Lecture 4 - The `len()` and `type()` functions, objects, string indices, slices and concatenation
Learning outcomes

- At the end of this lecture, students should be able to:
  - Understand that a variable stores a reference to the object
  - Understand that string objects are a sequence of characters
  - Use the len() function to calculate how many characters are in a string
  - Obtain a single character from a string
  - Slice strings
  - Concatenate strings
**Program execution**

- The statements in a Python program are executed in sequence.

```python
"""Calculates the radius of a circle.
Author: Damir Azhar
"""

```import math
```

```python
area = 221.67
radius = math.sqrt(area / math.pi)
print("Radius of circle with area ", area, "is", radius)
```

Radius of circle with area 221.67 is 8.399985266079987

- Variables can only store one value, i.e., assigning a new value to a variable means that you lose access to the previous value.

```python
number = 34
number = 56
number = number - 10
print("Finally", number)
```

Finally 46
Exercise

Give the output

```
num1 = 7
num2 = 3
num3 = 2
num4 = 4

num5 = num1
num1 = num2 * num1 + 4
num2 = num5 + num2
num5 = num3
num3 = num4 - num3 + 1
num4 = num5

print(num1, num2, num3, num4, num5)
```
Strings are any sequence of characters enclosed inside single quotes (‘...’) or double quotes ("..."). We have already met strings when we needed to print a message to the standard output, e.g.,

```
print("Area of circle")
```

Examples of strings:

- "A"
- 'A longer string'
- "45.78"
- " "
- ""
- ""
Another Python type - strings

- Strings can be assigned to variables in order to store them in the program memory. Strings can be printed.

- For example:

```python
word1 = "Har"
word2 = "Hardy"
word3 = word1

print(word2, word3, word1)

Hardy Har Har
```
The Python `len()` function

- Python has a built-in function, `len()`, which can be used to determine the length of a string.

  ```python
  1 word1 = "Fantastico"
  2 length1 = len(word1)
  3 length2 = len("012 3 4")
  4 print(length1, length2)
  ```

- In the example code above there are two calls to the `len()` function (on the right hand side of lines 2 and 3).

- The `len()` function is said to return the number of characters in the string passed to the function (inside the parentheses).

  ```bash
  10 7
  ```
The Python `len()` function

```python
1 word1 = "Fantastico"
2 length1 = len(word1)
3 length2 = len("012 3 4")
4 print(length1, length2)
```

```
10 7
```

- Functions use round brackets (parentheses).

- On line 2 of the code, the string, `word1`, is passed to the `len()` function. On line 3 of the code, the string, "012 3 4", is passed to the `len()` function.

- The `len()` function returns the number of characters in the string (passed to the function inside the parentheses).

Remember: firstly the right hand side of the assignment operator is evaluated and then the resulting value is passed to the variable on the left of the assignment operator.
In Python everything is an object

- The world is made up of real world objects e.g. students, dogs, cars, cats, books, words, numbers. Objects are the things our programs deal with and in our programs we want to represent these objects.

- So far, in our programs, we have used:
  - Integer objects which represent whole numbers,
  - Floating point objects which represent decimal numbers, and,
  - String objects which represent sequences of characters.

- We have used variables to store these types of objects in the program memory.
In Python everything is an object

```python
box_size = 5
box_area = box_size * box_size
```

- We often visualise variables as being a box containing a value (the last value assigned to the variable). Given the code:

  We visualise the two variables:

- In fact, every variable in Python stores a reference (the memory address) of the value assigned to it:
In Python everything is an object

- Storing the reference (the memory address) of the value assigned to a variable makes sense:

```python
initial = "A"
phrase = "The early bird catches the worm but the second mouse gets the cheese!"
phrase = "Illiterate? Write For Help"
```

because the information inside an object can have different sizes.
Exercise

Given the following code:

```java
item1 = "Blah!"
item2 = "Blah?"
item3 = item2
item2 = item1
```

how many string objects are there in memory?

Given the memory diagram below, i.e., fill in the variable addresses:

```plaintext
item1
item2
item3
101
111
"Blah!"
"Blah?"
```
**None**

None is a special value which can be assigned to a variable and it means that the variable is not referencing (pointing to) any object.

```python
initial = "A"
phrase = "The early bird catches the worm but the second mouse gets the cheese!"
phrase = None
```

A variable which contains the value None can be printed:

```python
phrase = None
print(phrase)  # None
```
The inbuilt type() function

Every Python object has a specific type. The type of any Python object can be obtained by using the `type()` function. This function returns a string stating the object type. For example

```python
num1 = 7
num2 = 26.7
word = "numero"

print(type(num1))
print(type(num2))
print(type(word))
```

The output, `<class 'int'>`, means that there is the definition of this type of object in a file named `int.py` (inside the Python libraries).
Special characters in a string

- Some characters perform operations such as inserting a new line or a tab space. To insert a new line into a string we use the escape sequence `\n` within the string, and `\t` is used to insert a tab space.

```python
shopping = "Carrots, \npumpkin, \nchocolate"
print(shopping)
```

- To insert a double quote into the output (if your string is enclosed inside double quotes), use the escape sequence `\"`, and to insert a single quote into the output, (if your string is enclosed inside single quotes), use the escape sequence `\'`.

```python
print(1, "\"Super\" Man")
print(2, '\"Super\" Man\')
print(3, '"Super" Man')
print(4, "Super Man\n")
```
More about strings

- A string is a sequence of characters and every character in a string has an index, i.e., its position in the string. The index starts from position 0. For example:

  ```python
  greeting = "Hello World"
  print(first_letter, last_letter)
  ```

- Every character in the string can be accessed using the variable name, square brackets and the index value:

  ```python
  greeting = "Hello World"
  first_letter = greeting[0]
  last_position = len(greeting) - 1
  last_letter = greeting[last_position]
  print(first_letter, last_letter)
  ```
What is the problem with the following code?

```
last_letter = greeting[len(greeting)]
```

An `IndexError` occurs if you try to access a position in the string which doesn't exist.
Strings - negative index

To access a character from the end of the string, a negative index can be used. For example:

```python
greeting = "Hello World"
last_letter = greeting[-1]
second_to_last = greeting[-2]
print(last_letter, second_to_last)
```

Does the following code cause a problem?

```python
greeting = "Hello World"
a_letter = greeting[-len(greeting)]
```
Slicing strings

As well as obtaining a single character from a string, a whole sections of the string can be obtained. This is called **slicing**.

To get a section of a string we use square brackets, the index of the first character in the section we want, a colon followed by the index of the character after the end of the required section.

```python
greeting = "Hello World"
first_part = greeting[0:5]
second_part = greeting[6:11]
print(second_part, first_part)
```

World Hello
Slicing strings

- When slicing a string, if the start of the slice is omitted, the slice starts from the first character in the string. When slicing a string, if the end of the slice is omitted, the slice goes to the end of the string.

For example,

```python
# Example string
greeting = "Hello World"

# Slicing the string
first_part = greeting[:5]
second_part = greeting[6:]

print(second_part, first_part)
```

```
World Hello
```
The `+` operator can be used to join two strings, e.g.,

```python
first_name = "Alan"
last_name = "Turing"
full_name = first_name + " " + last_name
print("***", full_name, "***")
```

How does the Python interpreter know if the `+` operator is adding two numbers or concatenating two strings?

```python
first = "4"
second = "5"
sum = 4 + 5
number = first + second
print(sum, number)
```
The * operator can be used to create a new string object with characters of a string repeated two or more times, e.g.,

```python
praise = "good!"
lots_of_praise = praise * 4
print(praise)
print(lots_of_praise)
```

```
good!
good!good!good!good!
```

What is the meaning of the words "to create a new" string object in the statement above?
s = "Dogs have masters. Cats have staff."
print("1.", s[1: 6])
print("2.", s[:2] * 3)
print("3.", s[-3])
print("4.", s[4] + s[1])
print("5.", s[-4:])
Complete the following program so that it prints the name between two rows of stars. The output has three spaces on each side of the name. Your code should work for names of any length.

```python
name = "Philomena Evangeline"
extras = 3

**************************
Philomena Evangeline
**************************
In Python:

- Variables store a reference to the object.
- String objects are a sequence of characters.
- The `len()` function is used to calculate how many characters are in a string.
- We use the index number to obtain a single character from a string.
- We can slice strings.
- We use the `+` operator to concatenate strings.
Examples of Python features used in this lecture

```python
words = "Prince Charming"
length = len(words)

letter1 = words[3]
letter2 = words[-5]
letter3 = words[len(words) - 2]

letters1 = words[3:6]
letters2 = words[:6]
letters3 = words[6:]
letters4 = words[len(words) - 3:]

word2 = letter1 + letter2
phrase = word2 + " " + letter3
print(letters1, letters2, letters3, letters4, phrase)
```