Practical Programming
in Python

Inspired by 'Practical Programming' by Paul Gries, Jennifer Campbell, Jason Montojo

Lecture 4
Working with Text

Strings, String Operations, Printing Information, Reading from the Keyboard

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Abstract

"Nothing is so obvious that it's obvious… The use of the word "obvious" indicates the absence of a logical argument."

– Errol Morris

Text plays a central role in computer programs.
We will introduce a non-numeric data type that represents text.
We will see how to make programs more interactive by printing messages and getting information from the user.

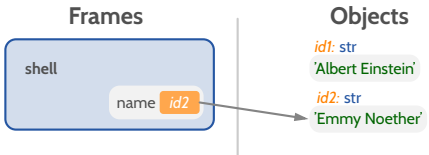
Overview

- Computers have been invented to do arithmetic
- Now they spend a lot (most?) of their time processing text
- Email, web browsers, word processors…
- Text input & output (I/O) allow for user interaction
- In Python text is represented as *strings*
- Strings are sequences of *characters*

Manipulating text is an important part of programming.

String Examples

```
>>> 'Albert Einstein'
'Albert Einstein'
>>> name = "Emmy Noether"
>>> name
'Emmy Noether'
```

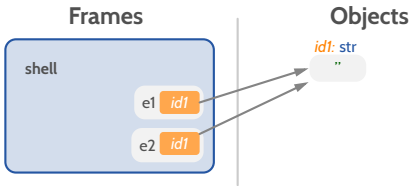


- Python *string literals* are characters surrounded by *quotes*; they are also expressions
- Python strings have the type `str`
- The quotes can be single or double quotes
- Use what you prefer
- But please use double quotes for *docstrings*
- Strings can be assigned to variables

Characters are letters, digits, punctuation and so on.

String Facts

```
>>> e1 = ''
>>> e1
''
>>> e2 = ""
>>> e2
''
```



- Strings can be *empty*
- Python strings can have arbitrary length (within memory limits)

Note that Python caches the empty string.

String Quoting Rules

- Quotes must match

```
>>> 'Charles Darwin"
  File "<stdin>", line 1
    'Charles Darwin"
                   ^
SyntaxError: EOL while scanning string literal
```

- If you need quotes inside a string, use the other quotes to surround (*delimit*) the string

```
>>> 'that's not going to work'
  File "<stdin>", line 1
    'that's not going to work'
         ^
SyntaxError: invalid syntax
```

```
>>> "that's much better!"
'that's much better!'
```

Notice the weird coloring in the second example. What might cause this?

String Length

- We often need to know the length of a string
- The builtin function `len` give us just that:

```
>>> len('Jane Goodall')
12
>>> len('123!')
4
>>> len(' ')
1
>>> len('')
0
```

- The length is the number of characters between the quotes
- The empty string has length `0`

Note that a string with only spaces is *not* empty.

String Concatenation

```
>>> 'Jane' + ' Goodall'
'Jane Goodall'
>>> 'Margaret Hamilton' + ""
'Margaret Hamilton'
```

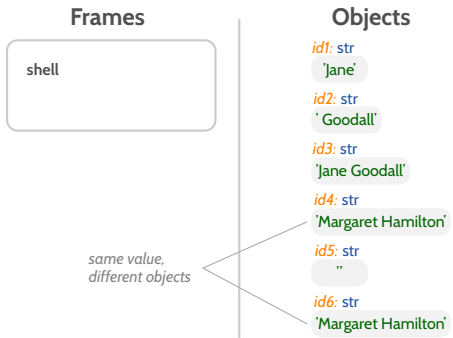
- It is common to *concatenate* strings
- In python this is done with the + operator
- Concatenation creates a new object

The + operator is meaningful for many types. We'll see more examples later.

String Concatenation

```
>>> 'Jane' + ' Goodall'
'Jane Goodall'
>>> 'Margaret Hamilton' + ""
'Margaret Hamilton'
```

- It is possible concatenate a string with the empty string
- This yields a string with the same value



Note there are now two *distinct* objects with the same value.

String Concatenation

- What happens when we try to add a number to a string?

```
>>> 'NH' + 3
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: must be str, not int
```

- The error message depends on the order of the operands

```
>>> 8 + ' planets'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) for +: 'int' and 'str'
```

Python can't figure out what we want to do here.

String Concatenation

- Use the builtin `str` function to convert a number to a string:

```
>>> 'There are ' + str(4) + ' lights!'
'There are 4 lights!'
```

```
>>> 'One mile is ' + str(1.60934) + ' km.'
'One mile is 1.60934 km.'
```

The concatenation operator must be applied to two strings.

String Conversions

- If a string looks like an integer, you can convert it to an integer using the builtin function `int`:

```
>>> int('0')
0
>>> int('13')
13
>>> int('-721')
-721
```

- For floating point variables we use the function `float`:

```
>>> float('-721')
-721.0
>>> float('47.1')
47.1
```

This is extremely useful when reading in data.

String Conversions

- This does not work for all strings:

```
>>> int('thirteen')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: invalid literal for int() with base 10: 'thirteen'
```

```
>>> float('pi')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: could not convert string to float: 'pi'
```

That's a problem when dealing with user input. We'll learn how to handle it soon.

Repeating Strings

- We can repeat strings using the `*` operator:

```
>>> 'ATT' * 5
'ATTATTATTATTATT'
>>> '-' * 8
'--------'
```

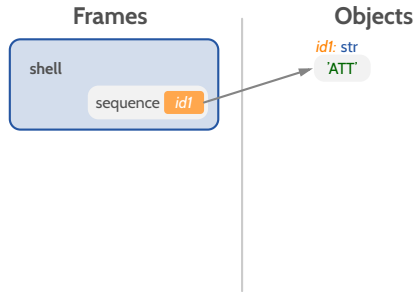
- Repeating with `0` or a negative number yields the empty string:

```
>>> 'GC' * 0
''
>>> 'TATATATATA' * -3
''
```

Speak precisely: this is *repetition*, *not* multiplication.

String Expressions

```
>>> sequence = 'ATT'
>>> len(sequence)
3
>>> new_sequence = sequence + 'GGC'
>>> new_sequence *= 2
```



- String literals can be assigned to variables

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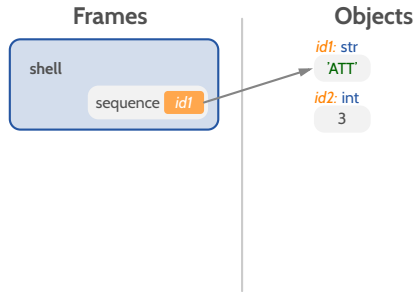

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- The `len` function yields information about a string object but doesn't change it

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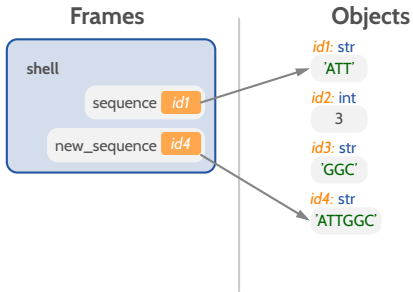
- Expressions with string results always create new objects



String Expressions

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>>> sequence = 'ATT'
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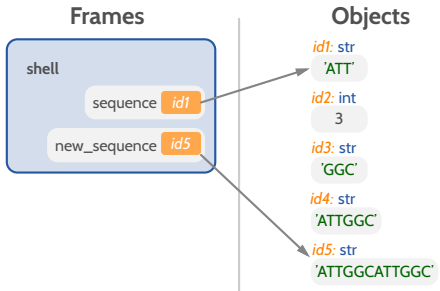
- String literals can be assigned to variables
- The `len` function yields information about a string object but doesn't change it
- Expressions with string results always create new objects
- This also applies to augmented assignment operators

Strings, just like numbers, are *immutable*.



Special Characters

- What if you want single and double quotes in one string? You could do this:

```
>>> 'She said, "That' + "'" + 's hard to read."'
'She said "That\'s hard to read."'
```

- The backslash `\` is an *escape character*
- `\'` is an *escape sequence*
- Escape sequences have length 1:

```
>>> len('that\'s')
6
```

Escape sequences are useful for formatted output.

Escape Sequences

Escape Sequence	Description
`\'`	single quote
`\"`	double quote
`\\`	backslash
`\t`	tab
`\n`	newline
`\r`	carriage return

Multiline Strings

- Strings defined with single or double quotes must be defined on one line:

```
>>> 'one:
  File "<stdin>", line 1
    'one
       ^
SyntaxError: EOL while scanning string literal
```

- We can define multiline strings using three quotes:

```
>>> """one
... two
... three"""
'one\ntwo\nthree'
```

Note the newline escape sequences in the representation.

Normalizing Newlines

- Different operating systems use different characters to indicate the end of a line:

System	Sequence
Mac OSX & Linux/Unix	`\n`
Windows	`\r\n`
Old Mac OS	`\r`

- Python *normalizes* newlines
- It always uses `\n` to indicate a new line
- Python programmers can write the same code for all systems

Printing Information

- We use the builtin function `print` to show messages to the users of our programs:

```
>>> print(1 + 1) # printing the result of an expression
2
>>> print("You can't take the sky from me.") # printing a string
You can't take the sky from me.
```

- Note that the quotes are stripped when printing a string
- The `print` function renders escape sequences instead of showing them:

```
>>> print('one\ttwo\nthree\tfour')
one     two
three   four
```

The `print` function doesn't do any styling. It always renders plain text.

Printing Information

- The `print` function takes a comma-separated list of values
- The values are separated by a space and the last value is followed by a newline
- The values can have different types

```
>>> print(1, 2, 3)
1 2 3
>>> print(1, 'two', 'three', 4.0) # three different types
1 two three 4.0
```

- Calling `print` without arguments produces a newline:

```
>>> print()

>>>
```

You will use the `print` function *a lot*.

Printing Information

- The `print` function has some extra helpful features

```
>>> help(print)
print(...)
    print(value, ..., sep=' ', end='\n', file=sys.stdout, flush=False)

    Prints the values to a stream, or to sys.stdout by default.
    Optional keyword arguments:
    file:  a file-like object (stream); defaults to the current sys.stdout.
    sep:   string inserted between values, default a space.
    end:   string appended after the last value, default a newline.
    flush: whether to forcibly flush the stream.
```

- The parameters `sep`, `end`, `file` and `flush` have assignment statements in the header!
- These are called *default parameters*
- Default parameters are values that the parameters take if we don't specify them

We are not concerned with the `file` and `flush` parameters for now.

Printing Information

- We can supply different values by using *keyword arguments* (often called `kwargs`)
- That's just fancy talk for assigning a parameter in a function call:

```
>>> print('a', 'b', 'c') # using the default separator ' '
a b c
>>> print('a', 'b', 'c', sep=', ') # changing the separator to  ', '
a, b, c
```

- Changing the `end` parameter is mostly useful in programs:

```
print('The absolute values of 4 and -5 are ', end=' ')
print(abs(4), ' and ', abs(-5), '.', sep='')
```

```
The absolute values of 4 and -5 are 4 and 5.
```

Similar results can be achieved with escape sequences.

Reading from the Keyboard

- We use the builtin function `input` to read user input from the keyboard
- The `input` function returns what the user enters as a string:

```
>>> species = input()
  Amblyrhynchus cristatus
>>> species
'Amblyrhynchus cristatus'
```

- Even if the input looks like a number:

```
>>> human_population = input() # user enters an estimate as of 26.10.2018 21:57 CEST
  7622432117
>>> human_population
'7622432117'
>>> type(human_population)
<class 'str'>
```

We just accidentally learned about that the `type` function.

Reading from the Keyboard

- If we need a number, we need to use conversion functions:

```
>>> human_population = input() # user enters an estimate as of 26.10.2018 21:57 CEST
  7622432117
>>> human_population = int(human_population)
>>> human_population
7622432117
>>> human_population += 9 # estimate per second as of 26.10.2018 21:57 CEST
>>> human_population
7622432126
```

- We can apply the conversion directly:

```
>>> human_population = int(input()) # user enters an estimate as of 26.10.2018 21:57 CEST
  7622432117
>>> human_population
7622432117
>>> human_population += 9 # estimate per second as of 26.10.2018 21:57 CEST
>>> human_population
7622432126
```

There is a problem if the user doesn't enter a valid integer.

Reading from the Keyboard

- We can tell the user what we want by providing a *prompt*:

```
>>> human_population = int(input('Please enter a population number: '))
Please enter a population number: 7622432117
>>> human_population
7622432117
```

Designing user interaction is hard. Think of the user's perspective, ask for help.

Exercises Lecture 4