Programming - Python

Comment – Text within the code that is ignored by the computer. A Python comment is preceeded by a #.

```
# This is an example of a comment
```

Output – Processed information that is sent out from a computer

Python	Pseudocode

`print("Hello World!")`
Hello World!
`print("Hello", "World!")`
Hello World!
`print("Hello"+"World!")`
HelloWorld!
`print("Hello\nWorld!")`
Hello
World!
	`OUTPUT "Hello World"`

Input – Data sent to a computer to be processed

`print("Enter name")`
`name=input()`
`print("Hello", name)`
`print("Enter age")`
`age=int(input())`
	`OUTPUT "Enter name"`
	`name ← USERINPUT`
	`OUTPUT "Hello", name`
	`OUTPUT "Enter age"`
	`age ← USERINPUT`

Assignment - The allocation of data values to variables, constants, arrays and other data structures so that the values can be stored.

- *Variable* – Value that can change during the running of a program. By convention we use lower case to identify variables (eg `a=12`)
- *Constant* – Value that remains unchanged for the duration of the program. By convention we use upper case letters to identify constants. (e.g. `PI=3.141`)

When writing code it is advantageous to use a named constant because you only have to change the value of the constant, rather than changing the value each time it is use. Compare the following two programs that do the same thing. If we wish to change the value of the constant 12, we only need to change the value once if we use a named constant, otherwise we need to change the value every it is used which.

`# Only need to change the value of A once`
 	
`A=12`
`b=A*3`
`c=A+1`
`d=A-4`
	`# Need to change the value each time it is used`
	
	`b=12*3`
	`c=12+1`
	`d=12-4`

It is good practice to give meaningful names to variables and constants.

Example variable names

Variable name has no meaning so we should not use	`a="Bart Simpson"`
Camel case: Start of each word apart from the first has a capital letter	`nameOfStudent="Bart Simpson"`
Snake case: uses an underscore between each word	`name_of_student ="Bart Simpson"`

Data Types – determines what value a variable can hold and the operation that can be performed on a variable

Integer	`age = 12`	A whole number
Float (real) number	`height = 1.52`	A number with a decimal point
Character	`a = 'a'`	A single letter, number or symbol
String	`name = "Bart"`	Multiple characters
Boolean	`a = True` `b = False`	Has two values; true or false
Pointer		Represents the memory location of the data in memory

Arithmetic Operators

Add	`7 + 2 = 9`	`7 + 2`
Subtract	`7 - 2 = 5`	`7 - 2`
Multiply	`7 * 2 = 14`	`7 * 2`
Divide	`4 / 2 = 2`	`4 / 2`
power	`2 ** 3 = 8`	`2 ** 3`
Integer division	`7 // 2 = 3`	`7 DIV 2`
Modulus (remainder)	`7 % 2 = 1`	`7 MOD 2`

Rounding	`round(3.14159, 2), round to 2 d.p.`

Truncation – remove all digits after the decimal point	`import math`
	`math.trunc(3.141) -> 3`
	
	`int(3.141) -> 3`

Round up to nearest integer	`math.ceil(3.141) -> 4`
Round down to nearest integer	`math.floor(3.141) -> 3`

Relational Operators – Allows the Comparison of values

Less than	`<`	<	`7<2`	`-> False`
Greater than	`>`	<	`7 > 2`	`-> True`
Equal to	`==`	==	`7==2`	`-> False`
Not equal to	`!=`	≠ or <>	`7!=2`	`-> True`
Less than or equal to	`<=`	≤	`7<=2`	`-> False`
Greater than or equal to	`>=`	≥	`7>=2`	`-> True`

Boolean Operators

AND	and	`7 < 2 and 1 < 2`	`-> False`
OR	or	`7 < 2 or 1 < 2`	`-> False`
NOT	not	`not 7 < 2`	`-> True`

Sequencing represents a set of steps. Each line of code will have some operation and these operations will be carried out in order line-by-line

Using + operator for adding
 	
`a = 1`
`b = 2`
`c = a + b`
`print(c) -> 3`
	`a ← 1`
	`b ← 2`
	`c ← a + b`
	`OUTPUT c`

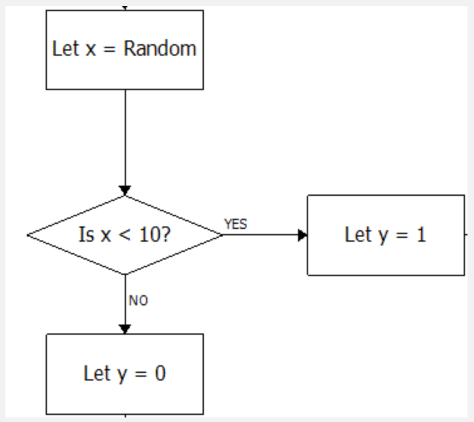
Using + operator for concatenation
 	
`a = 'Hello '`
`b = 'World'`
`c = a + b`
`print(c) -> Hello World`
	`a ← 'Hello '`
	`b ← 'World'`
	`c ← a + b`
	`OUTPUT c`

Random number

Random integer	`import random` `random.randint(0,9)`	`RANDOM_INT(0,9)`
Choice	`random.choice('a','b','c')`	
Random value from 0 to 1	`random.random()`	

Selection represents a decision in the code according to some condition. The condition is met then the block of code is executed otherwise it is not. Often alternative blocks of code are executed according to some condition.

```
x=RANDOM_INT()
IF  x < 10 THEN
  y=1
ELSE
  y=0
ENDIF
```



IF ...	`IF i > 2 THEN`
	`  j ← 10`
	`ENDIF`
		`if i > 2:`
		`  j=10`

IF ... ELSE ...	`IF i > 2 THEN`
	`  j ← 10`
	`ELSE`
	`  j ← 3`
	`ENDIF`
		`if i > 2:`
		`    j=10`
		`else:`
		`    j=3`

IF ... ELSE IF ... ELSE	`IF i ==2 THEN`	`if i ==2:`

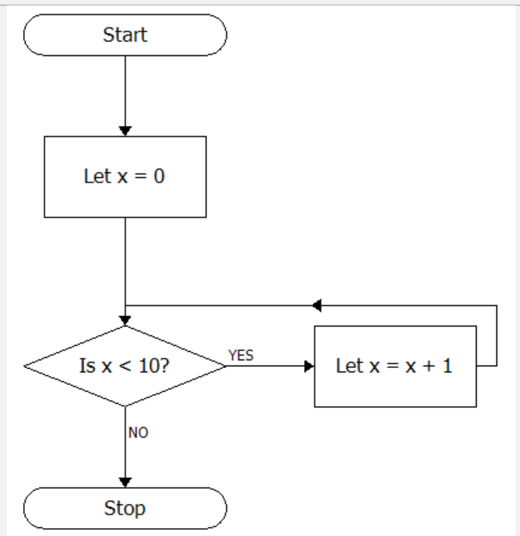
	`j ← 10`
	`ELSE IF i==3`
	` j ← 3`
	`ELSE`
	` j ← 1`
	`ENDIF`
		` j=10`
		`elif i==3:`
		` j=3`
		`else:`
		` j=1`

Iteration Sometimes we wish the code to repeat a set of instructions

Indefinite iteration

`WHILE` loops are used when the we do not know beforehand the number of iterations needed and this varies according to some condition. The condition is defined at the start of the interative structure.

```
x = 0
while (x < 10):
      x = x + 1
```



`while True:`
` print("Hello World")`
	`WHILE TRUE`
	` OUTPUT "Hello World"`
	`ENDWHILE`

`a=0`
`while a<4:`
` print(a)`
` a=a+3`
	`a ← 0`
	`WHILE a < 4`
	` OUTPUT a`
	` a ← a + 3`
	`ENDWHILE`

`REPEAT` loops are another indefinite iteration but are not supported by Python. Here the condition is at the end of the iterative structure

```
a ← 1
REPEAT
  OUTPUT a
  a ← a + 1
UNTIL a←4
```

Definite Iteration

`FOR` loops are used when we know before hand the number of iterations we wish to make.

`for a in range(3):`
` print(a)`
	`FOR a ← 0 TO 3`
	`    OUTPUT a`
	`ENDFOR`

Nested structures - Use constructs (e.g. `WHILE, FOR, IF`) inside one another.

use a nested FOR loop to print out a grid	`for i in range (10):`
	` for i in range (10):`
	`  print ("x ",end="")`
	` print()`

Use a nested while and if to print out only even numbers	`i=0`
	`while i<51:`
	` if (i%2==0):`
	`  print(i)`
	` i=i+1`

Lists (Arrays)

Allow us to storage multiple values in a single data structure

Create a list	`shapes=["square","circle"]`
Access element by index pos	`shapes[1] -> circle`
Append item to list	`shapes.append("triangle")`
Remove item from list	`shapes.remove("circle")`
Remove item from list by index	`shapes.pop(1)`
Insert item into list	`shapes.insert(2,"rectangle")`
Number of elements in a list	`len(shapes)`
Get index pos of item in list	`shapes.index("triangle")`

Concatenating lists	`shapesGroup1["square","circle"]`
	`shapesGroup2=["triangle"]`
	`shapes=shapesGroup1+shapesGroup2`

Loop through list	`for i in range(len(shapes)):` ` print(shapes[i])`
Reverse elements in a list	`shapes.reverse()`
Order elements in a list	`shapes.sort()`

2D lists - A list if lists

Create a 2D list	`d = [ [23, 14, 17], [12, 18, 37],` ` [16, 67, 83]]`

Another way to create a 2D list	`a = [23, 14, 17]`
	`b = [12, 18, 37]`
	`c = [16, 67, 83]`
	`d = [a,b,c]`

Access element by index position	`d[1][2] -> 37`

Strings

Get length of a string	`len("Hello")`	`LEN("Hello")`
Character to character code	`ord("a") -> 97`	`ORD("a")`
Character code to character	`chr(101) -> 'e'`	`CHR(101)`
String to integer	`a=int("12")`	`a=INT("12")`
String to float	`a=float("12.3")`	`a=FLOAT("12.3")`
integer to string	`a=str(12)`	`a=STR(12)`
real to string	`a=str(12.3)`	`a=STR(12.3)`

Date/time string conversions

date/time to string	`import datetime`
	`t = datetime.datetime.now()`
	`print("current date and time:", t)`
	`print("Full year:", t.strftime("%Y"))`
	`print("year:", t.strftime("%y"))`
	`print("month:", t.strftime("%m, %B, %b"))`
	`print("day:", t.strftime("%d"))`
	`print("hour", t.strftime("%H"))`
	`print("minute:", t.strftime("%M"))`
	`print("second:", t.strftime("%S"))`
	`print("time:", t.strftime("%H:%M:%S"))`
	`print("date and time:",t.strftime("%m/%d/%Y, %H:%M:%S"))`

string to date/time	`import datetime`
	`date_str = "8 February, 2020, 20:56:48"`
	`print("date_string =", t)`
	`print("type of date_str =", type(date_str))`
	`date_obj =`
	`datetime.datetime.strptime(date_str, "%d %B, %Y, %H:%M:%S")`
	`print(date_obj)`

Concatenation -merge multiple strings together	`a="hello "`
	`b="world"`
	`c=a+b`
	`print(c) ->`
	`hello world`

Return the position of a character If there is more than 1 of the same character the position of the first character is returned.	`student = "Hermione"` `student.index('i')`
Find the character at a specified position	`student = "Hermione"` `print(student[2]) -> r`

sub strings - select parts of a string

Example	`student="Harry Potter"`	
Output the first two characters	`print(student[0:2])`	Ha
Output the first three characters	`print(student[:3])`	Har
Output characters 2-4	`print(student[2:5])`	Rry
Output the last 3 characters	`print(student[-3:])`	Ter
Output a middle set of characters	`print(student[4:-3])`	y Pot

*A negative value is taken from the end of the string.

Records

Records are data structures that contain different fields often with different data types. We can retrieve and update the record using the field name, in contrast to lists we have to use the index position to access and element.

Create a record	`class Player(object):`
	` def __init__(self, name=None, team=None, salary=None):`
	`  self.name = name`
	`  self.team =  team`
	`  self.salary = salary`

Add values to record	`messi = Player('Lionel Messi', 'Barcelona', 5000000)`
	
	`beckham = Player()`
	`beckham.name = 'David Beckham'`
	`beckham.team = 'Manchester United'`
	`beckham.salary = 2000000`

To retrieves values	`print(messi.name, messi.team, messi.salary))`

Subroutines are a way of managing and organising programs in a structured way. This allows us to break up programs into smaller chunks.

- Can make the code more modular and more easy to read as each function performs a specific task.
- Functions can be reused within the code without having to write the code multiple times.
- Subroutines are "out-of line" code that are run by writing the name of the subroutine.
- Data are input into a subroutine via parameters

- **Procedures** are subroutines that do not return values
- **Functions** are subroutines that have both input and output and erturn values

Procedure: No input parameters or return	`SUB greeting()`
	` OUTPUT "hello"`
	`ENDSUB`
		`def greeting():`
		` print("hello")`
		
		`call: greeting()`

Procedure: One input parameter, no return	`SUB greeting(name)`
	` OUTPUT "Hello",name`
	`ENDSUB`
		`def greeting(name):`
		` print("Hello",name)`
		
		`greeting("grey")`

Function: 1 input parameter, and 1 return value	`SUB add(n)`
	` a ← 0`
	` FOR a ← 0 TO n`
	`  a ← a + n`
	` ENDFOR`
	` RETURN a`
	`ENDSUB`
		`def add(n):`
		` a=0`
		` for a in range(n+1):`
		` a=a+n`
		` return a`

Function: Two input parameters, and 1 return value	`SUB (num1,num2)`
	` sum=num1+num2`
	` return sum`
		`def add(num1,num2):`
		` sum=num1+num2`
		` return sum`
		
		`greeting(1,2)`

The **scope** of a variable determines which parts of a program can access and use that variable.

A **global variable** is a variable that can be used anywhere in a program. The issue with global variables is that one part of the code may inadvertently modify the value because global variables are hard to track.

A **local variable** is a variable that can only be accessed within a subroutine. Local variables are not recognized outside subroutine. Local variables only exist while the subroutine is executing. There is no way of modifying or changing the behavior of a local variable outside its scope.

Global variables need to defined throughout the running of the whole program. This is an inefficient use of memory resources. Local variables are defined only when they are needed an so have less demand on memory. Local variables only exist within the subroutine.

Reading and writing files

Open file Whatever we are doing to a file whether we are reading, writing or adding to or modifying a file we first need to open it using:

```
open(filename,access_mode)
```

There are a range of access mode depending on what we want to do to the file, the principal ones are given below:

Access Mode	Description
r	Opens a file for reading only
w	Opens a file for writing only. Create a new file if one does not exist. Overwrites file if it already exists.
a	Append to the end of a file. Create a new file if one does not exist.
rb	Open a binary file for reading
wb	Opens a binary file for writing only. Create a new file if one does not exist. Overwrites file if it already exists.

Reading text files

read – Reads in the whole file into a single string	`f=open("filetxt","r")`
	`print(f.read())`
	`f.close()`

readline – Reads in each line one at a time	`f=open("file.txt","r")`
	`print(f.readline())`
	`print(f.readline())`
	`print(f.readline())`
	`f.close()`

readlines – Reads in the whole file into a list	`f=open("file.txt","r")`
	`print(f.readlines())`
	`f.close()`

Writing text files

Write in single lines at a time	`file=open("days.txt",'w')`
	`file.write("Monday\n")`
	`file.write("Tuesday\n")`
	`file.write("Wednesday\n")`
	`file.close()`

Write in a list	`say=["How\n","are\n","you\n"]`
	`file=open("say.txt",'w')`
	`file.writelines(say)`
	`file.close()`

Read CSV (Comma Separated values) files

CSV files can be read in spreadsheets and they are a very useful file format. Python is set up to read these files using:

```
csv.reader(file)
```

Example code:

```
import csv
def read_csv_file(csv_file):
 l=[]
 file=open(csv_file)
 r=csv.reader(file)
 num=0
 for i in r:
  l.append(i)
  num=num+1
  file.close()
 return l
print(read_csv_file("file.csv"))
```

Reading binary files

Use the specifier *rb*.

```
f = open("file.bin", "rb")
print(f.read())
f.close()
```

Writing binary files

Create a byte object using a byte literal by including a b at the before the string. Use the specifier *wb*.

```
s = b"Hello World"
f = open("file.bin", "wb")
f.write(s)
f.close()
```

Reading to files using Pickle

Pickle converts python objects into bytes

```
f = open("file.bin", "rb")
print(f.read())
f.close()
```

Writing to files using Pickle

```
import pickle
f=open("file.pic","wb")
pickle.dump("Hello",f)
pickle.dump("World",f)
```

```
f.close()
```

Exception Handling

An exception occurs when a program cannot deal with an error. The program needs to handle the exception otherwise the program will terminate.

We use try and except blocks to catch exceptions.

Simple try and except	`try:`
	` statement`
	`Except:`
	` Statement`

Try and except with multiple exceptions	`try:`
	` statement`
	`except exception 1:`
	` statement`
	`except exception 2:`
	` statement`

Try and except and else	`try:`
	` statement`
	`except exception:`
	` statement`
	`else:`
	` statement`

Finally is a block of code that mush execute whether an exception is raised or not	`try:`
	` statement`
	`except:`
	` statement`
	`finally:`
	` statement`

Examples of Common Exception Errors in Python

TypeError Occurs when a wrong data type is used	`try:`
	` b = "cat" + 3`
	`except TypeError:`
	` print("Type error")`

FileNotFoundError Occurs when a file does not exist	`try:`
	` file=open("nonExistentFile","r")`
	`except FileNotFoundError:`
	` print("File Not Found")`

NameError Occurs when a variable that has been referenced has not been assigned	`try:`
	` print(b)`
	`except NameError:`
	` print("Name Error")`
	`else:`
	`  print("all Good")`

ZeroDivisionError When a division by zero occurs	`try:`
	` print(3/0)`
	`except ZeroDivisionError:`
	` print("Zero division error")`

ValueError Incorrect value	`try:`
	` num = int("a")`
	`except ValueError:`
	` print("Value Error")`

IndexError When a referenced index in a list is out of range	`try:`
	` a=[1,2,3,4,5]`
	` print(a[6])`
	`except IndexError:`
	` print("Index Error")`
	`finally:`
	` print("This will always be run")`

Data Validation Routines

Check if an entered string has a minimum length	`OUTPUT "Enter String"`
	`s ← USERINPUT`
	`IF LEN(S) > 5 THEN`
	` OUTPUT "STRING OK"`
	`ELSE`
	` OUTPUT "TOO SHORT"`
	`ENDIF`

Check is a string is empty	`OUTPUT "Enter String"`
	`s ← USERINPUT`
	`IF LEN(S) == 0 THEN`
	` OUTPUT "EMPTY STRING"`
	`ENDIF`

Check if data entered lies within a given range	`OUTPUT "Enter number" s num ←`
	`USERINPUT`
	`IF num > 1 AND num < 10`
	` OUTPUT "Within range"`
	`ENDIF`

Authentication Routine

```
OUTPUT "Enter Username"
username ← USERINPUT
OUTPUT "Enter Password"
password ← USERINPUT

WHILE username != "bart" OR password !="abc"

 OUTPUT "Login failed"
 OUTPUT "Enter Username"
 username ← USERINPUT
 OUTPUT "Enter Password"
 password ← USERINPUT

ENDWHILE

OUTPUT "Login Successful"
```

Debugging

Syntax errors – Errors in the code that mean the program will not even run at all. Normally this is things like missing brackets, spelling mistakes and other typos.

Runtime errors – Errors during the running of the program. This might be because the program is writing to a memory location that does not exist for instance. eg. An array index value that does not exist.

Logical errors - The program runs to termination, but the output is not what is expected. Often these are arithmetic errors.

Test data

Code needs to be tested with a range of different input data to ensure that it works as expected under all situations. Data entered need to be checked to ensure that the input values are:

- within a certain range
- in correct format
- the correct length
- The correct data type (eg float, integer, string)

The program is tested using normal, erroneous or boundary data.

Normal data - Data that we would normally expect to be entered. For example for the age of secondary school pupils we would expect integer values ranging from 11 to 19.

Erroneous data - Data that are input that are clearly wrong. For instance, if some entered 40 for the age of a school pupil. The program should identify this as invalid data but at the same time should be able to handle this sensibly which returns a sensible message and the program does not crash.

Boundary data - Data that are on the edge of what we might expect. For instance if someone entered their age as 10, 11, 19 or 20.