# Lecture 1

## Introduction to Python

UTAS
Sultanate of Oman
September 2022

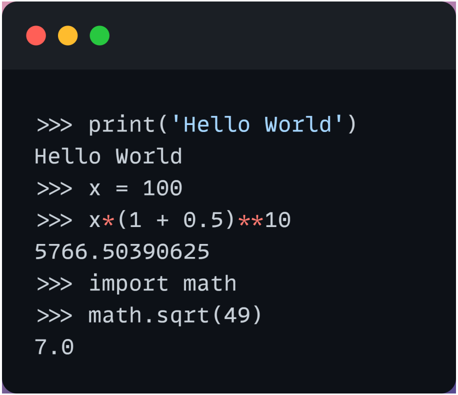
CSSY2201 : Introduction to Cryptography

# Plan

1. Python Basics
   - Operators
   - Conditional Statements
   - Loops
   - Built-in Data Types in Python
   - Functions
2. Manipulating Files
3. Modules
   - Manage modules
   - Virtual environments
4. Data Encoding
   - ASCII
   - Base64
   - utf-8

# test the installation of python

Type the following on the shell



```
>>> print('Hello World')
Hello World
>>> x = 100
>>> x*(1 + 0.5)**10
5766.50390625
>>> import math
>>> math.sqrt(49)
7.0
```

# Names in Python

Names in Python are **case sensitive** and cannot start with a number. They can contain letters, numbers, and underscores. Some examples include :

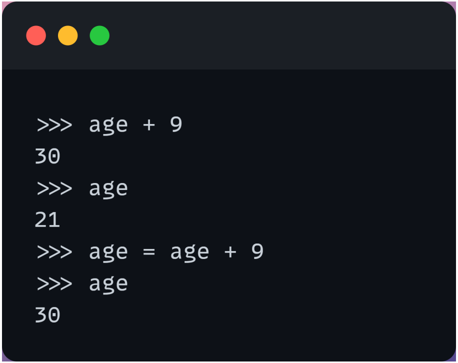
- alice
- Alice
- _alice
- _2_alice_
- alice_2

The language includes a number of reserved words, such as `and`, `assert`, `break`, `class`, `continue`, `def`, `del`, `elif`, `else`, `except`, `exec`, `finally`, `for`, `from`, `global`, `if`, `import`, `in`, `is`, `lambda`, `not`, `or`, `pass`, `print`, `raise`, `return`, `try`, `while`

# Variables

Values are stored in variables ; the use of a variable is signified by the = sign, which is also known as the assignment operator.

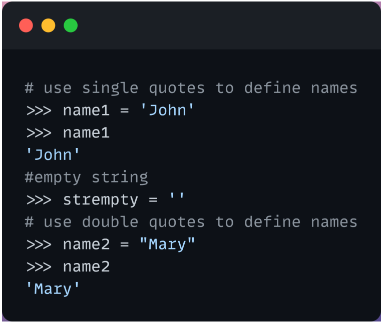
Variables can be overwritten or used in calculations. type into your shell :



```
>>> age + 9
30
>>> age
21
>>> age = age + 9
>>> age
30
```

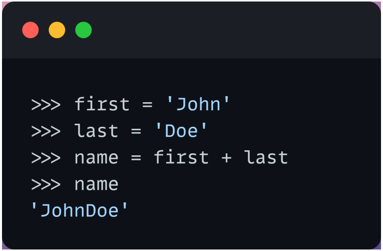
# Strings

Using Strings



```
# use single quotes to define names
>>> name1 = 'John'
>>> name1
'John'
#empty string
>>> strempty = ''
# use double quotes to define names
>>> name2 = "Mary"
>>> name2
'Mary'
```

Strings concatenation with + symbol



```
>>> first = 'John'
>>> last = 'Doe'
>>> name = first + last
>>> name
'JohnDoe'
```

# Arithmetic Operators

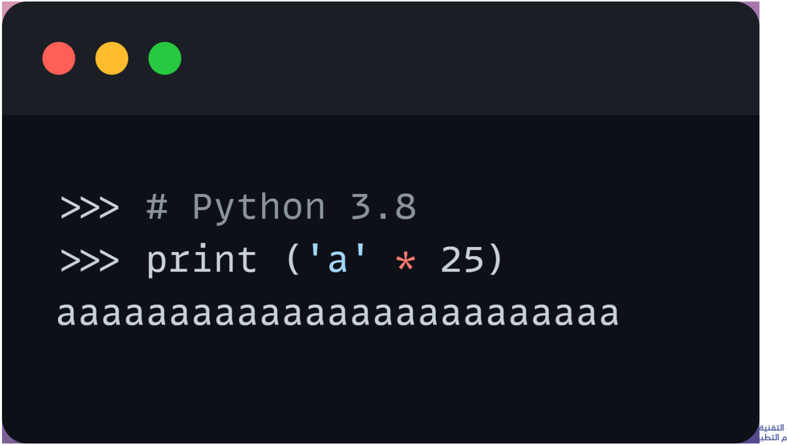
| OPERATOR | DESCRIPTION | EXAMPLE |
|---|---|---|
| + | Addition | 10 + 20 will give 30 |
| - | Subtraction | 10 - 5 will give 5 |
| * | Multiplication | 10 * 10 will give 100 |
| / | Division | 10 / 2 will give 5 |
| % | Modulus | 20 % 10 will give 0 |
| ** | Exponent | 10**2 will give 100 |
| // | Floor Division | 9//2 is equal to 4 and 9.0//2.0 is equal to 4.0 |

## Examples for mod operator % :

| EXPRESSION | DESCRIPTION | SYNTAX |
|---|---|---|
| `28 (mod 26)` | 28 is equivalent to 2 mod 26 | `28 % 26` |
| `29 (mod 26)` | 29 is equivalent to 3 mod 26 | `29 % 26` |
| `30 (mod 26)` | 30 is equivalent to 4 mod 26 | `30 % 26` |

# Multiplication Operator with the strings

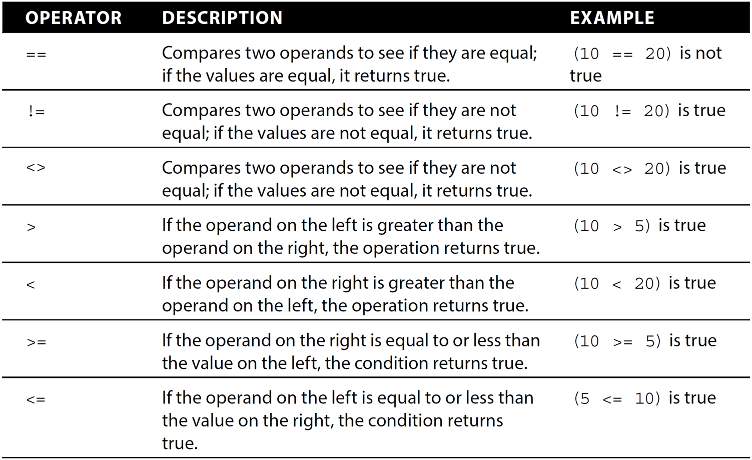
Use the $*$ operator to create specifically formatted strings that may be used in some attacks such as buffer overflows.



```
>>> # Python 3.8
>>> print ('a' * 25)
aaaaaaaaaaaaaaaaaaaaaaaaa
```

# Comparison Operators

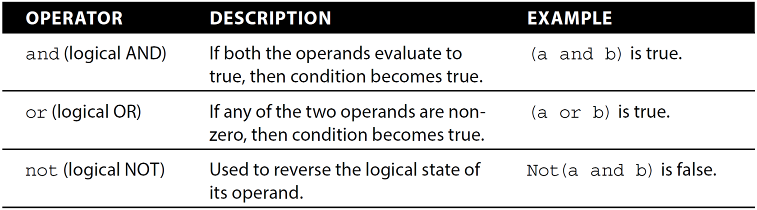
also known as relational operators, compare the operands (values) on either side and return true or false based on the condition



| OPERATOR | DESCRIPTION | EXAMPLE |
|---|---|---|
| `==` | Compares two operands to see if they are equal; if the values are equal, it returns true. | `(10 == 20)` is not true |
| `!=` | Compares two operands to see if they are not equal; if the values are not equal, it returns true. | `(10 != 20)` is true |
| `<>` | Compares two operands to see if they are not equal; if the values are not equal, it returns true. | `(10 <> 20)` is true |
| `>` | If the operand on the left is greater than the operand on the right, the operation returns true. | `(10 > 5)` is true |
| `<` | If the operand on the right is greater than the operand on the left, the operation returns true. | `(10 < 20)` is true |
| `>=` | If the operand on the right is equal to or less than the value on the left, the condition returns true. | `(10 >= 5)` is true |
| `<=` | If the operand on the left is equal to or less than the value on the right, the condition returns true. | `(5 <= 10)` is true |

# Logical Operators

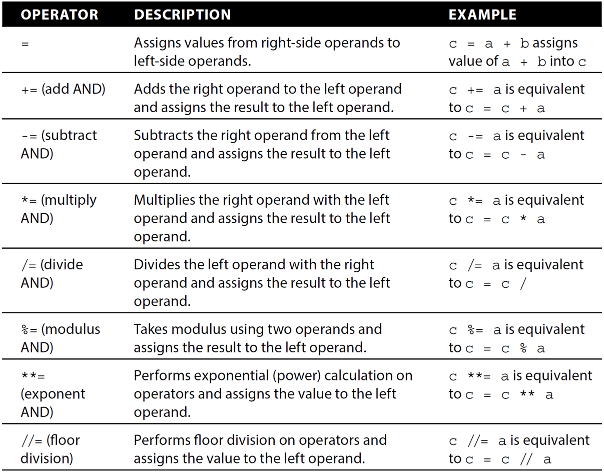
`and`, `or` and `not`



| OPERATOR | DESCRIPTION | EXAMPLE |
|---|---|---|
| `and` (logical AND) | If both the operands evaluate to true, then condition becomes true. | `(a and b)` is true. |
| `or` (logical OR) | If any of the two operands are non-zero, then condition becomes true. | `(a or b)` is true. |
| `not` (logical NOT) | Used to reverse the logical state of its operand. | `Not(a and b)` is false. |

# Assignment Operators

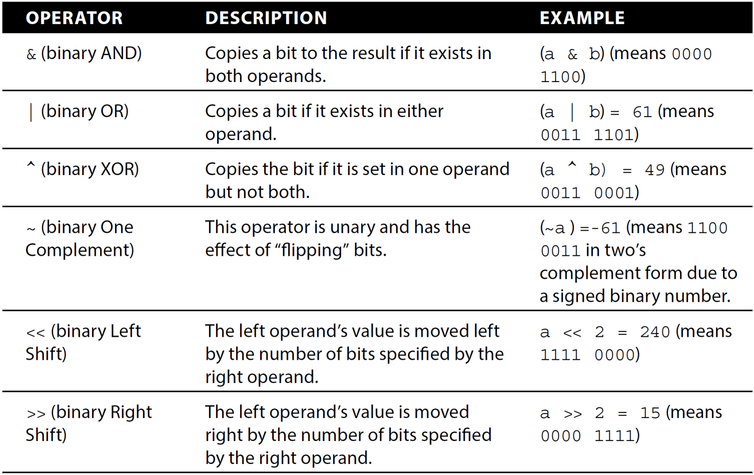
In addition to using the equal sign, Python offers many assignments that work as a shorthand for more extended tasks.



| OPERATOR | DESCRIPTION | EXAMPLE |
|---|---|---|
| = | Assigns values from right-side operands to left-side operands. | `c = a + b` assigns value of `a + b` into `c` |
| += (add AND) | Adds the right operand to the left operand and assigns the result to the left operand. | `c += a` is equivalent to `c = c + a` |
| -= (subtract AND) | Subtracts the right operand from the left operand and assigns the result to the left operand. | `c -= a` is equivalent to `c = c - a` |
| *= (multiply AND) | Multiplies the right operand with the left operand and assigns the result to the left operand. | `c *= a` is equivalent to `c = c * a` |
| /= (divide AND) | Divides the left operand with the right operand and assigns the result to the left operand. | `c /= a` is equivalent to `c = c /` |
| %= (modulus AND) | Takes modulus using two operands and assigns the result to the left operand. | `c %= a` is equivalent to `c = c % a` |
| **= (exponent AND) | Performs exponential (power) calculation on operators and assigns the value to the left operand. | `c **= a` is equivalent to `c = c ** a` |
| //= (floor division) | Performs floor division on operators and assigns the value to the left operand. | `c //= a` is equivalent to `c = c // a` |

# Bitwise Operators

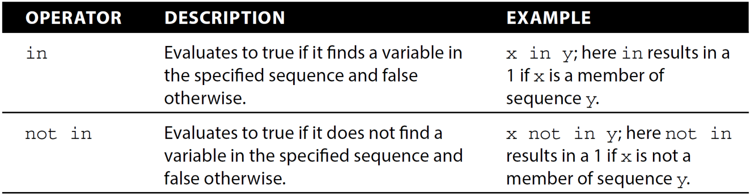
The bitwise operators work on bits and perform bit-by-bit operations.



| OPERATOR | DESCRIPTION | EXAMPLE |
|---|---|---|
| & (binary AND) | Copies a bit to the result if it exists in both operands. | (a & b) (means 0000 1100) |
| \| (binary OR) | Copies a bit if it exists in either operand. | (a \| b) = 61 (means 0011 1101) |
| ^ (binary XOR) | Copies the bit if it is set in one operand but not both. | (a ^ b) = 49 (means 0011 0001) |
| ~ (binary One Complement) | This operator is unary and has the effect of "flipping" bits. | (~a ) =-61 (means 1100 0011 in two's complement form due to a signed binary number. |
| << (binary Left Shift) | The left operand's value is moved left by the number of bits specified by the right operand. | a << 2 = 240 (means 1111 0000) |
| >> (binary Right Shift) | The left operand's value is moved right by the number of bits specified by the right operand. | a >> 2 = 15 (means 0000 1111) |

# Membership Operators

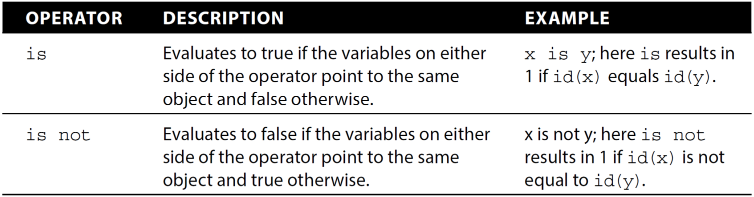
Membership operators test for membership in a sequence, such as strings, lists, or tuples.



| OPERATOR | DESCRIPTION | EXAMPLE |
|---|---|---|
| `in` | Evaluates to true if it finds a variable in the specified sequence and false otherwise. | `x in y`; here `in` results in a 1 if `x` is a member of sequence `y`. |
| `not in` | Evaluates to true if it does not find a variable in the specified sequence and false otherwise. | `x not in y`; here `not in` results in a 1 if `x` is not a member of sequence `y`. |

# Identity Operators

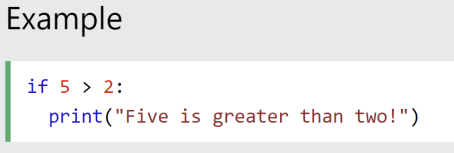
Identity operators compare the memory locations of two objects.



| OPERATOR | DESCRIPTION | EXAMPLE |
|---|---|---|
| `is` | Evaluates to true if the variables on either side of the operator point to the same object and false otherwise. | `x is y`; here `is` results in 1 if `id(x)` equals `id(y)`. |
| `is not` | Evaluates to false if the variables on either side of the operator point to the same object and true otherwise. | x is not y; here `is not` results in 1 if `id(x)` is not equal to `id(y)`. |

# Python Indentation

- Indentation refers to the spaces at the beginning of a code line.
- Where in other programming languages the indentation in code is for readability only, the indentation in Python is very important.
- Python uses indentation to indicate a block of code.

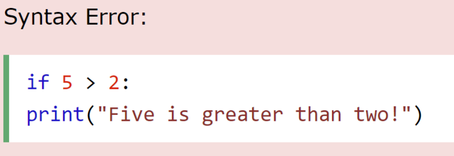


Example

```
if 5 > 2:
  print("Five is greater than two!")
```

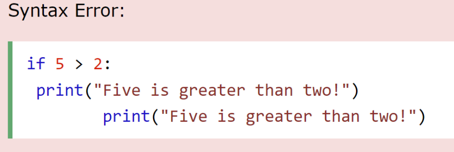
# Python Indentation

- These two examples will generate a syntax error



Syntax Error:

```
if 5 > 2:
print("Five is greater than two!")
```

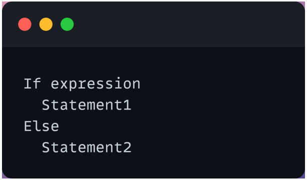


Syntax Error:

```
if 5 > 2:
 print("Five is greater than two!")
      print("Five is greater than two!")
```

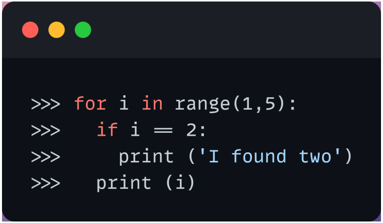
# IF, ELSE Statement

conditional statements perform different actions and decide whether a condition is true or false by the IF statement



```
If expression
  Statement1
Else
  Statement2
```

To use it in an actual program, type the following



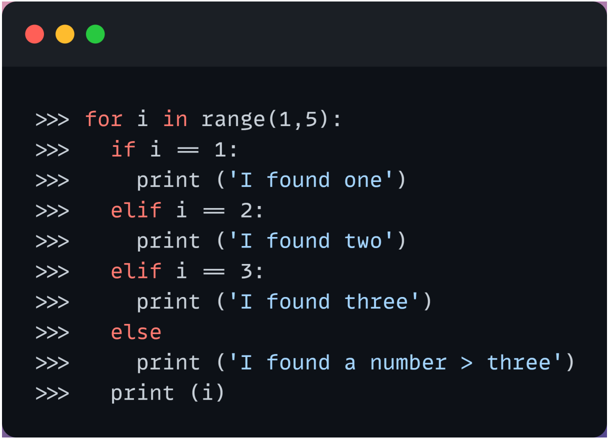
```
>>> for i in range(1,5):
>>>   if i == 2:
>>>     print ('I found two')
>>>   print (i)
```

# ELIF

Python also makes use of `ELSE` and `ELIF`.

`ELSE` will capture the execution if the condition is false.

`ELIF` stands for else if ;

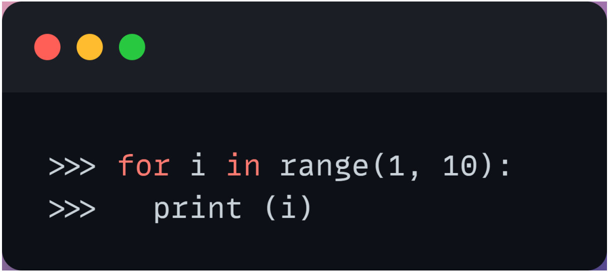


```
>>> for i in range(1,5):
>>>   if i == 1:
>>>     print ('I found one')
>>>   elif i == 2:
>>>     print ('I found two')
>>>   elif i == 3:
>>>     print ('I found three')
>>>   else
>>>     print ('I found a number > three')
>>>   print (i)
```

When you use scripting or programming languages, you can perform a set of statements in multiple repetitions. Loops give us the ability to run logic until a specific condition is met

# for loop

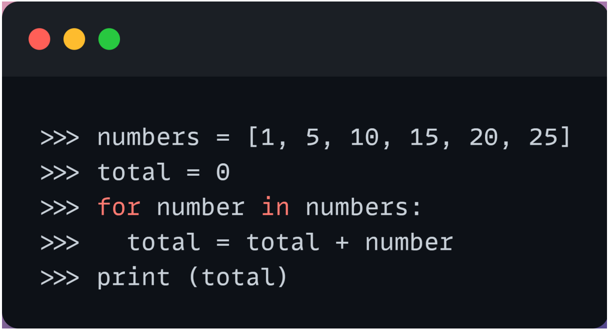
The for loop is used to iterate over a set of statements that need to be repeated n number of times. The for statement can be used to execute as a counter in a range of numbers. The following syntax prints out the values 1, 2, 3, 4, 5, 6, 7, 8, 9 :



```
>>> for i in range(1, 10):
>>>   print (i)
```

# for loop

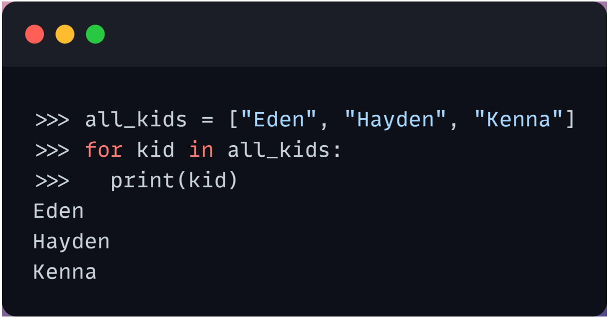
The for loop can also execute against the number of elements in a list. Examine the following snippet, which produces the result 76 :



```
>>> numbers = [1, 5, 10, 15, 20, 25]
>>> total = 0
>>> for number in numbers:
>>>   total = total + number
>>> print (total)
```

# for loop

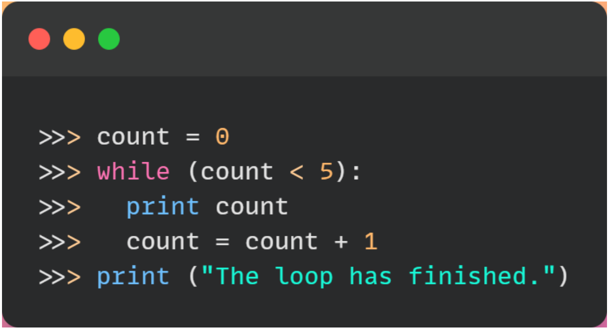
the same technique is useful against string arrays. The following outputs three names Eden, Hayden, and Kenna :



```
>>> all_kids = ["Eden", "Hayden", "Kenna"]
>>> for kid in all_kids:
>>>   print(kid)
Eden
Hayden
Kenna
```

# while loop

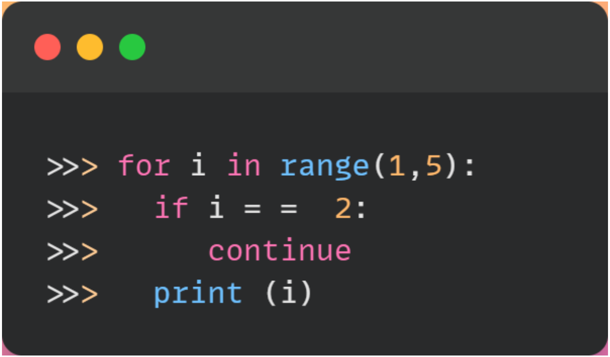
The while loop is used to execute a block of statements while a condition is true. The block of statements may be one or more lines. **The indentation** defines the block. Once a condition becomes false, the execution exits the loop and continues.



```
>>> count = 0
>>> while (count < 5):
>>>   print count
>>>   count = count + 1
>>> print ("The loop has finished.")
```

# continue statement

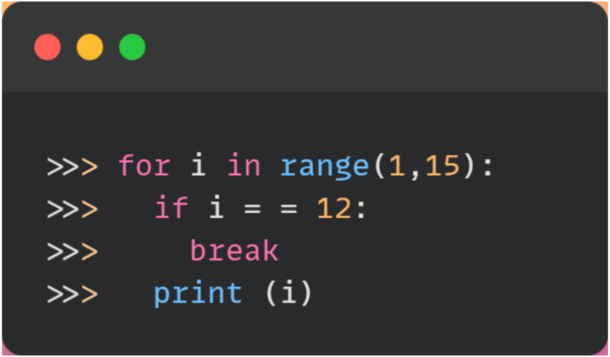
The continue statement is used to tell Python to skip the remaining statements in the current loop block and continue to the next iteration. The following snippet will produce an output of 1, 3, 4. The continue statement skips printing when i equals 2 :



```
>>> for i in range(1,5):
>>>   if i = =  2:
>>>      continue
>>>   print (i)
```

# break statement

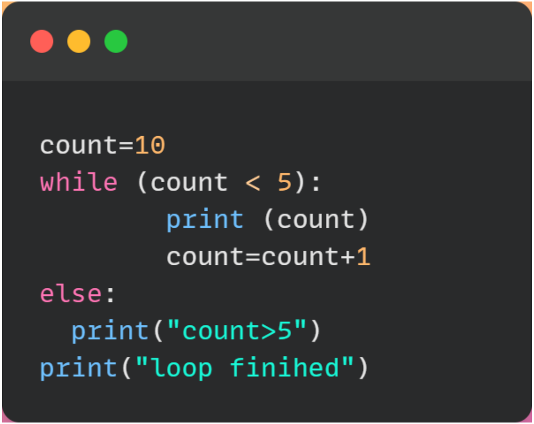
The break statement exits out from a loop. The following snippet produces an output of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11. Once i = 12, the loop is abandoned :



```
>>> for i in range(1,15):
>>>   if i = = 12:
>>>     break
>>>   print (i)
```

# else statement in loops

You can use the else statement in conjunction with the for and while loops to catch conditions that fail. Notice that since the count==10, the while loop does not execute. You should only see the two final print messages :



```
count=10
while (count < 5):
        print (count)
        count=count+1
else:
  print("count>5")
print("loop finihed")
```

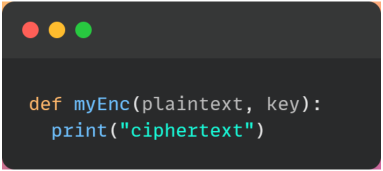
- Binary Types : memoryview, bytearray, bytes
- Boolean Type : bool
- Set Types : frozenset, set
- Mapping Type : dict
- Sequence Types : range, tuple, list
- Numeric Types : complex, float, int
- Text Type : str

You check for the datatype of a variable by the function `type()`

| Example | Data type |
|---|---|
| x = "Hello World" | str |
| x = 20 | int |
| x=31.6 | float |
| x=2j+3 | complex |
| x = ["apple", "banana", "cherry"] | list |
| x = ("apple", "banana", "cherry") | tuple |
| x = range(6) | range |
| x = {"name" : "John", "age" : 36} | dict |
| x = {"apple", "banana", "cherry"} | set |
| x = frozenset({"apple", "banana", "cherry"}) | frozenset |
| x = True | bool |
| x = b"Hello" | bytes |
| x = bytearray(5) | bytearray |
| x = memoryview(bytes(5)) | memoryview |

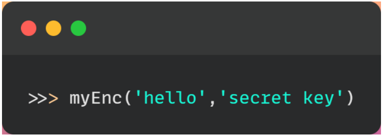
Functions are reusable code. You create a new function and assign it a name by using the `def` keyword.

Using an IDLE (ex Spyder) type :



```
def myEnc(plaintext, key):
  print("ciphertext")
```

Save the file as `MyFunctions.py`. and type in he command line :

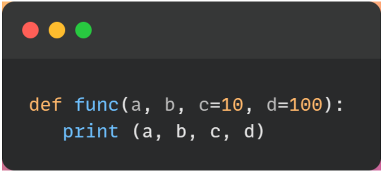


```
>>> myEnc('hello','secret key')
```

the output should be `ciphertext`

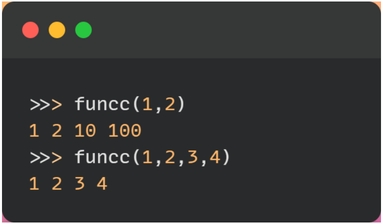
The `def` keyword is used to define the function myEnc. It takes 2 arguments and returns an output. We use functions to build logic we intend to use multiple times.

In Python, you can declare some arguments as **optional** :



```
def func(a, b, c=10, d=100):
   print (a, b, c, d)
```

when tested on the command line :



```
>>> funcc(1,2)
1 2 10 100
>>> funcc(1,2,3,4)
1 2 3 4
```

| Mode | Explanation |
|---|---|
| "r" | Read - Default value. Opens a file for reading, error if the file does not exist |
| "a" | Append - Opens a file for appending, creates the file if it does not exist |
| "w" | Write - Opens a file for writing, creates the file if it does not exist |
| "x" | Create - Creates the specified file, returns an error if the file exists |

You can specify if the file should be handled as binary or text mode

| | |
|---|---|
| "t" | Text - Default value. Text mode |
| "b" | Binary - Binary mode (e.g. images) |

Example : `f = open("demofile.txt")`

which is the same as :

```
f = open("demofile.txt", "rt")
```

Because `"r"` for read, and `"t"` for text are the default values, you do not need to specify them.

# read files

Use the read() method for reading the content of the file :

```
f = open("demofile.txt", "r")
print(f.read())
```

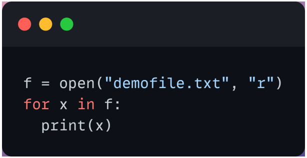
You can read the 5 first charachter of the file :

```
f = open("demofile.txt", "r")
print(f.read(5))
```

you can return one line by using the readline() method :

```
f = open("demofile.txt", "r") print(f.readline())
```

you can read the whole file, line by line :



```
f = open("demofile.txt", "r")
for x in f:
  print(x)
```

Use close() method to close the file after use :

```
f.close()
```

# write in a file

To write to an existing file, you must add a parameter to the open() function :

- Open the file "demofile2.txt" and append content to the file :

  ```
  f = open("demofile2.txt", "a")
  f.write("Now the file has more content!")
  f.close()
  ```

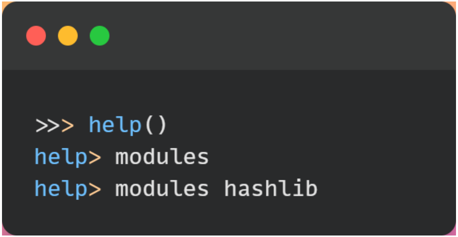
- Open the file "demofile3.txt" and overwrite the content :

  ```
  f = open("demofile3.txt", "w")
  f.write("Woops! I have deleted the content!")
  f.close()
  ```

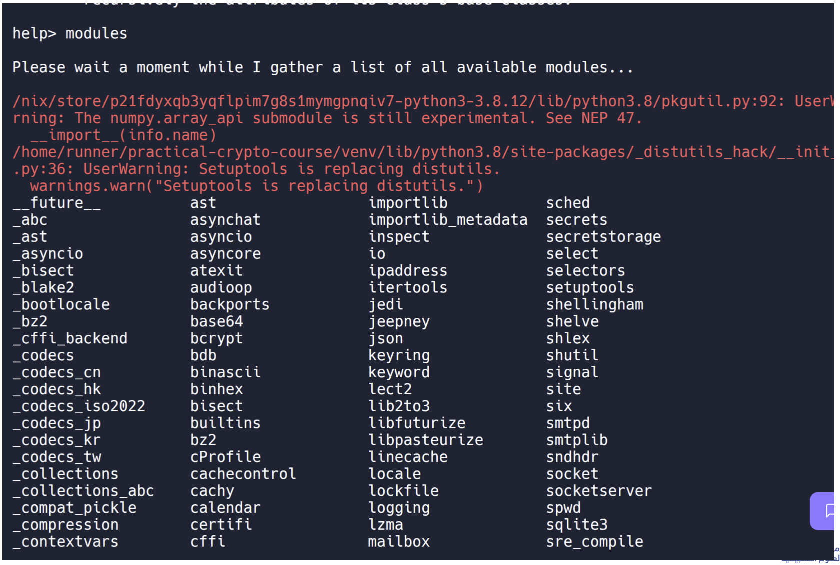
- Create a file called "myfile.txt" :

  ```
  f = open("myfile.txt", "x")
  ```

Python modules are special packages that extend the language. when a module is preinstalled, we can use the `import` command to upload it. To examine the modules that are preinstalled on your system, type the following in the command line :



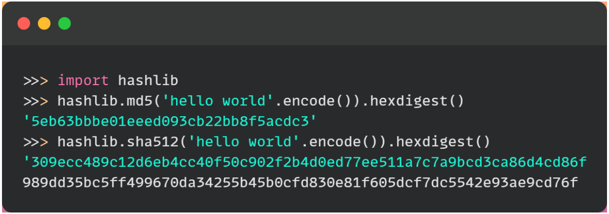
```
>>> help()
help> modules
help> modules hashlib
```



```
        recursively the attributes of its class's base classes.

help> modules

Please wait a moment while I gather a list of all available modules...

/nix/store/p21fdyxqb3yqflpim7g8s1mymgpnqiv7-python3-3.8.12/lib/python3.8/pkgutil.py:92: UserW
rning: The numpy.array_api submodule is still experimental. See NEP 47.
  __import__(info.name)
/home/runner/practical-crypto-course/venv/lib/python3.8/site-packages/_distutils_hack/__init_
.py:36: UserWarning: Setuptools is replacing distutils.
  warnings.warn("Setuptools is replacing distutils.")
__future__          ast                 importlib           sched
_abc                asynchat            importlib_metadata  secrets
_ast                asyncio             inspect             secretstorage
_asyncio            asyncore            io                  select
_bisect             atexit              ipaddress           selectors
_blake2             audioop             itertools           setuptools
_bootlocale         backports           jedi                shellingham
_bz2                base64              jeepney             shelve
_cffi_backend       bcrypt              json                shlex
_codecs             bdb                 keyring             shutil
_codecs_cn          binascii            keyword             signal
_codecs_hk          binhex              lect2               site
_codecs_iso2022     bisect              lib2to3             six
_codecs_jp          builtins            libfuturize         smtpd
_codecs_kr          bz2                 libpasteurize       smtplib
_codecs_tw          cProfile            linecache           sndhdr
_collections        cachecontrol        locale              socket
_collections_abc    cachy               lockfile            socketserver
_compat_pickle      calendar            logging             spwd
_compression        certifi             lzma                sqlite3
_contextvars        cffi                mailbox             sre_compile
```

# Example of a module

The hashlib is a built-in module that is preinstalled.
Type `import hashlib`, then in the terminal type `hashlib.` (enter the dot after hashlib). You should see a list of methods.
Let's try one :



```
>>> import hashlib
>>> hashlib.md5('hello world'.encode()).hexdigest()
'5eb63bbbe01eeed093cb22bb8f5acdc3'
>>> hashlib.sha512('hello world'.encode()).hexdigest()
'309ecc489c12d6eb4cc40f50c902f2b4d0ed77ee511a7c7a9bcd3ca86d4cd86f
989dd35bc5ff499670da34255b45b0cfd830e81f605dcf7dc5542e93ae9cd76f
```

# install a module

- Use pip command on terminal : The pip command looks for the package in PyPI, resolves its dependencies, and installs everything in your current Python environment to ensure that requests will work. The `pip install <package>` command always looks for the latest version of the package and installs it

or

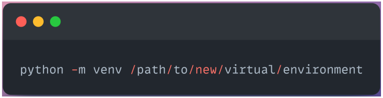
- Use conda command on terminal OR Anaconda Navigator if Anaconda is installed : The conda command is the primary interface for managing installations of various packages. It can Query and search the Anaconda package index and current Anaconda installation. Create new conda environments. Install and update packages into existing conda environments. The navigator is just an extension for conda command.

# Virtual environments

- A virtual environment is a Python environment such that the Python interpreter, libraries and scripts installed into it are isolated from those installed in other virtual environments, and (by default) any libraries installed in a "system" Python, i.e., one which is installed as part of your operating system.
- A virtual environment is a directory tree which contains Python executable files and other files which indicate that it is a virtual environment.
- Common installation tools such as setuptools and pip work as expected with virtual environments. In other words, when a virtual environment is active, they install Python packages into the virtual environment without needing to be told to do so explicitly.

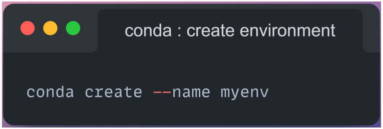
# Create Virtual environments

- The venv module provides support for creating isolated "virtual environments" with their own site directorie. Each environment has its own Python binary and can have its own independent set of installed Python packages in its site directories.



```
python -m venv /path/to/new/virtual/environment
```

- if you are using Anaconda. Use the Anaconda Navigator to create and manage environments or the conda command :



conda : create environment

```
conda create --name myenv
```

# ASCII encoding

- ASCII, abbreviated from American Standard Code for Information Interchange, is a character-encoding standard for electronic communication. ASCII codes represent text in computers, telecommunications equipment, and other devices. Most modern character-encoding schemes are based on ASCII, although they support many additional characters.
- In ASCII encoding, each letter is converted to one byte. Look at the following examples :

$$A = 65\; or\; 0b01000001$$

$$B = 66\; or\; 0b01000010$$

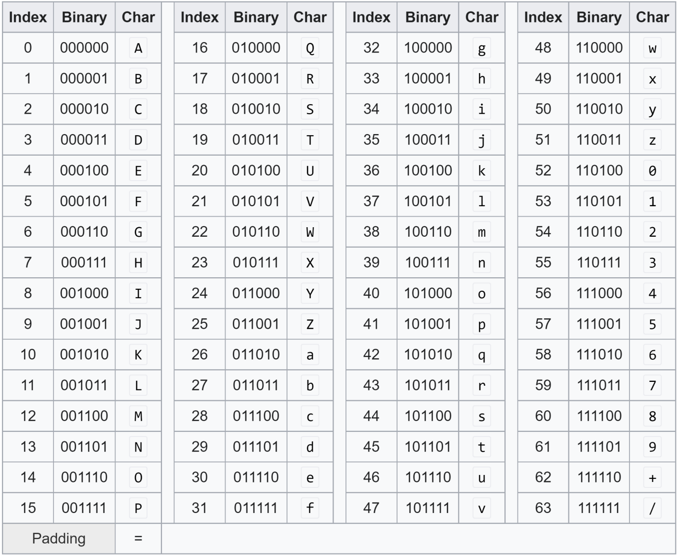
$$C = 67\; or\; 0b01000011$$

$$ABC = 0b01000001\, 0b01000010\, 0b01000011$$

# Base64 Encoding Text

- Base64, also known as privacy enhanced electronic mail (PEM), is the encoding that converts binary data into a textual format ; it can be passed through communication channels where text can be handled in a safe environment. PEM is primarily used in the email encryption process. To use the functions included in the Base64 module, you will need to import the library in your code. Base64 offers a decode and encode module that both accepts input and provides output.
- To break ASCII encoding into Base64-encoded text, each sequence of six bits encodes to a single character.

# Base64 table



| Index | Binary | Char | Index | Binary | Char | Index | Binary | Char | Index | Binary | Char |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 000000 | A | 16 | 010000 | Q | 32 | 100000 | g | 48 | 110000 | w |
| 1 | 000001 | B | 17 | 010001 | R | 33 | 100001 | h | 49 | 110001 | x |
| 2 | 000010 | C | 18 | 010010 | S | 34 | 100010 | i | 50 | 110010 | y |
| 3 | 000011 | D | 19 | 010011 | T | 35 | 100011 | j | 51 | 110011 | z |
| 4 | 000100 | E | 20 | 010100 | U | 36 | 100100 | k | 52 | 110100 | 0 |
| 5 | 000101 | F | 21 | 010101 | V | 37 | 100101 | l | 53 | 110101 | 1 |
| 6 | 000110 | G | 22 | 010110 | W | 38 | 100110 | m | 54 | 110110 | 2 |
| 7 | 000111 | H | 23 | 010111 | X | 39 | 100111 | n | 55 | 110111 | 3 |
| 8 | 001000 | I | 24 | 011000 | Y | 40 | 101000 | o | 56 | 111000 | 4 |
| 9 | 001001 | J | 25 | 011001 | Z | 41 | 101001 | p | 57 | 111001 | 5 |
| 10 | 001010 | K | 26 | 011010 | a | 42 | 101010 | q | 58 | 111010 | 6 |
| 11 | 001011 | L | 27 | 011011 | b | 43 | 101011 | r | 59 | 111011 | 7 |
| 12 | 001100 | M | 28 | 011100 | c | 44 | 101100 | s | 60 | 111100 | 8 |
| 13 | 001101 | N | 29 | 011101 | d | 45 | 101101 | t | 61 | 111101 | 9 |
| 14 | 001110 | O | 30 | 011110 | e | 46 | 101110 | u | 62 | 111110 | + |
| 15 | 001111 | P | 31 | 011111 | f | 47 | 101111 | v | 63 | 111111 | / |
| Padding |  | = |  |  |  |  |  |  |  |  |  |

- Examine the 24 bits from the previous section :

$$0b01000001\ 0b01000010\ 0b01000011$$

- Break the line into 6-bit groups :

$$0b010000\,010100\,001001\,000011$$

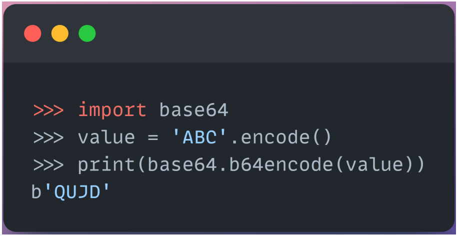
- When you convert the four groups to decimal, you will see that they are equal to the following :

$$16\ 20\ 9\ 3$$

- You now convert the numbers to Base64 :

$$Q\,U\,J\,D$$

- Therefore, when you encode "ABC" to Base64, you should end up with QUJD, as shown here :



```
>>> import base64
>>> value = 'ABC'.encode()
>>> print(base64.b64encode(value))
b'QUJD'
```

- In the event that the text cannot be broken down into groups of six, you will see the padding character, which is shown using the equal sign $=$. If the example had four bytes, then the output would look like the following :

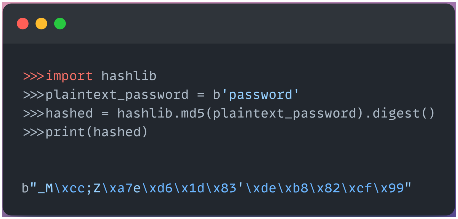
```
>>> import base64
>>> value = 'ABC'.encode()
>>> print(base64.b64encode(value))
b'QUJD'
```

# utf-8

- UTF-8 is a variable-width character encoding used for electronic communication. Defined by the Unicode Standard, the name is derived from Unicode (or Universal Coded Character Set) Transformation Format 8-bit.
- UTF-8 is capable of encoding all 1,112,064 valid character code points in Unicode using one to four one-byte (8-bit) code units. Code points with lower numerical values, which tend to occur more frequently, are encoded using fewer bytes. It was designed for backward compatibility with ASCII : the first 128 characters of Unicode, which correspond one-to-one with ASCII, are encoded using a single byte with the same binary value as ASCII, so that valid ASCII text is valid UTF-8 encoded Unicode as well.

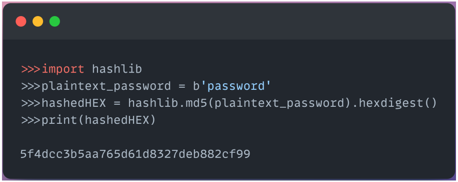
# utf-8

- When dealing with displaying ciphertexts and hashes (digests), the output is binary (raw bytes). when you try to display this what you get :



```
>>>import hashlib
>>>plaintext_password = b'password'
>>>hashed = hashlib.md5(plaintext_password).digest()
>>>print(hashed)


b"_M\xcc;Z\xa7e\xd6\x1d\x83'\xde\xb8\x82\xcf\x99"
```

- to be readable, convert it to hexadecimal or base64 like follows :



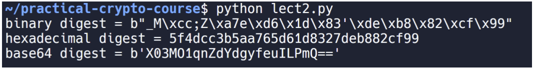
```
>>>import hashlib
>>>plaintext_password = b'password'
>>>hashedHEX = hashlib.md5(plaintext_password).hexdigest()
>>>print(hashedHEX)

5f4dcc3b5aa765d61d8327deb882cf99
```

# utf-8

- or simply produce the binary digest and use *hex* and *base64.b64encode* functions to produce the hexadecimal and base64 representation of the digest :

```
import hashlib
import base64
plaintext_password = b'password'
hashed = hashlib.md5(plaintext_password).digest()
print("binary digest =", hashed)
hhex=hashed.hex()
print("hexadecimal digest =", hhex)
encoded = base64.b64encode(hashed)
print("base64 digest =", encoded)
```

- result will be the same hash displayed in binary, hexadecimal, and base64 encoding.



```
~/practical-crypto-course$ python lect2.py
binary digest = b"_M\xcc;Z\xa7e\xd6\x1d\x83'\xde\xb8\x82\xcf\x99"
hexadecimal digest = 5f4dcc3b5aa765d61d8327deb882cf99
base64 digest = b'X03M01qnZdYdgyfeuILPmQ=='
```