform arithmetic and logical operations over variables and values.**

Interacting with the External World
(Users, and Files)

- Printing to the Screen (Hello World!)

```
>>> print "Python is really a great language,", "isn't it?";
Python is really a great language, isn't it?
```

- Reading Keyboard Input: *raw_input([prompt])*

```
# file.py
str = raw_input("Enter your input: ");
print "Received input is : ", str
```

```
Enter your input: Hello Python
Received input is :  Hello Python
```

- Reading and Writing Files

```
#!/usr/bin/python

# Open a file
fo = open("foo.txt", "wb")
fo.write( "Python is a great language.\nYeah its great!!\n");

# Close opend file
fo.close()
```

```
#!/usr/bin/python

# Open a file
fo = open("foo.txt", "r+")
str = fo.read(10);
print "Read String is : ", str
# Close opend file
fo.close()
```

Ref: *http://www.tutorialspoint.com/*

Python Basics: Functions

- **Defining and Calling Functions:**
  - A **function** is a block of organized, *reusable* code that is used to perform a single, related action.
  - Functions provides better *abstraction* and *modularity* for your application and a high degree of code reusing
    - Makes your code simpler and easier to read!
  - Calling a function: Once the basic structure is finalized, you can execute it by calling it from another function or directly from the Python prompt.

Defining Functions

- By defining a function, we can put a routine into this function, and we will be able to execute this routine simply by calling this function.

- For example, we introduce a function “add5”, which add t onto the integer we passed into the function.

- Example:

```
In [58]: def add5(x):
             return x+5
```

- In this function, x is the integer we passed into the function. And the function will return the value of x+5 back.

Calling the Function

- To call the function add5 we just defined, we simply do:

```
In [59]: result = add5(10)
         result

Out[59]: 15
```

  - By passing number 10 into the add5 function, 5 is added.
  - The result then equals to 15.

❖PYTHON PROGRAMMING CAN BE YOUR CALCULATOR!

Exercise A – Printing to the Screen

- Open the Jupyter Notebook in Google Colab.
- We will discuss the section titled “The Very First Step” (Exercise 0).
- We will complete the section titled “The Very First Step” (Exercise 0).

Python Operators

- **What is an operator?**
  - Python operators are very similar to the mathematical operators we use everyday. For example, +, -, *…

Python Basic Operators

- **Python Operator Types:**
    - Arithmetic Operator
    - Comparison Operators
    - Logical (or Relational) Operators
    - Assignment Operator

Python Arithmetic Operators

Assume variable **a** holds 10 and variable **b** holds 20 then:

Addition	a **+** b = 30
Subtraction	b **–** a = 10
Multiplication	a ***** b = 200
Division	b **/** a = 2
Reminder	b **%** a = 0
Exponent	a ****** b = 10^{20}

In [3]:
```
temperatureC = (temperatureF - 32)*0.5556
print(temperatureC)
```

```
25.5576
```

Python Comparison Operators

Assume variable **a** holds 10 and variable **b** holds 20 then:

Equality	a == b = False
Inequality	a != b = True
Less than	a < b = True
Greater than	a > b = False
Less than or equal	a <= b = True
Greater than or equal	a >= b = False

```
In [4]: temperatureF > 80

Out[4]: False
```

Python Logical Operators

Assume variable **a** holds True and variable **b** holds False then:

Logical AND	a **and** b = False
Logical OR	a **or** b = True
Logical NOT	**not** a = False

```
In [9]: humidity = 50
        temperatureF > 80 or humidity > 30

Out[9]: True
```

Python Data Types

- In computer programming, a data type is a classification identifying one of various types of data, just like in real life we separate words “Hello!” and numbers “12345”.

- **Standard Data Types in Python:**
  - **Numbers**, e.g., 1000
  - **String**, e.g., “Hello world!”
  - **Boolean** e.g. True
  - **List**, a container e.g., [365, 12, 30]
  - **Dictionary**, a key-indexed container.

Python Types: Numbers

- **Numbers**

  - Store numeric values,
  - Example:

```
In [1]: width = 20
        height = 15
        width * height

Out[1]: 300
```

  - In this example, “width = 20” defines variable width to be 20, and “height = 15” defines height to be 15. This sort of number is called **integer** or **int**.

  - After initializing width and height, we can calculate width * height as shown in the example.

  - To use real numbers (also called **float / double**), add a dot:

```
In [10]: width = 20.5
         height = 15.25
         width * height

Out[10]: 312.625
```

Python Types: Lists

- **Lists:**
  - Lists are the most versatile of Python's compound data types. A list contains items separated by commas and enclosed within square brackets.
  - Example:

```
In [2]: a = ['blue', 'red', 100, 365]
        a
Out[2]: ['blue', 'red', 100, 365]
```

  - In this example, we assign four items to list a. The items are string 'blue', string 'red', number 100, and number 365.
  - We print a's items in the second command, and get its four items printed.
  - Note that items in the list have different types (string and int) – this is not common among programming languages.

Python Types: Lists

- **Lists:**
  - It is possible to change individual elements of a list.
  - Example:

```
In [7]: a = ['blue', 'red', 100, 365]
        a[2] = a[2] + 50
        a[2]

Out[7]: 150
```

Note that list's subscript starts from 0

  - In this example we modify the **third** element in the list by adding 50 to its value
  - We then print the third element by using *name*[*index*]

Python Types: Lists

- **Lists:**
  - Many “operations” and “methods” available for lists:

Is the value in the list?	100 in a = True
Is the value not in the list?	‘yellow’ not in a = True
Length of the list	len(a) = 4
Index of an element	a.index(‘red’) = 1
Append element	a.append(10)
Reverse the list	a.reverse()

+ sort, concatenate, insert, sum and many more at:
https://docs.python.org/2/tutorial/datastructures.html#more-on-lists

Python Types: Range

- **Creating number sequences:**
  - **range(n)** for integer n > 0 returns the list [0, 1, … n-1]

```
In [26]: a = range(10)
         print(*a)
```

```
0 1 2 3 4 5 6 7 8 9
```

  - **range(m,n)** returns the list [m, m+1, … n-1]

```
In [31]: a = range(5,10)
         print(*a)
```

```
5 6 7 8 9
```

  - **range(m,n,o)** returns the list [m, m+o, … n-1]

```
In [32]: a = range(0,10,2)
         print(*a)
```

```
0 2 4 6 8
```

Exercise B – Lists, Variables and Data Types

- Open the Jupyter Notebook in Google Colab.
- We will discuss the section titled “Variables and Types” (Exercise 1, 2 and 3).
- We will complete the section titled “Variables and Types” (Exercise 1, 2 and 3).

Python Types: Strings

- **Strings:**
  - Strings in Python are identified as a contiguous set of characters in between quotation marks.
  - Example:

```
In [34]: string = "ABCDEFG."
         string
Out[34]: 'ABCDEFG.'
```

  - In this example, we assign “ABCDEFG.” to variable string. And we print string.
  - The result we get is still “ABCDEFG.”
  - You can use double “ or single ‘ quotation marks for strings in Python, they are equivalent.

Python Types: Strings

- **Strings:**

  ○ Strings can be subscripted (indexed). This is because they are essentially lists of characters.

  ○ Example: In the string defined as str = “ABCDEFG.”, we query the **fifth** letter in this string.

```
In [35]: string = "ABCDEFG."
         string[4]

Out[35]: 'E'
```

Because it’s a list, first letter has index 0

Python Types: Strings

- **Strings:**
  - Many “operations” and “methods” available for strings:

Is the letter in the string?	‘A’ in string = True
Is the substring in the string?	‘CDE’ in string = True
Length of the string	len(string) = 8
Index of a letter (first)	string.index(‘A’) = 0
Append element	string + “Z” = “ABCDEFG.Z”
Make lowercase	string.lower() = “abcdefg.”

and many more at
https://docs.python.org/2/library/stdtypes.html#string-methods

Python Types: Dictionaries

- **Dictionaries:**
  - Represents a set of key-value pairs where keys are unique (i.e. numbers, strings) but values need not be. It's not ordered.
  - Example:

```
In [54]: D = {'Name': 'Zara', 'Age': 7, 'Class': 'First'}
         print ('Name: ' + D['Name'])
         print ('Age: '  + str(D['Age']))

Name: Zara
Age: 7
```

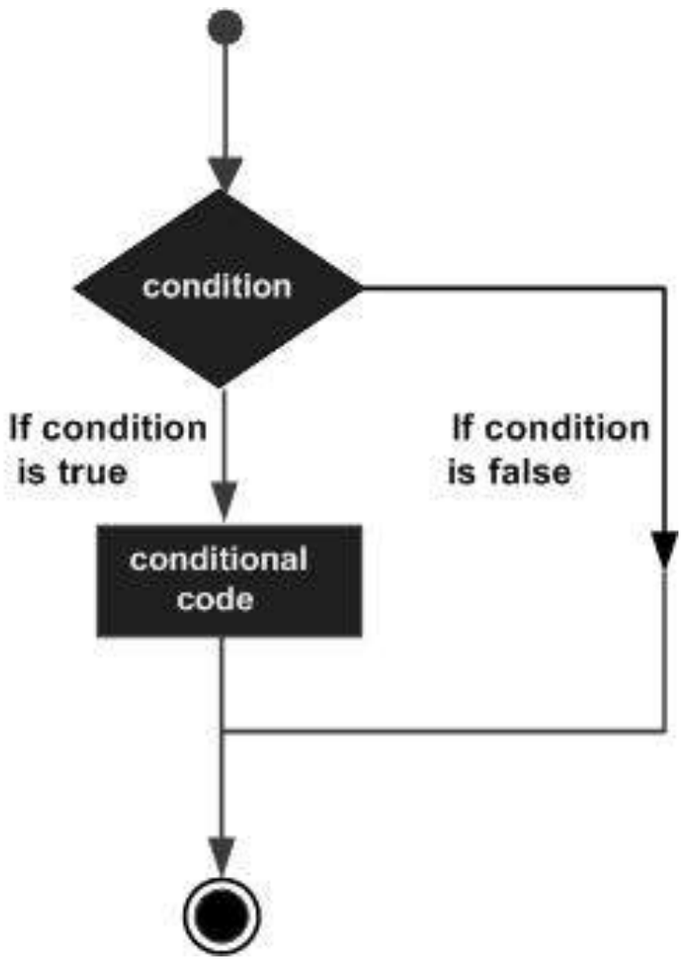
  - Updating a dictionary

```
In [56]: D = {'Name': 'Zara', 'Age': 7, 'Class': 'First'}
         D['Age'] = 8 # Update entry
         D['School'] = 'UCLA' # Add new entry
         D

Out[56]: {'Age': 8, 'Class': 'First', 'Name': 'Zara', 'School': 'UCLA'}
```

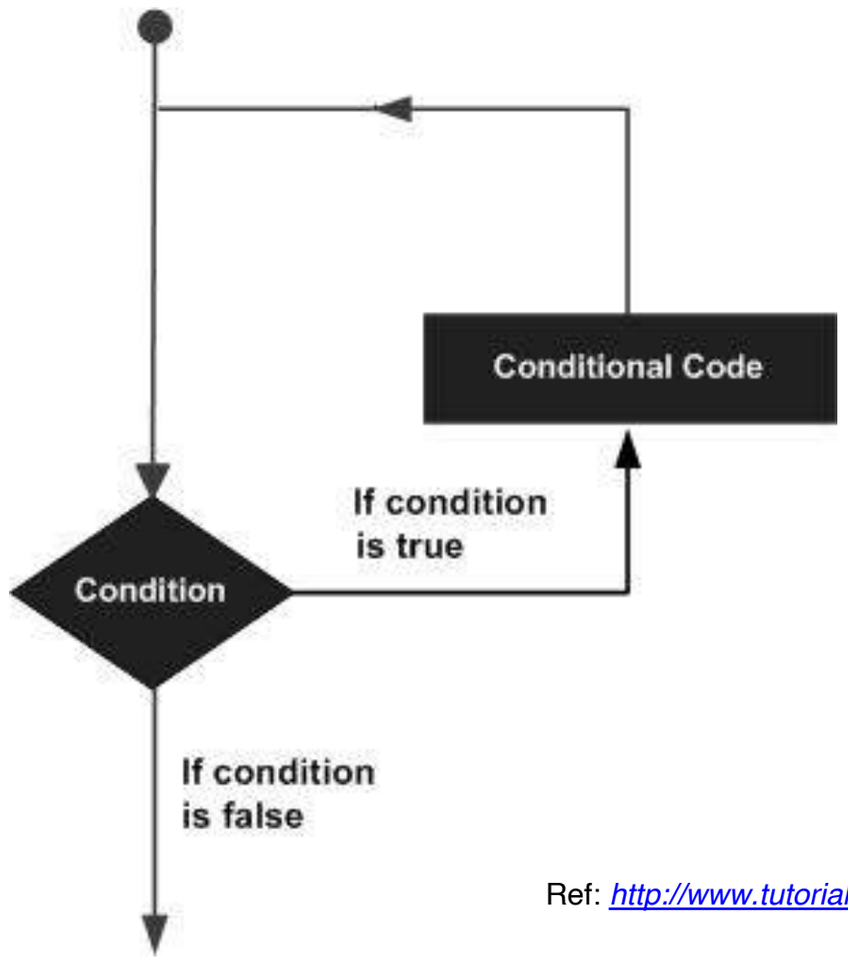
Beyond Sequential Execution: Control Flow Tools

- Programming languages provide various control structures that allow for more complicated execution paths instead of just sequential
  - *Make decisions* on what to do *dynamically* while the program runs!

If…then



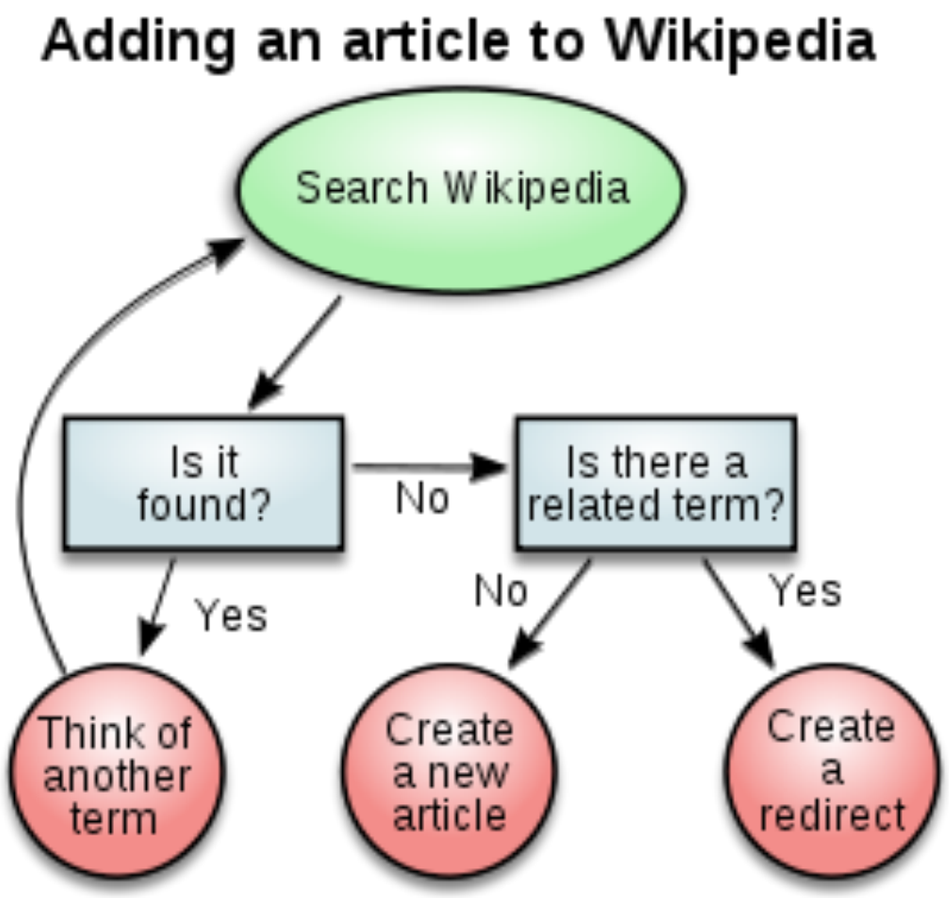
Loop



Ref: http://www.tutorialspoint.com/

Python Basics: Decision Making

- **Decision Making:**
  - Conditional constructs are used to incorporate *decision making* into programs.
  - The result of this decision making determines the sequence in which a program will execute **instructions**.



Python Basics: Decision Making

- ***if* Statement**
  - The **if** statement contains a logical expression using which data is compared, and a decision is made based on the result of the comparison.

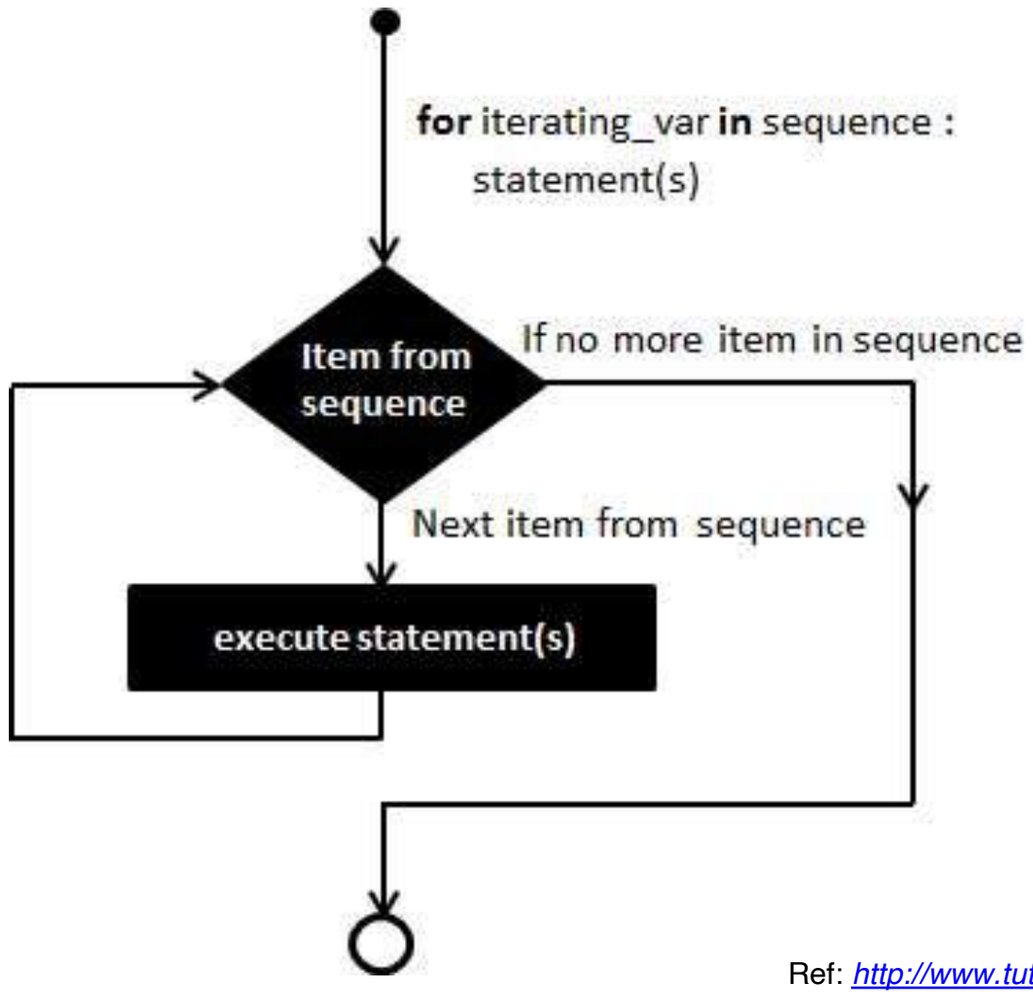
  - Example:

```
>>> x = int(raw_input("Please enter an integer: "))
Please enter an integer: 42
>>> if x < 0:
...     x = 0
...     print 'Negative changed to zero'
... elif x == 0:
...     print 'Zero'
... elif x == 1:
...     print 'Single'
... else:
...     print 'More'
...
More
```

  - In this example, we input integer 42, which is not less than 0, not equal to 0, and not equal to 1. Therefore, it falls into the option that “print ‘More’”.
  - Any non-zero and non-null values are treated as TRUE by Python

Python Basics: Looping

- ***for*** **statement**
  - The **for** loop in Python has the ability to iterate over the items of any sequence, such as a list, tuple, or a string.



Ref: *http://www.tutorialspoint.com/*

Python Basics: Looping

- ***for*** **statement**
  - The **for** loop in Python has the ability to iterate over the items of any sequence, such as a list or a string.

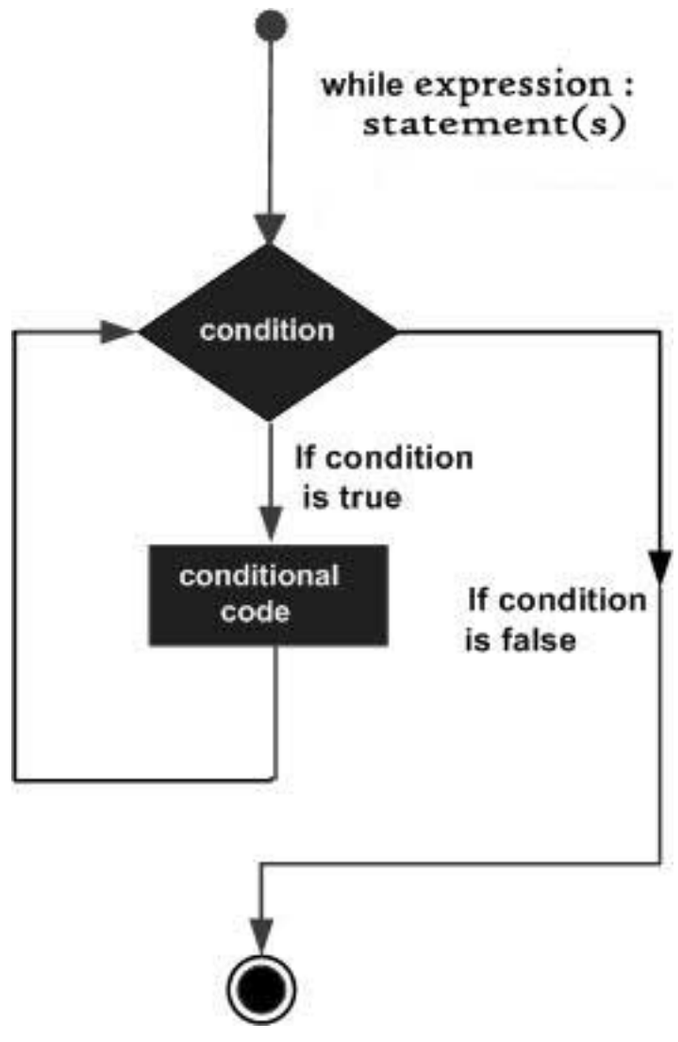
  - Example:

```
>>> # Measure some strings:
... a = ['cat', 'window', 'defenestrate']
>>> for x in a:
...     print x, len(x)
...
cat 3
window 6
defenestrate 12
```

  - In this example, all the items in list a get printed.
  - *len(x)* is a built-in function in Python, which returns the length of x.
  - In this example, x is a string, such as “cat”. len(x) returns “cat”’s length, which is 3.

Python Basics: Looping

- ***while*** **statement**
  - The **while** loop in Python has the ability to iterate over a statement or group of statements while a given condition is TRUE



Ref: *http://www.tutorialspoint.com/*

Python Basics: Looping

- ***while*** **statement**
  - The **while** loop in Python has the ability to iterate over a statement or group of statements while a given condition is TRUE

  - Example:

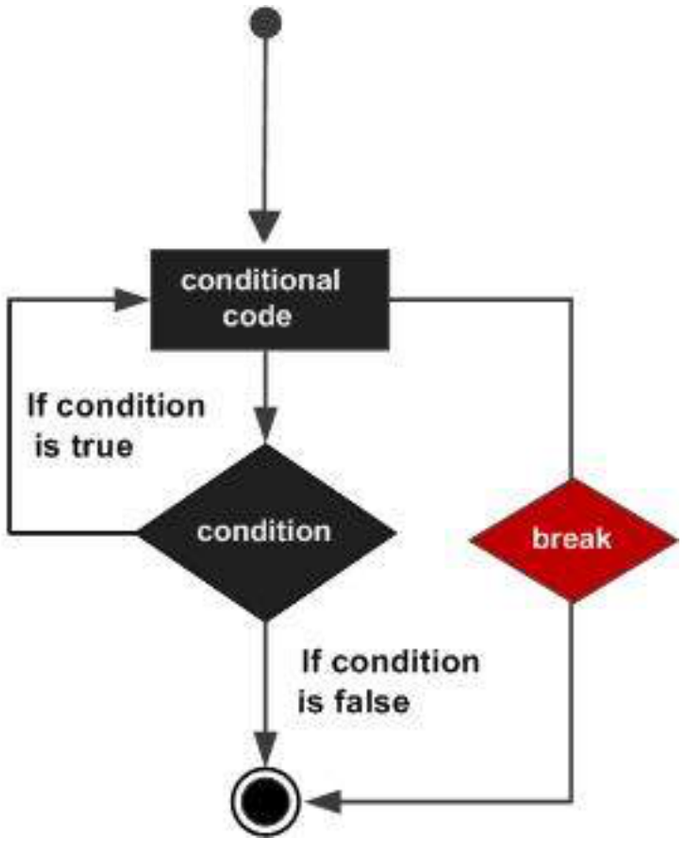
```
count = 0
while (count < 9):
   print 'The count is:', count
   count = count + 1

print "Good bye!"
```

```
The count is: 0
The count is: 1
The count is: 2
The count is: 3
The count is: 4
The count is: 5
The count is: 6
The count is: 7
The count is: 8
Good bye!
```

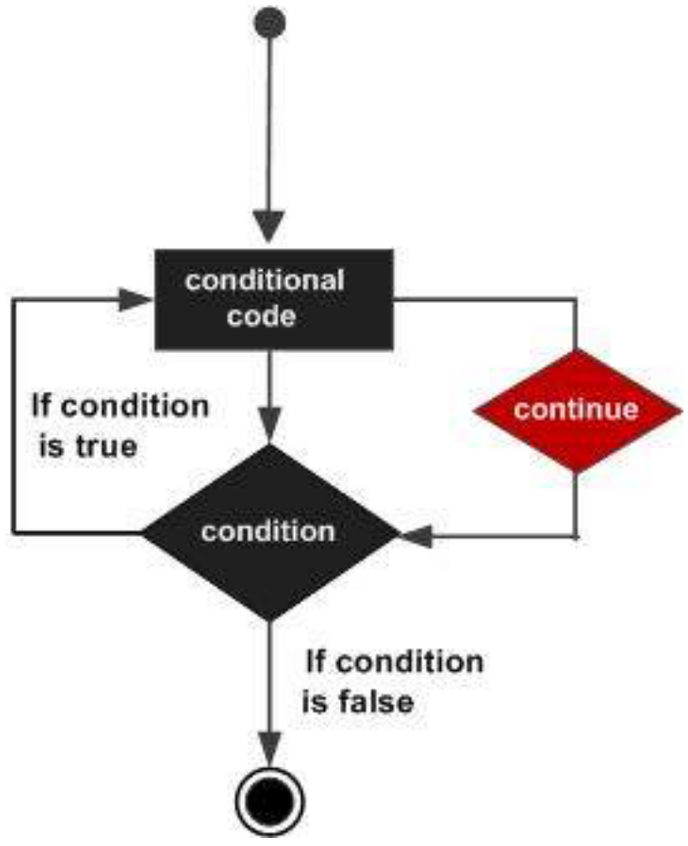
Ref: *http://www.tutorialspoint.com/*

  - Caution: “infinite loop” if a condition never becomes false.

Python Basics: Loop Control Statements




```
for letter in 'Python':
   if letter == 'h':
      break
   print 'Current Letter :', letter
```




```
for letter in 'Python':
   if letter == 'h':
      continue
   print 'Current Letter :', letter
```

Ref: *http://www.tutorialspoint.com/*

Exercise C – Looping

- Open the Jupyter Notebook in Google Colab.
- We will discuss the sections titled “A Simpler way to print: Using for loops”, “Interacting with the outside world: I/O” and “if Checks” (Exercise 4, 5 and 6).
- We will complete these sections as well (Exercise 4, 5 and 6).

Python Modules and Namespaces

- A **module** is a file consisting of Python code which can define functions, variables etc.
  - The code for a module named *mname* normally resides in the file *mname.py* which is searched for in selected folders on the computer
  - Any Python source file can be used as as a module by executing an **import** statement in some other Python source file.

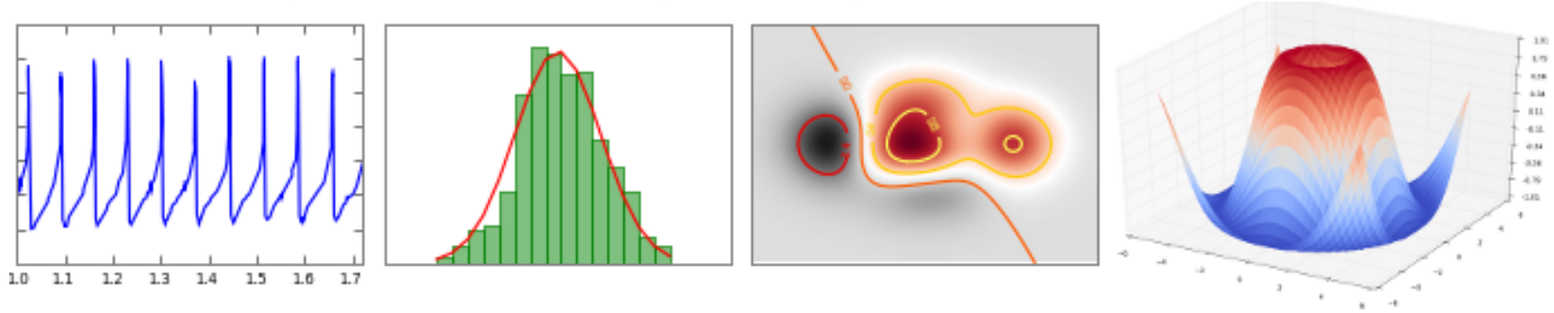
```
# file: support.py
def print_func( par ):
   print "Hello : ", par
   return
```

```
# some other file
import support
# Now one can call function defined in that module as follows
support.print_func("Zara")
```

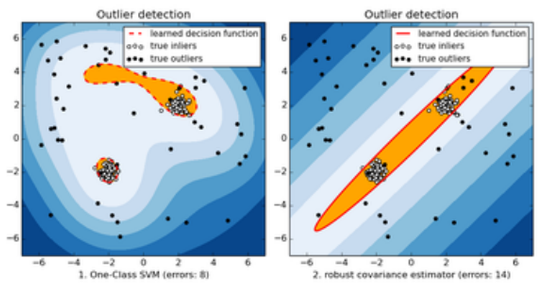
- To prevent confusion with same variable and function names being used in different modules, they belong to a module's **namespace** which is a dictionary of variable names (keys) and their corresponding objects (values).
- Each function has its own *local namespace*, and a Python statement can directly access variables in the *local namespace* and in a *global namespace*.

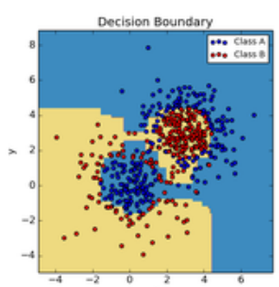
Some Very Useful Python Modules

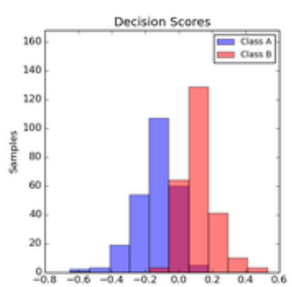
- **matplotlib:** a python plotting library

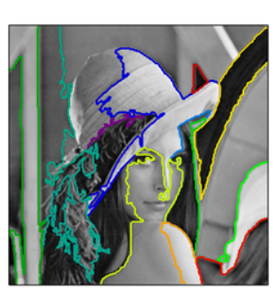


- **NumPy:** computing with n-dimensional arrays
- **Tensorflow**: AI, machine learning and data science
- **SciPy:** data science, numerical integration and optimization
- **Sympy:** symbolic mathematics
- **scikit-learn:** data mining and machine learning









- **pygame, pyget:** games
- and many many more…

Exercise D – Wrapping Up

- Open the Jupyter Notebook in Google Colab.
- We will discuss the section titled “The Game Loop: while loop” (Exercise 7).
- We will complete the section as well. (Exercise 7).

Python: Object Oriented Programming

- Class: Bundle together data and functions
- Class
  - We focus on the functionality
  - Think in terms of objects (Entities when building systems)

Eg: Student record management at UCLA

- Entities
  - Student
  - ECE-Student

1. ECE-Student uses capabilities defined in Student
2. Student: Group together data and function

Python Abstractions

- Classes can be used to build very powerful abstractions
- Complete libraries are built using them

Example System: https://github.com/ARM-software/mango