Programming in Python 3

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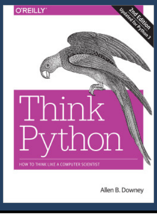
1

Book recommendation

Think Python, How to Think Like a Computer Scientist

Freely available via: http://www.greenteapress.com/thinkpython/

Second edition: Python 3


O'REILLY
2nd Edition Updated for Python 3
Think Python
HOW TO THINK LIKE A COMPUTER SCIENTIST
Allen B. Downey

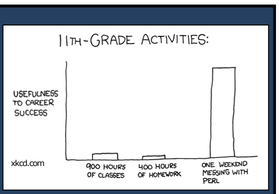
2

Topics

- Choosing a programming language
- Python applications
- Variables, expressions and statements
- Functions
- Conditionals and user intervention
- Fruitful functions and program development
- Strings
- Lists
- Files and exceptions

3

Why learn programming?



Structuring your work
- Repeatable and fast
- Separate source data and 'working data' – automatic conversion by a program!

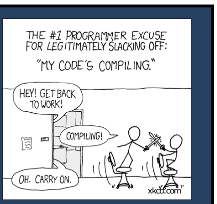
Developing models
- Combined with PCRaster

or other modules

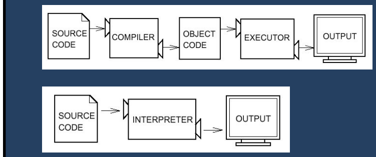
Other reasons
- Other software, e.g. developing a www site, creating a graphical user interface

4

Choosing a language (1)



Compiled versus interpreted programming languages:



5

Choosing a language (2)

Low-level languages versus high-level languages

Difference in language concept
- Low-level language: similar to concepts of a computer
- High-level language: closer to how humans think

6

Low-level language: example program (C++)

To print

Hello, world.

on the screen, we need in C++ the following program

```
#include <iostream.h>

void main()
{
  cout << "Hello, world." << endl;
}
```

7

High-level language: example program (Python)

To print

Hello, world.
on the screen, we need in Python the following program

```
print(“Hello, world.”)
```

8

Choosing a language (3)

Compared to low-level languages, a high-level language
- results in shorter programs
- is easier to learn
- results in longer runtimes (but not always)

Examples of computer languages
- Machine languages: compiled, low-level
- C++, Fortran, Java: compiled, low-level
- Perl, Python, PCRaster, MATLAB: interpreted, high-level

9

Why Python?

- High-level language: easier to learn
- Free and open source software
- Runs on all platforms (i.e. Microsoft Windows, Linux, Unix, Apple Macintosh)
- Comes with many modules (preprogrammed stuff)
- Common in the GIS world
- Used as framework for spatio-temporal modelling in PCRaster

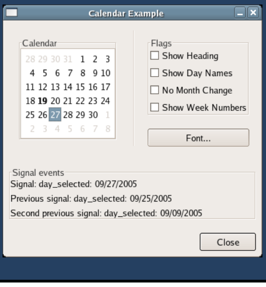
Website and software: http://www.python.org

python

10

Example Python applications (1)

- Widgets



28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	**19**	20	21	22	23	24
25	26	27	28	29	30	1
2	3	4	5	6	7	8

☐ Show Heading
☐ Show Day Names
☐ No Month Change
☐ Show Week Numbers

Signal events
Signal: day_selected: 09/27/2005
Previous signal: day_selected: 09/25/2005
Second previous signal: day_selected: 09/09/2005

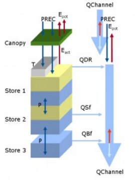
11

Example Python applications (2)

- Simulation models

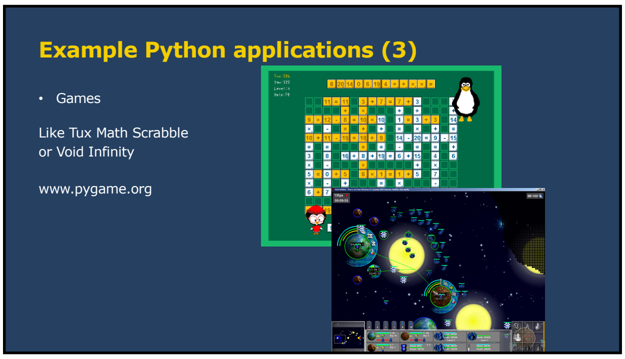
Like spatio-temporal modelling with PCRaster

http://www.pcraster.eu



Model concept of PCR-GLOBWB.

12



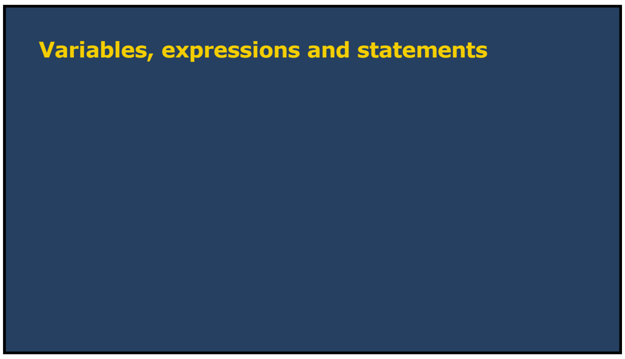
Example Python applications (3)

- Games

Like Tux Math Scrabble
or Void Infinity

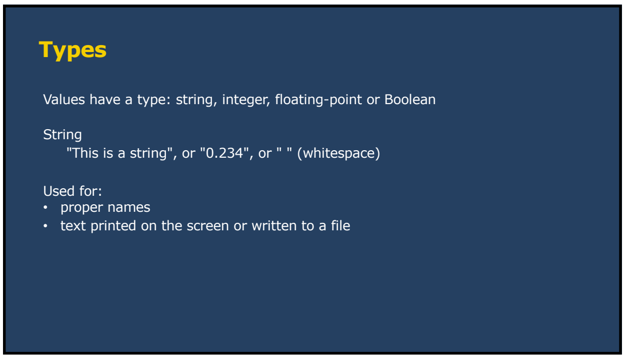
www.pygame.org

13



Variables, expressions and statements

14



Types

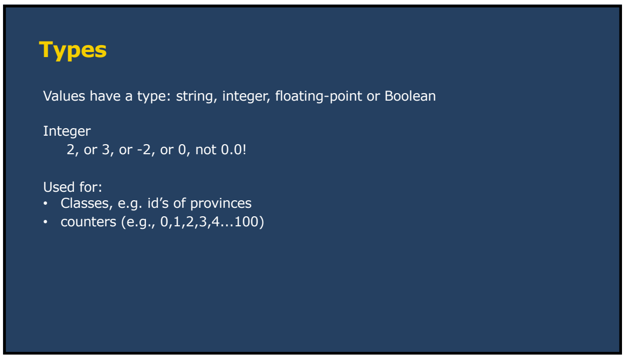
Values have a type: string, integer, floating-point or Boolean

String
"This is a string", or "0.234", or " " (whitespace)

Used for:

- proper names
- text printed on the screen or written to a file

15



Types

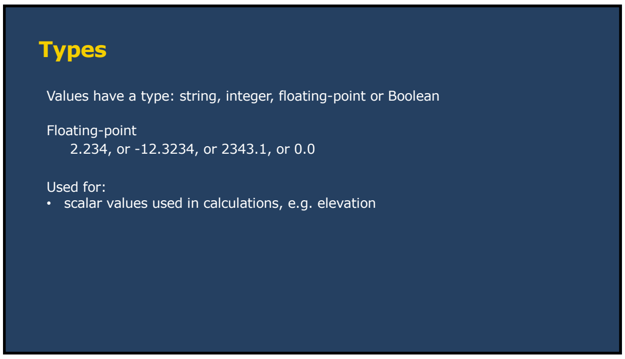
Values have a type: string, integer, floating-point or Boolean

Integer
2, or 3, or -2, or 0, not 0.0!

Used for:

- Classes, e.g. id's of provinces
- counters (e.g., 0,1,2,3,4...100)

16



Types

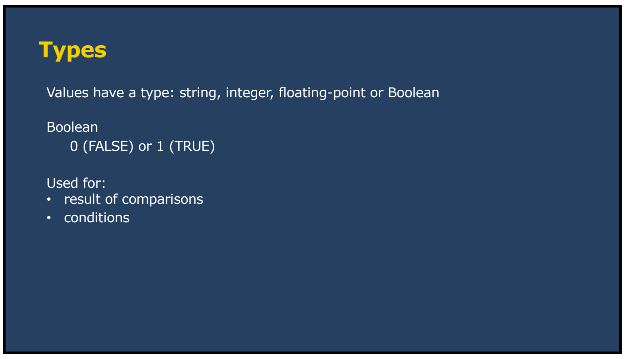
Values have a type: string, integer, floating-point or Boolean

Floating-point
2.234, or -12.3234, or 2343.1, or 0.0

Used for:

- scalar values used in calculations, e.g. elevation

17



Types

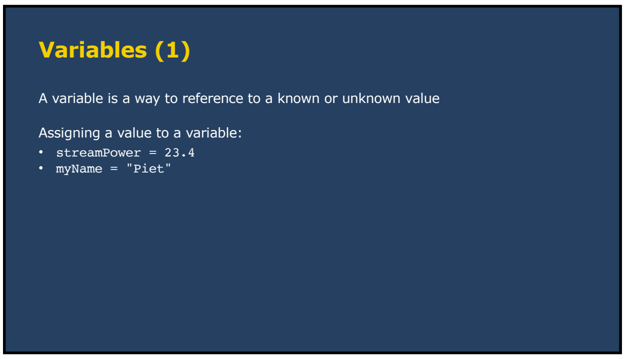
Values have a type: string, integer, floating-point or Boolean

Boolean
0 (FALSE) or 1 (TRUE)

Used for:

- result of comparisons
- conditions

18



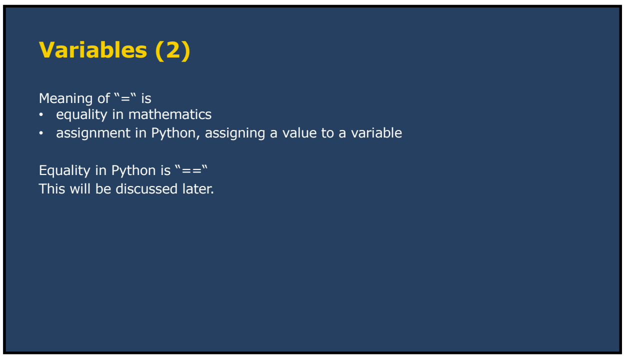
Variables (1)

A variable is a way to reference to a known or unknown value

Assigning a value to a variable:

- `streamPower = 23.4`
- `myName = "Piet"`

19



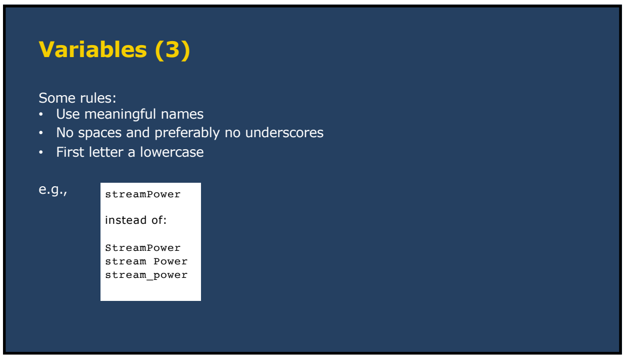
Variables (2)

Meaning of "=" is

- equality in mathematics
- assignment in Python, assigning a value to a variable

Equality in Python is "=="
This will be discussed later.

20



Variables (3)

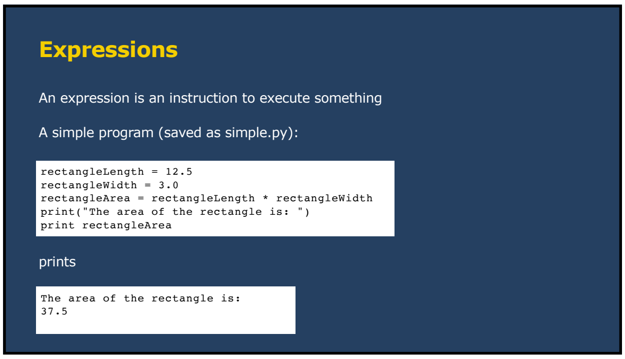
Some rules:

- Use meaningful names
- No spaces and preferably no underscores
- First letter a lowercase

e.g.,

```
streamPower

instead of:

StreamPower
stream Power
stream_power
```

21



Expressions

An expression is an instruction to execute something

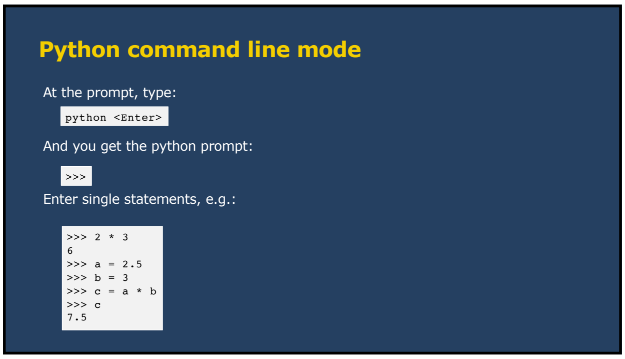
A simple program (saved as simple.py):

```
rectangleLength = 12.5
rectangleWidth = 3.0
rectangleArea = rectangleLength * rectangleWidth
print("The area of the rectangle is: ")
print rectangleArea
```

prints

```
The area of the rectangle is:
37.5
```

22



Python command line mode

At the prompt, type:

```
python <Enter>
```

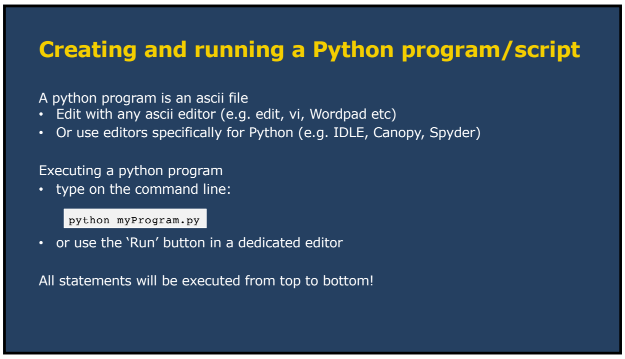
And you get the python prompt:

```
>>>
```

Enter single statements, e.g.:

```
>>> 2 * 3
6
>>> a = 2.5
>>> b = 3
>>> c = a * b
>>> c
7.5
```

23



Creating and running a Python program/script

A python program is an ascii file

- Edit with any ascii editor (e.g. edit, vi, Wordpad etc)
- Or use editors specifically for Python (e.g. IDLE, Canopy, Spyder)

Executing a python program

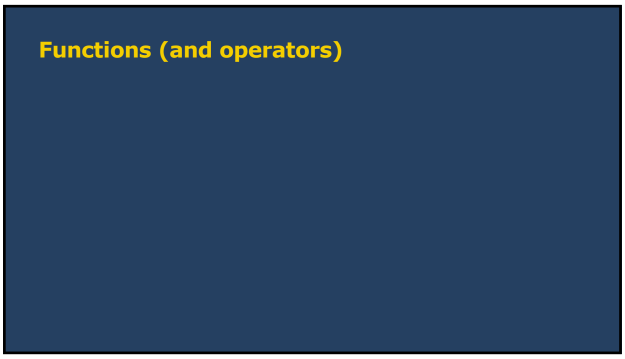
- type on the command line:

```
python myProgram.py
```

- or use the 'Run' button in a dedicated editor

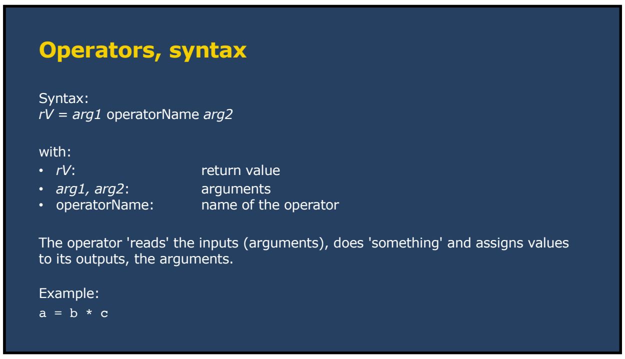
All statements will be executed from top to bottom!

24



Functions (and operators)

25



Operators, syntax

Syntax:
rV = arg1 operatorName *arg2*

with:

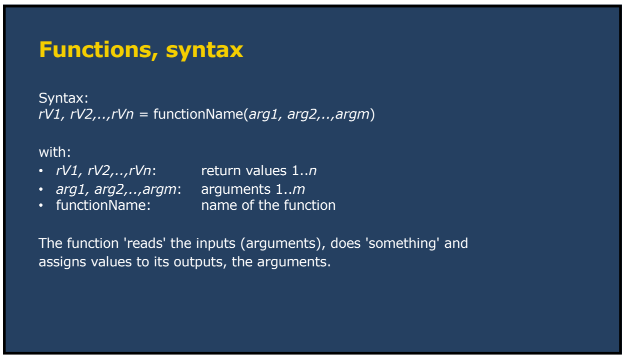
- *rV*: return value
- *arg1, arg2*: arguments
- operatorName: name of the operator

The operator 'reads' the inputs (arguments), does 'something' and assigns values to its outputs, the arguments.

Example:

```
a = b * c
```

26



Functions, syntax

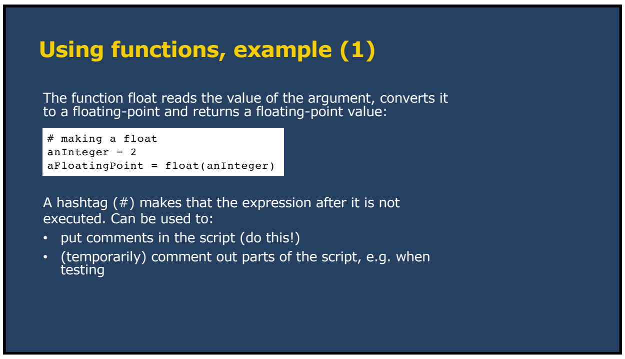
Syntax:
rV1, rV2,..,rVn = functionName(*arg1, arg2,..,argm*)

with:

- *rV1, rV2,..,rVn*: return values 1..*n*
- *arg1, arg2,..,argm*: arguments 1..*m*
- functionName: name of the function

The function 'reads' the inputs (arguments), does 'something' and assigns values to its outputs, the arguments.

27



Using functions, example (1)

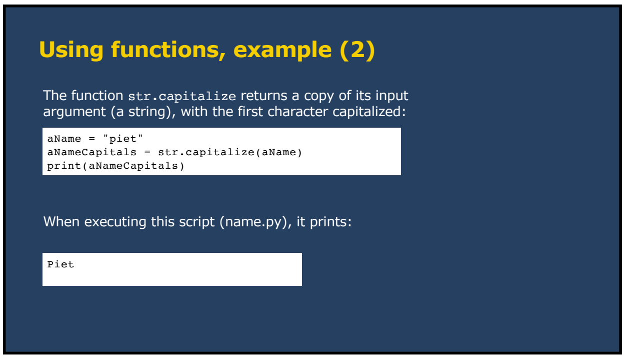
The function float reads the value of the argument, converts it to a floating-point and returns a floating-point value:

```
# making a float
anInteger = 2
aFloatingPoint = float(anInteger)
```

A hashtag (#) makes that the expression after it is not executed. Can be used to:

- put comments in the script (do this!)
- (temporarily) comment out parts of the script, e.g. when testing

28



Using functions, example (2)

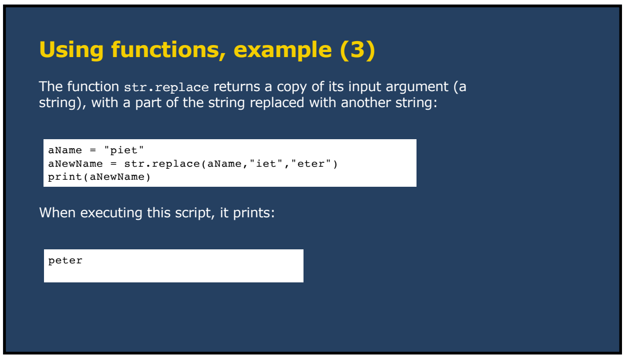
The function `str.capitalize` returns a copy of its input argument (a string), with the first character capitalized:

```
aName = "piet"
aNameCapitals = str.capitalize(aName)
print(aNameCapitals)
```

When executing this script (name.py), it prints:

```
Piet
```

29



Using functions, example (3)

The function `str.replace` returns a copy of its input argument (a string), with a part of the string replaced with another string:

```
aName = "piet"
aNewName = str.replace(aName,"iet","eter")
print(aNewName)
```

When executing this script, it prints:

```
peter
```

30

Modules/libraries

A module is a file with a collection of related functions. It needs to be imported at the top of a program, e.g.:

```
import math
```

Functions from a module are called using dot notation, e.g.:

```
logRunoff=math.log10(runoff)
```

The `str` module is an ‘internal’ module and you do not need to import it to use function from `str`.

31

Creating functions

Python comes with many built-in functions (most of them in modules)

You can also create functions yourself:

- New functions are built as a combination of existing python components (expressions)
- The definition of a new function is given in the main program or in an associated file
- A new function can be used anywhere in the program below where it is defined

32

Function definition, syntax

def *functionName*(*arg1*,*arg2*,..,*argn*):
    statement1
    ..
    statementm
    return *varReturn1*,...,*varReturnl*

with:

- *functionName*: the name of the new function
- *arg1, arg2, ..., argn*: input arguments
- *statement1, ...,statementm*: statements doing something with the inputs
- *varReturn1, ...,varReturnl*: variables returned by the function

33

Function definition, example

The function calculateRectangleArea with two input arguments returns one value:

```
def calculateRectangleArea(width, length):
   rectangleArea = width * length
   return rectangleArea

recLength = 12.5
recWidth = 3.0

recArea = calculateRectangleArea(recLength, recWidth)
print(recArea)
```

```
37.5
```

34

Function definition, example

A variable created in a function does not exist outside the function! E.g.:

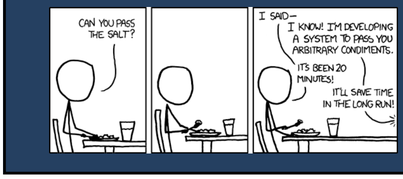
```
def calculateRectangleArea(width, length):
   rectangleArea = width * length
   return rectangleArea

recLength = 12.5
recWidth = 3.0

recArea = calculateRectangleArea(recLength, recWidth)
print(rectangleArea)
```

```
Traceback (most recent call last):
  File "test.py", line 9, in <module>
    print(rectangleArea)
NameError: name 'rectangleArea' is not defined
```

35

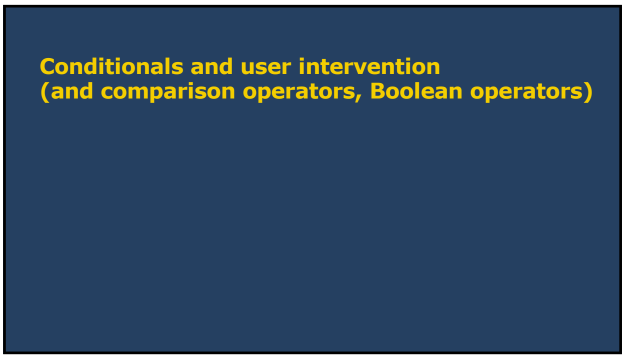
Why creating functions?

- Grouping statements serving one purpose makes the program easier to read and to debug
- Shorter scripts as repetitive code is eliminated
- Changing a single concept can be done at one place (in the function)
- Functions can be reused by others or in other programs of your own


CAN YOU PASS THE SALT?
I SAID—
I KNOW! I'M DEVELOPING A SYSTEM TO PASS YOU ARBITRARY CONDIMENTS.
IT'S BEEN 20 MINUTES!
IT'LL SAVE TIME IN THE LONG RUN!

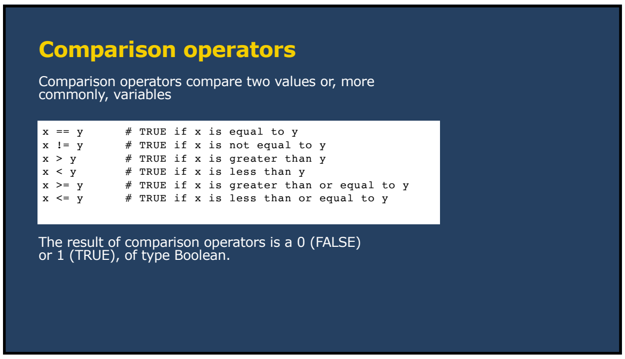
36

37



Conditionals and user intervention (and comparison operators, Boolean operators)

38



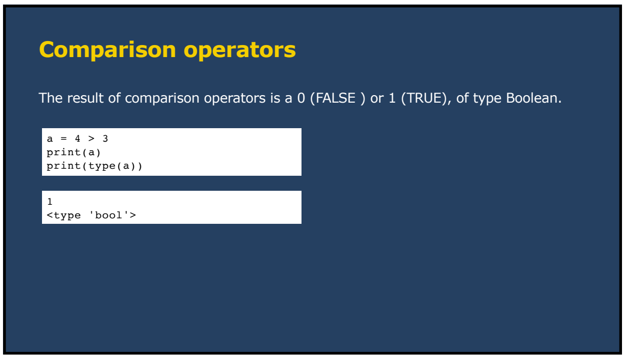
Comparison operators

Comparison operators compare two values or, more commonly, variables

```
x == y       # TRUE if x is equal to y
x != y       # TRUE if x is not equal to y
x > y        # TRUE if x is greater than y
x < y        # TRUE if x is less than y
x >= y       # TRUE if x is greater than or equal to y
x <= y       # TRUE if x is less than or equal to y
```

The result of comparison operators is a 0 (FALSE) or 1 (TRUE), of type Boolean.

39



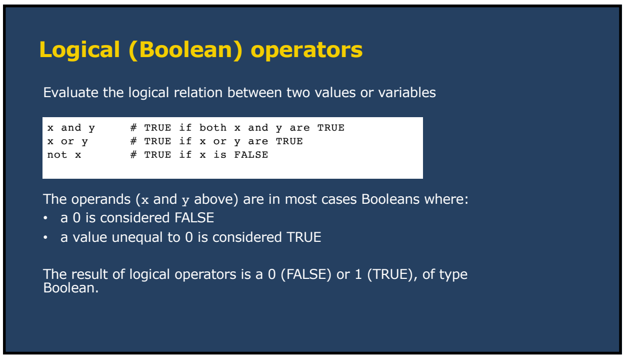
Comparison operators

The result of comparison operators is a 0 (FALSE) or 1 (TRUE), of type Boolean.

```
a = 4 > 3
print(a)
print(type(a))
```

```
1
<type 'bool'>
```

40



Logical (Boolean) operators

Evaluate the logical relation between two values or variables

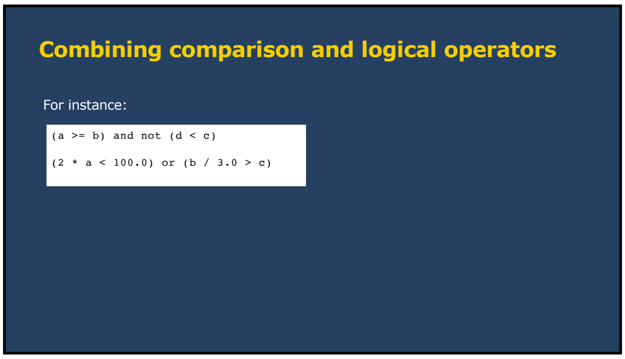
```
x and y     # TRUE if both x and y are TRUE
x or y      # TRUE if x or y are TRUE
not x       # TRUE if x is FALSE
```

The operands (x and y above) are in most cases Booleans where:

- a 0 is considered FALSE
- a value unequal to 0 is considered TRUE

The result of logical operators is a 0 (FALSE) or 1 (TRUE), of type Boolean.

41

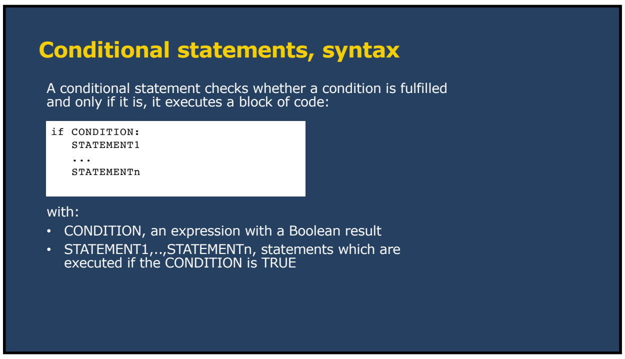


Combining comparison and logical operators

For instance:

```
(a >= b) and not (d < c)

(2 * a < 100.0) or (b / 3.0 > c)
```

42



Conditional statements, syntax

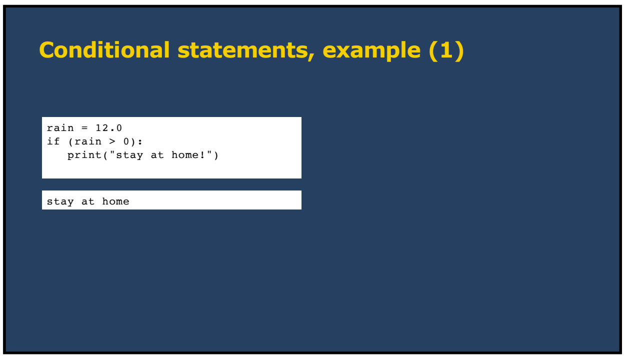
A conditional statement checks whether a condition is fulfilled and only if it is, it executes a block of code:

```
if CONDITION:
   STATEMENT1
   ...
   STATEMENTn
```

with:

- CONDITION, an expression with a Boolean result
- STATEMENT1,..,STATEMENTn, statements which are executed if the CONDITION is TRUE

43

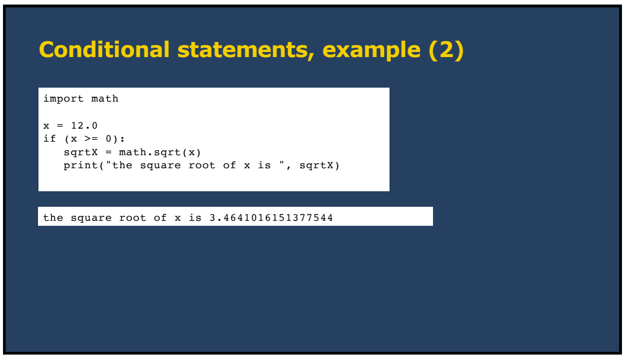


Conditional statements, example (1)

```
rain = 12.0
if (rain > 0):
   print("stay at home!")
```

```
stay at home
```

44

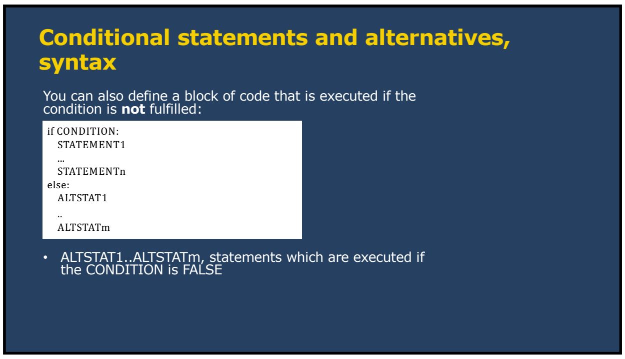


Conditional statements, example (2)

```
import math

x = 12.0
if (x >= 0):
   sqrtX = math.sqrt(x)
   print("the square root of x is ", sqrtX)
```

```
the square root of x is 3.4641016151377544
```

45



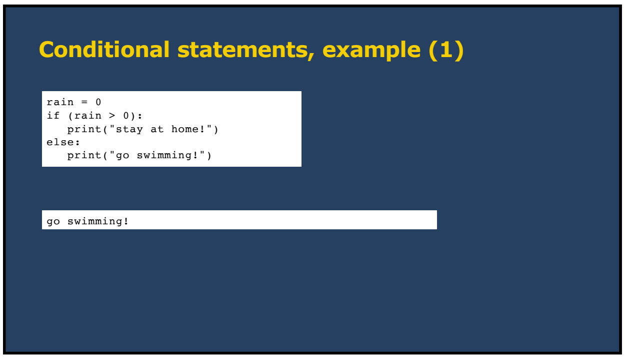
Conditional statements and alternatives, syntax

You can also define a block of code that is executed if the condition is **not** fulfilled:

```
if CONDITION:
   STATEMENT1
   …
   STATEMENTn
else:
   ALTSTAT1
   ..
   ALTSTATm
```

- ALTSTAT1..ALTSTATm, statements which are executed if the CONDITION is FALSE

46

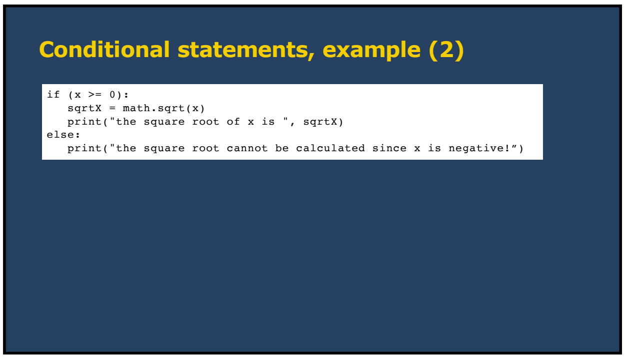


Conditional statements, example (1)

```
rain = 0
if (rain > 0):
   print("stay at home!")
else:
   print("go swimming!")
```

```
go swimming!
```

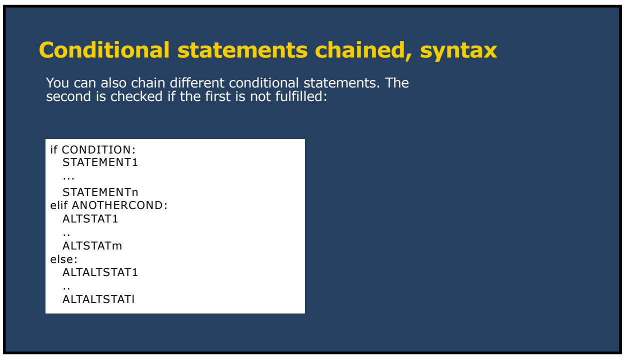
47



Conditional statements, example (2)

```
if (x >= 0):
   sqrtX = math.sqrt(x)
   print("the square root of x is ", sqrtX)
else:
   print("the square root cannot be calculated since x is negative!”)
```

48

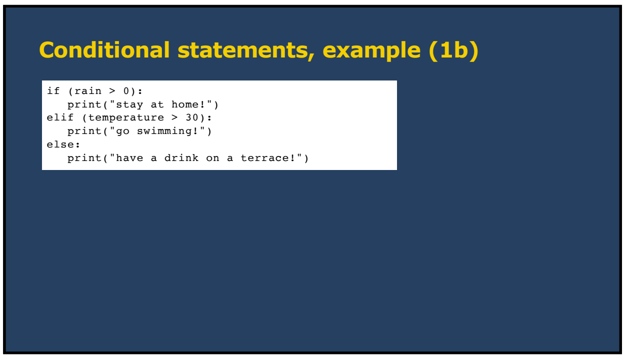


Conditional statements chained, syntax

You can also chain different conditional statements. The second is checked if the first is not fulfilled:

```
if CONDITION:
   STATEMENT1
   ...
   STATEMENTn
elif ANOTHERCOND:
   ALTSTAT1
   ..
   ALTSTATm
else:
   ALTALTSTAT1
   ..
   ALTALTSTATl
```

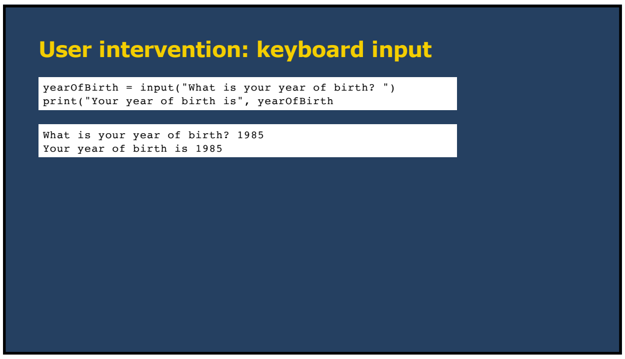
49



Conditional statements, example (1b)

```
if (rain > 0):
   print("stay at home!")
elif (temperature > 30):
   print("go swimming!")
else:
   print("have a drink on a terrace!")
```

50



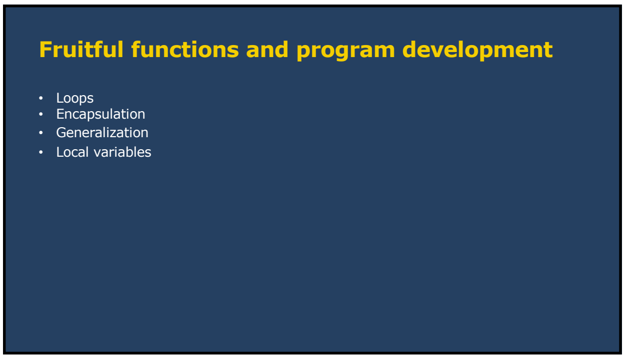
User intervention: keyboard input

```
yearOfBirth = input("What is your year of birth? ")
print("Your year of birth is", yearOfBirth
```

```
What is your year of birth? 1985
Your year of birth is 1985
```

51

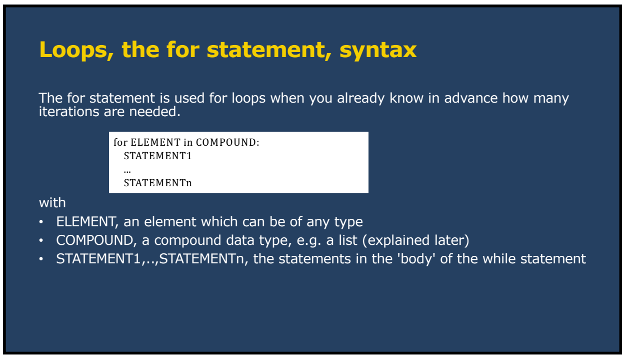
52



Fruitful functions and program development

- Loops
- Encapsulation
- Generalization
- Local variables

53



Loops, the for statement, syntax

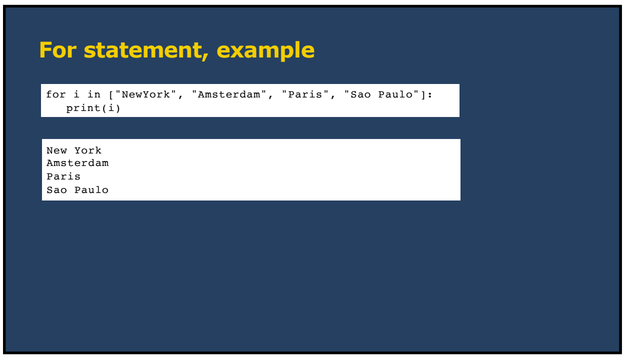
The for statement is used for loops when you already know in advance how many iterations are needed.

```
for ELEMENT in COMPOUND:
   STATEMENT1
   …
   STATEMENTn
```

with

- ELEMENT, an element which can be of any type
- COMPOUND, a compound data type, e.g. a list (explained later)
- STATEMENT1,..,STATEMENTn, the statements in the 'body' of the while statement

54

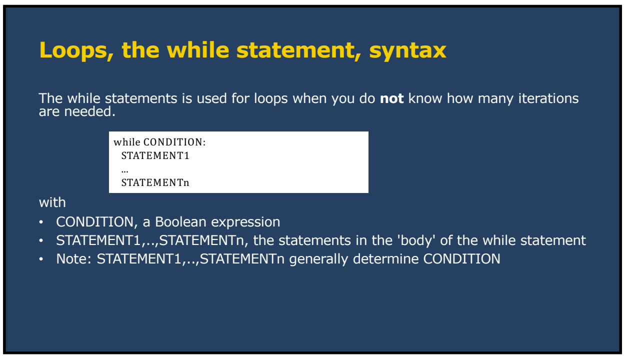


For statement, example

```
for i in ["NewYork", "Amsterdam", "Paris", "Sao Paulo"]:
   print(i)
```

```
New York
Amsterdam
Paris
Sao Paulo
```

55



Loops, the while statement, syntax

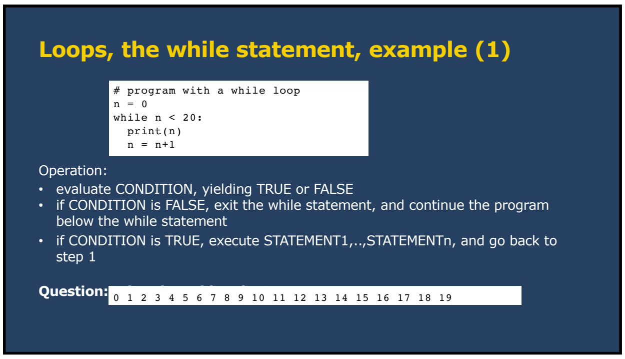
The while statements is used for loops when you do **not** know how many iterations are needed.

```
while CONDITION:
  STATEMENT1
  …
  STATEMENTn
```

with

- CONDITION, a Boolean expression
- STATEMENT1,..,STATEMENTn, the statements in the 'body' of the while statement
- Note: STATEMENT1,..,STATEMENTn generally determine CONDITION

56



Loops, the while statement, example (1)

```
# program with a while loop
n = 0
while n < 20:
  print(n)
  n = n+1
```

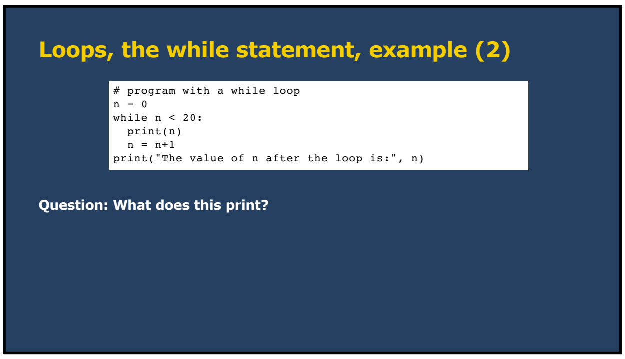
Operation:

- evaluate CONDITION, yielding TRUE or FALSE
- if CONDITION is FALSE, exit the while statement, and continue the program below the while statement
- if CONDITION is TRUE, execute STATEMENT1,..,STATEMENTn, and go back to step 1

Question:

```
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
```

57

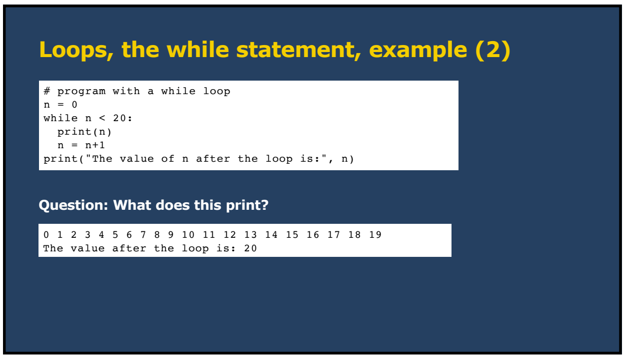


Loops, the while statement, example (2)

```
# program with a while loop
n = 0
while n < 20:
  print(n)
  n = n+1
print("The value of n after the loop is:", n)
```

Question: What does this print?

58



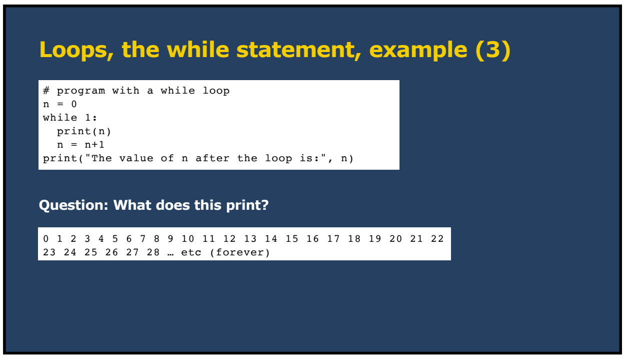
Loops, the while statement, example (2)

```
# program with a while loop
n = 0
while n < 20:
  print(n)
  n = n+1
print("The value of n after the loop is:", n)
```

Question: What does this print?

```
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
The value after the loop is: 20
```

59



Loops, the while statement, example (3)

```
# program with a while loop
n = 0
while 1:
  print(n)
  n = n+1
print("The value of n after the loop is:", n)
```

Question: What does this print?

```
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
23 24 25 26 27 28 … etc (forever)
```

60

Loops, the while statement, example (4)

```
# program with a while loop
n = 0
while n < 20:
  print(n)
  n = n+1
print("The value of n after the loop is:", n)
```

Change into:

```
# program with a while loop
n = 40
while n < 20:
  print(n)
  n = n+1
print("The value of n after the loop is:", n)
```

Question: What does this print?

```
The value after the loop is: 40
```

61

While statement, printing a table

```
import math

print("degrees\tfraction (m/m)")
slopeDegrees = 0.0
while slopeDegrees < 30.0:
   slopeRadians = (slopeDegrees / 360.0) * 2.0 * math.pi
   slopeFraction = math.tan(slopeRadians)
   print(slopeDegrees, "\t", slopeFraction)
   slopeDegrees = slopeDegrees + 5.0
```

```
degrees fraction (m/m)
0.0   0.0
5.0   0.0874886635259
10.0  0.176326980708
15.0  0.267949192431
20.0  0.363970234266
25.0  0.466307658155
```

62

Creating functions (1)

Rewrite the code in the previous slide as (encapsulation):

```
import math

def degreesToRadians(degrees):
   radians = (degrees / 360.0) * 2.0 * math.pi
   return radians

print("degrees\tfraction (m/m)")
slopeDegrees = 0.0
while slopeDegrees < 30.0:
   slopeRadians = degreesToRadians(slopeDegrees)
   slopeFraction = math.tan(slopeRadians)
   print(slopeDegrees, "\t", slopeFraction)
   slopeDegrees = slopeDegrees + 5.0
```

63

Creating functions (2)

Or even as:

```
import math

def degreesToRadians(degrees):
   radians = (degrees / 360.0) * 2.0 * math.pi
   return radians

def degreesToFraction(degrees):
   radians = degreesToRadians(degrees)
   fraction = math.tan(radians)
   return fraction

print("degrees\tfraction (m/m)")
slopeDegrees = 0.0
while slopeDegrees < 30.0:
   slopeFraction = degreesToFraction(slopeDegrees)
   print(slopeDegrees, "\t", slopeFraction)
   slopeDegrees = slopeDegrees + 5.0
```

64

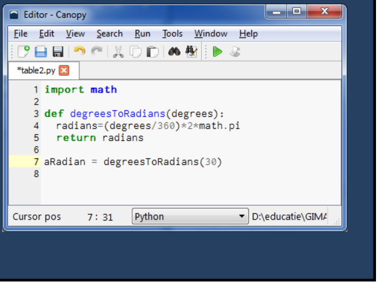
Creating functions (3)

```
import math

def degreesToRadians(degrees):
   radians = (degrees / 360.0) * 2.0 * math.pi
   return radians

def degreesToFraction(degrees):
   radians = degreesToRadians(degrees)
   fraction = math.tan(radians)
   return fraction

def printDegreesToFractionTable():
   print("degrees\tfraction (m/m)")
   slopeDegrees = 0.0
   while slopeDegrees < 30.0:
      slopeFraction = degreesToFraction(slopeDegrees)
      print(slopeDegrees, "\t", slopeFraction)
      slopeDegrees = slopeDegrees + 5.0

printDegreesToFractionTable()
```

65

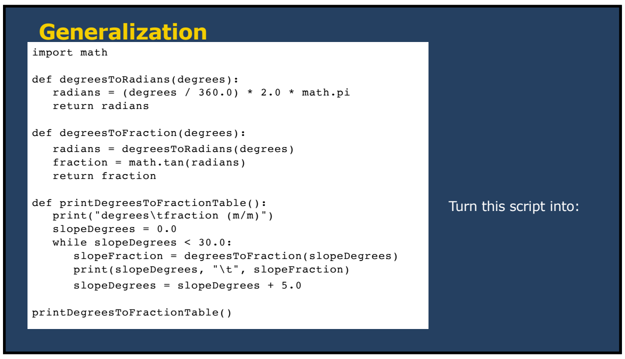
Why is encapsulation useful?

- Program is easier to read
- Reuse of code
- Easy debugging



```
import math

def degreesToRadians(degrees):
  radians=(degrees/360)*2*math.pi
  return radians

aRadian = degreesToRadians(30)
```

66

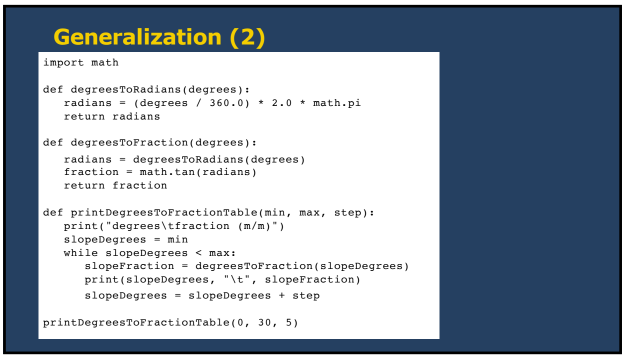


Generalization

```
import math

def degreesToRadians(degrees):
   radians = (degrees / 360.0) * 2.0 * math.pi
   return radians

def degreesToFraction(degrees):
   radians = degreesToRadians(degrees)
   fraction = math.tan(radians)
   return fraction

def printDegreesToFractionTable():
   print("degrees\tfraction (m/m)")
   slopeDegrees = 0.0
   while slopeDegrees < 30.0:
      slopeFraction = degreesToFraction(slopeDegrees)
      print(slopeDegrees, "\t", slopeFraction)
      slopeDegrees = slopeDegrees + 5.0

printDegreesToFractionTable()
```

Turn this script into:

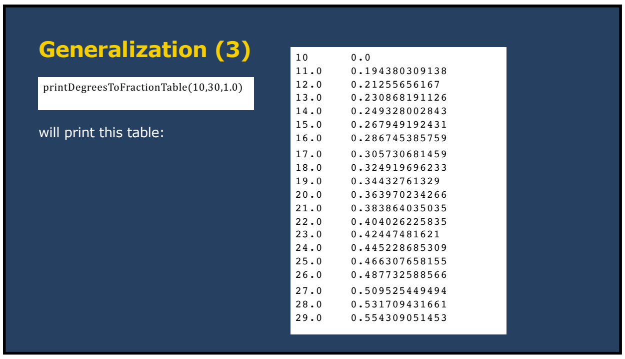
67



Generalization (2)

```
import math

def degreesToRadians(degrees):
   radians = (degrees / 360.0) * 2.0 * math.pi
   return radians

def degreesToFraction(degrees):
   radians = degreesToRadians(degrees)
   fraction = math.tan(radians)
   return fraction

def printDegreesToFractionTable(min, max, step):
   print("degrees\tfraction (m/m)")
   slopeDegrees = min
   while slopeDegrees < max:
      slopeFraction = degreesToFraction(slopeDegrees)
      print(slopeDegrees, "\t", slopeFraction)
      slopeDegrees = slopeDegrees + step

printDegreesToFractionTable(0, 30, 5)
```

68



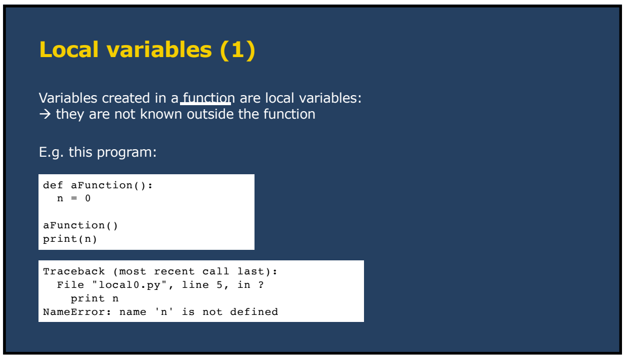
Generalization (3)

```
printDegreesToFractionTable(10,30,1.0)
```

will print this table:

```
10      0.0
11.0    0.194380309138
12.0    0.21255656167
13.0    0.230868191126
14.0    0.249328002843
15.0    0.267949192431
16.0    0.286745385759
17.0    0.305730681459
18.0    0.324919696233
19.0    0.34432761329
20.0    0.363970234266
21.0    0.383864035035
22.0    0.404026225835
23.0    0.42447481621
24.0    0.445228685309
25.0    0.466307658155
26.0    0.487732588566
27.0    0.509525449494
28.0    0.531709431661
29.0    0.554309051453
```

69



Local variables (1)

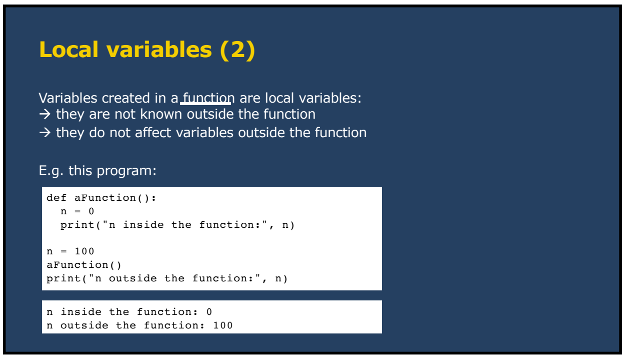
Variables created in a function are local variables:
→ they are not known outside the function

E.g. this program:

```
def aFunction():
  n = 0

aFunction()
print(n)
```

```
Traceback (most recent call last):
  File "local0.py", line 5, in ?
    print n
NameError: name 'n' is not defined
```

70



Local variables (2)

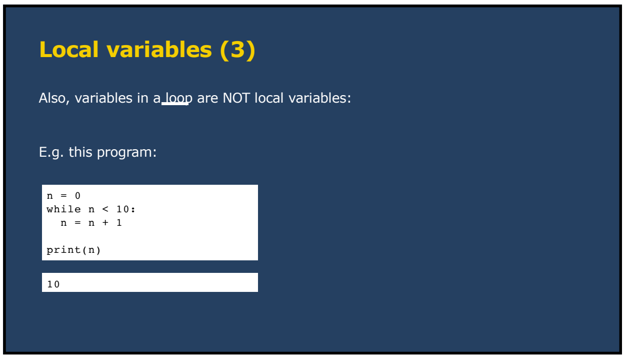
Variables created in a function are local variables:
→ they are not known outside the function
→ they do not affect variables outside the function

E.g. this program:

```
def aFunction():
  n = 0
  print("n inside the function:", n)

n = 100
aFunction()
print("n outside the function:", n)
```

```
n inside the function: 0
n outside the function: 100
```

71



Local variables (3)

Also, variables in a loop are NOT local variables:

E.g. this program:

```
n = 0
while n < 10:
  n = n + 1

print(n)
```

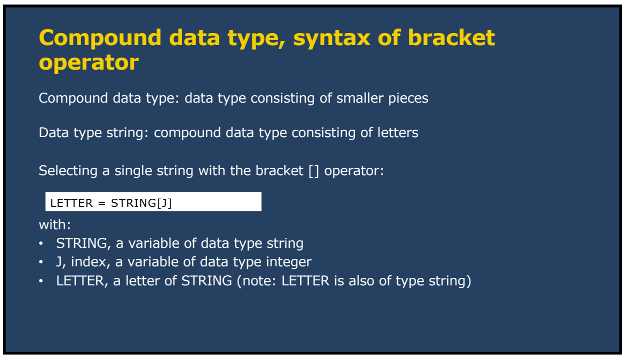
```
10
```

72

73

Strings

74



Compound data type, syntax of bracket operator

Compound data type: data type consisting of smaller pieces

Data type string: compound data type consisting of letters

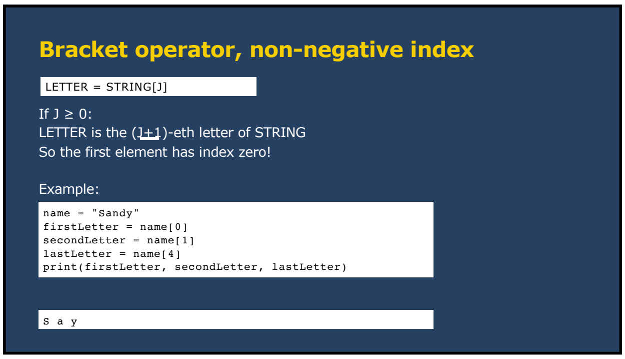
Selecting a single string with the bracket [] operator:

```
LETTER = STRING[J]
```

with:

- STRING, a variable of data type string
- J, index, a variable of data type integer
- LETTER, a letter of STRING (note: LETTER is also of type string)

75



Bracket operator, non-negative index

```
LETTER = STRING[J]
```

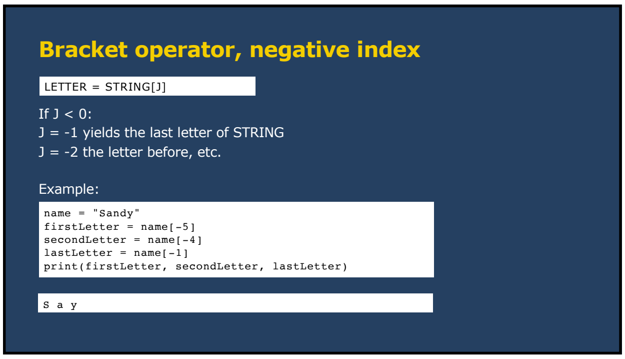
If J ≥ 0:
LETTER is the (J+1)-eth letter of STRING
So the first element has index zero!

Example:

```
name = "Sandy"
firstLetter = name[0]
secondLetter = name[1]
lastLetter = name[4]
print(firstLetter, secondLetter, lastLetter)
```

```
S a y
```

76



Bracket operator, negative index

```
LETTER = STRING[J]
```

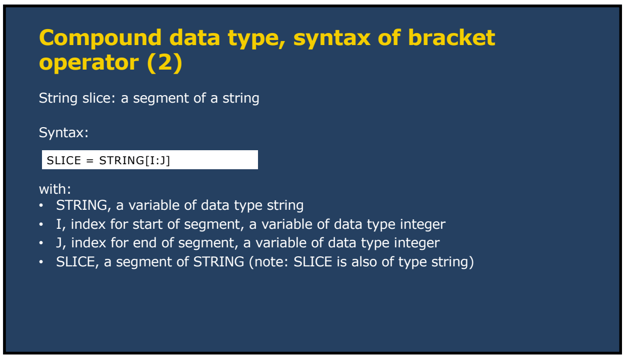
If J < 0:
J = -1 yields the last letter of STRING
J = -2 the letter before, etc.

Example:

```
name = "Sandy"
firstLetter = name[-5]
secondLetter = name[-4]
lastLetter = name[-1]
print(firstLetter, secondLetter, lastLetter)
```

```
S a y
```

77



Compound data type, syntax of bracket operator (2)

String slice: a segment of a string

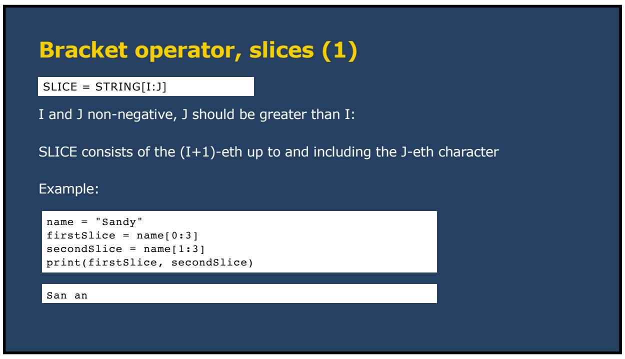
Syntax:

```
SLICE = STRING[I:J]
```

with:

- STRING, a variable of data type string
- I, index for start of segment, a variable of data type integer
- J, index for end of segment, a variable of data type integer
- SLICE, a segment of STRING (note: SLICE is also of type string)

78



Bracket operator, slices (1)

```
SLICE = STRING[I:J]
```

I and J non-negative, J should be greater than I:

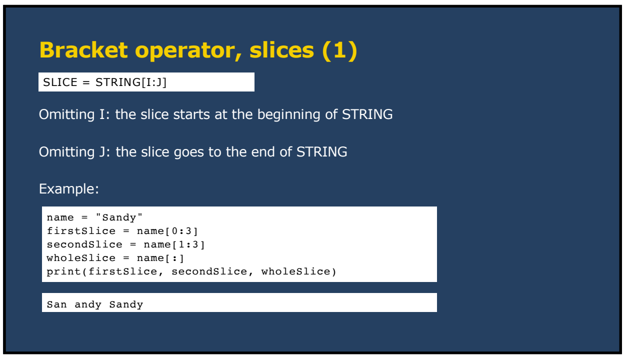
SLICE consists of the (I+1)-eth up to and including the J-eth character

Example:

```
name = "Sandy"
firstSlice = name[0:3]
secondSlice = name[1:3]
print(firstSlice, secondSlice)
```

```
San an
```

79



Bracket operator, slices (1)

```
SLICE = STRING[I:J]
```

Omitting I: the slice starts at the beginning of STRING

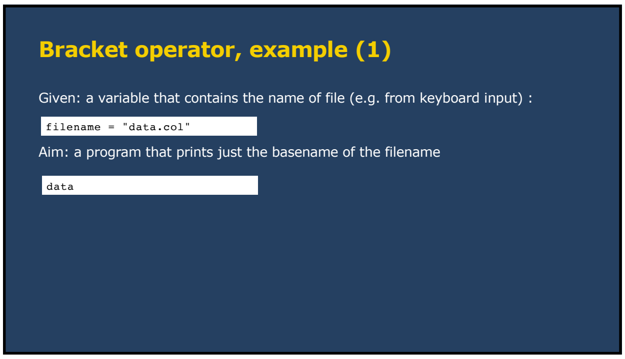
Omitting J: the slice goes to the end of STRING

Example:

```
name = "Sandy"
firstSlice = name[0:3]
secondSlice = name[1:3]
wholeSlice = name[:]
print(firstSlice, secondSlice, wholeSlice)
```

```
San andy Sandy
```

80



Bracket operator, example (1)

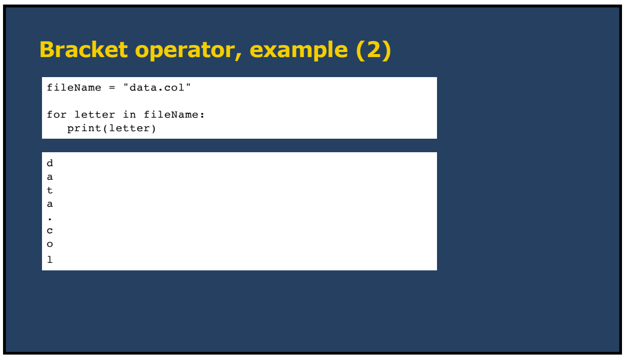
Given: a variable that contains the name of file (e.g. from keyboard input) :

```
filename = "data.col"
```

Aim: a program that prints just the basename of the filename

```
data
```

81

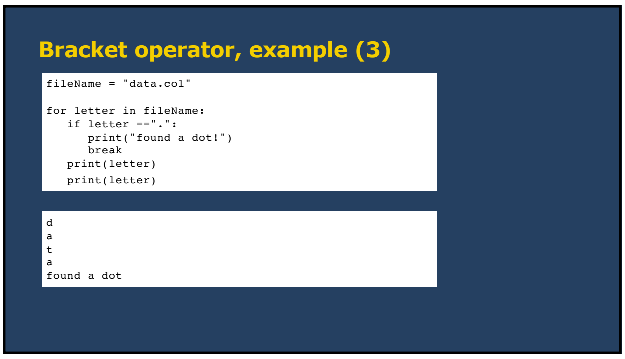


Bracket operator, example (2)

```
fileName = "data.col"

for letter in fileName:
   print(letter)
```

```
d
a
t
a
.
c
o
l
```

82

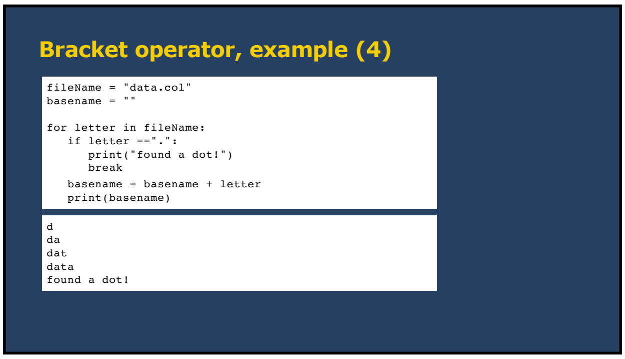


Bracket operator, example (3)

```
fileName = "data.col"

for letter in fileName:
   if letter ==".":
      print("found a dot!")
      break
   print(letter)
   print(letter)
```

```
d
a
t
a
found a dot
```

83

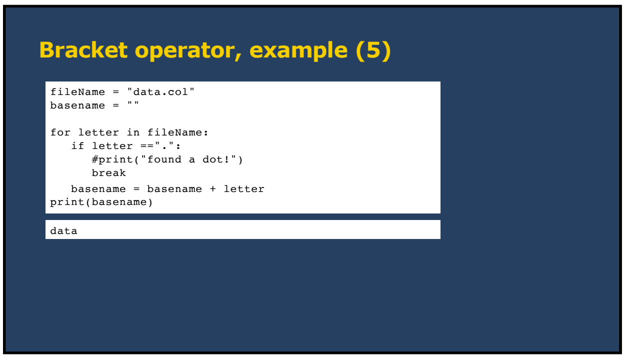


Bracket operator, example (4)

```
fileName = "data.col"
basename = ""

for letter in fileName:
   if letter ==".":
      print("found a dot!")
      break
   basename = basename + letter
   print(basename)
```

```
d
da
dat
data
found a dot!
```

84

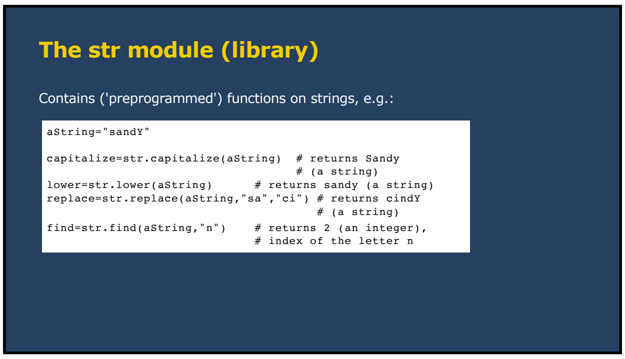


Bracket operator, example (5)

```
fileName = "data.col"
basename = ""

for letter in fileName:
   if letter ==".":
      #print("found a dot!")
      break
   basename = basename + letter
print(basename)
```

```
data
```

85

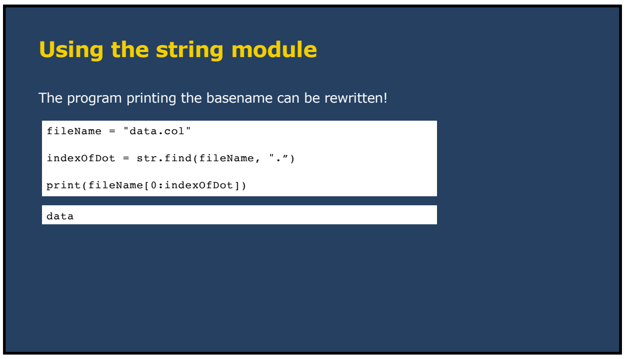


The str module (library)

Contains ('preprogrammed') functions on strings, e.g.:

```
aString="sandY"

capitalize=str.capitalize(aString)  # returns Sandy
                                    # (a string)
lower=str.lower(aString)      # returns sandy (a string)
replace=str.replace(aString,"sa","ci") # returns cindY
                                       # (a string)
find=str.find(aString,"n")    # returns 2 (an integer),
                              # index of the letter n
```

86



Using the string module

The program printing the basename can be rewritten!

```
fileName = "data.col"

indexOfDot = str.find(fileName, ".”)

print(fileName[0:indexOfDot])
```

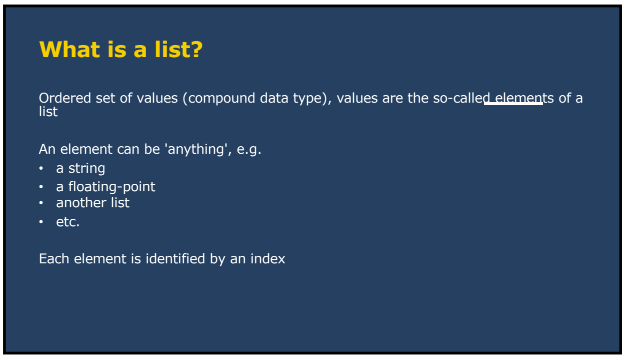
```
data
```

87

88

Lists

89



What is a list?

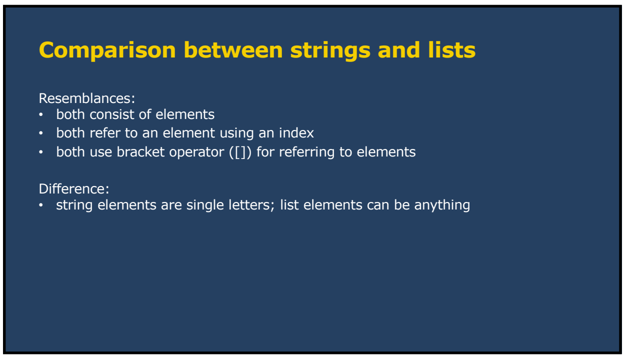
Ordered set of values (compound data type), values are the so-called elements of a list

An element can be 'anything', e.g.

- a string
- a floating-point
- another list
- etc.

Each element is identified by an index

90

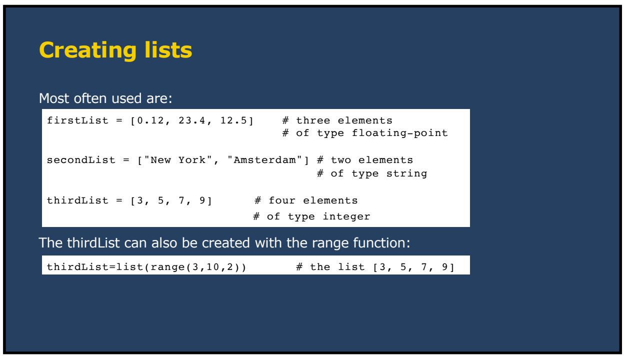


Comparison between strings and lists

Resemblances:
- both consist of elements
- both refer to an element using an index
- both use bracket operator ([]) for referring to elements

Difference:
- string elements are single letters; list elements can be anything

91



Creating lists

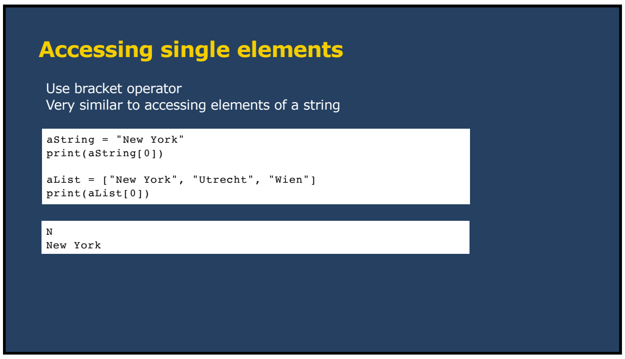
Most often used are:

```
firstList = [0.12, 23.4, 12.5]    # three elements
                                  # of type floating-point

secondList = ["New York", "Amsterdam"] # two elements
                                       # of type string

thirdList = [3, 5, 7, 9]      # four elements
                              # of type integer
```

The thirdList can also be created with the range function:

```
thirdList=list(range(3,10,2))       # the list [3, 5, 7, 9]
```

92



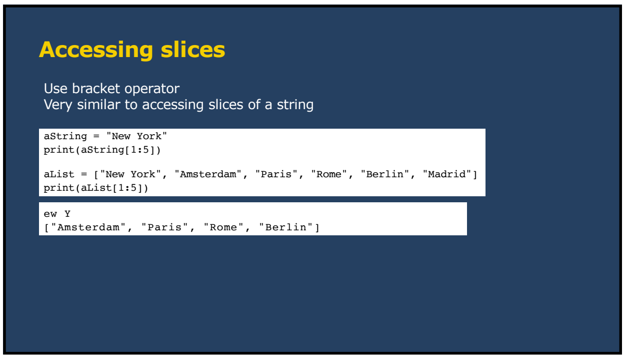
Accessing single elements

Use bracket operator
Very similar to accessing elements of a string

```
aString = "New York"
print(aString[0])

aList = ["New York", "Utrecht", "Wien"]
print(aList[0])
```

```
N
New York
```

93



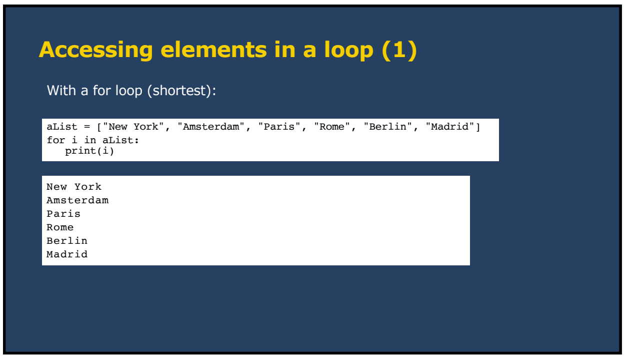
Accessing slices

Use bracket operator
Very similar to accessing slices of a string

```
aString = "New York"
print(aString[1:5])

aList = ["New York", "Amsterdam", "Paris", "Rome", "Berlin", "Madrid"]
print(aList[1:5])
```

```
ew Y
["Amsterdam", "Paris", "Rome", "Berlin"]
```

94



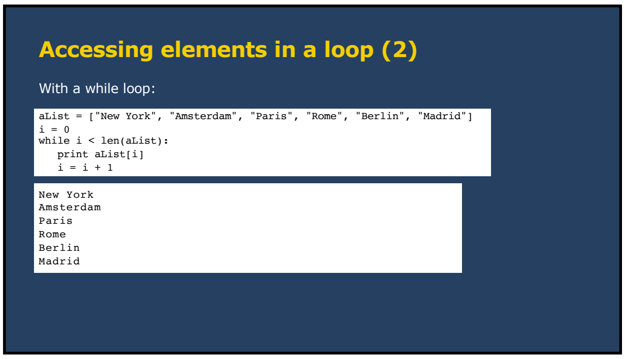
Accessing elements in a loop (1)

With a for loop (shortest):

```
aList = ["New York", "Amsterdam", "Paris", "Rome", "Berlin", "Madrid"]
for i in aList:
   print(i)
```

```
New York
Amsterdam
Paris
Rome
Berlin
Madrid
```

95



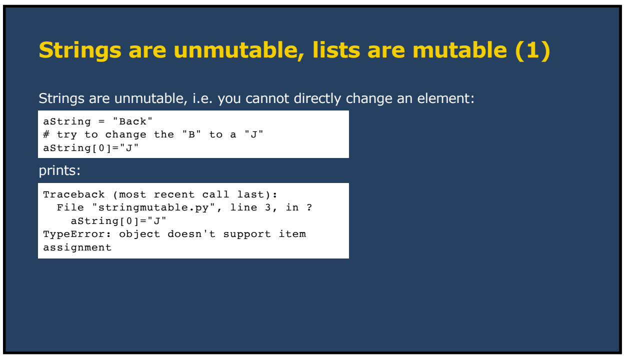
Accessing elements in a loop (2)

With a while loop:

```
aList = ["New York", "Amsterdam", "Paris", "Rome", "Berlin", "Madrid"]
i = 0
while i < len(aList):
   print aList[i]
   i = i + 1
```

```
New York
Amsterdam
Paris
Rome
Berlin
Madrid
```

96



Strings are unmutable, lists are mutable (1)

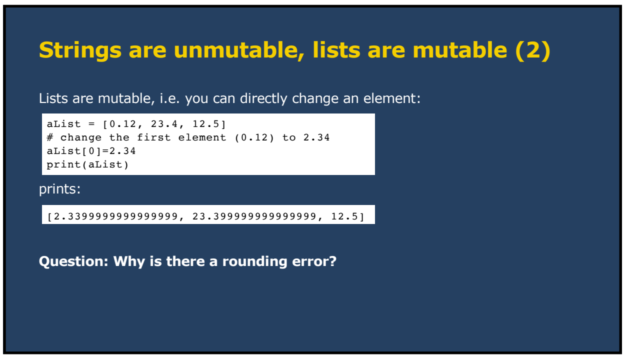
Strings are unmutable, i.e. you cannot directly change an element:

```
aString = "Back"
# try to change the "B" to a "J"
aString[0]="J"
```

prints:

```
Traceback (most recent call last):
  File "stringmutable.py", line 3, in ?
    aString[0]="J"
TypeError: object doesn't support item
assignment
```

97



Strings are unmutable, lists are mutable (2)

Lists are mutable, i.e. you can directly change an element:

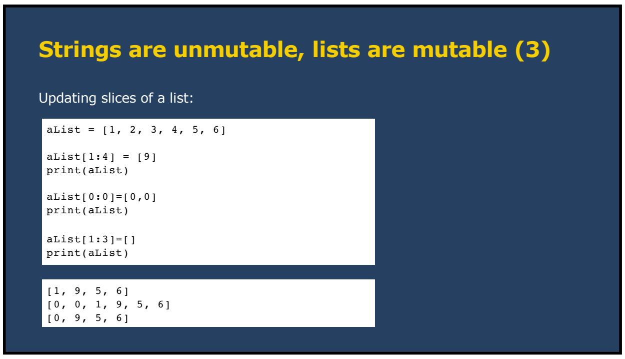
```
aList = [0.12, 23.4, 12.5]
# change the first element (0.12) to 2.34
aList[0]=2.34
print(aList)
```

prints:

```
[2.3399999999999999, 23.399999999999999, 12.5]
```

Question: Why is there a rounding error?

98



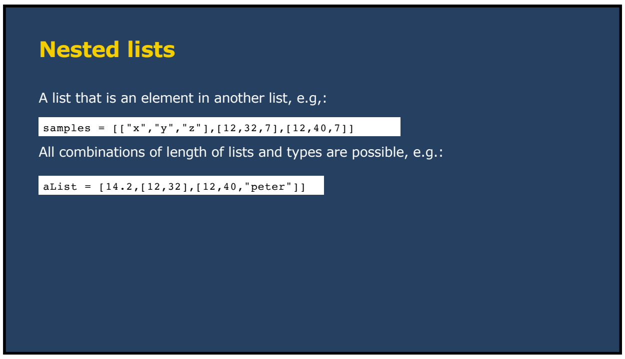
Strings are unmutable, lists are mutable (3)

Updating slices of a list:

```
aList = [1, 2, 3, 4, 5, 6]

aList[1:4] = [9]
print(aList)

aList[0:0]=[0,0]
print(aList)

aList[1:3]=[]
print(aList)
```

```
[1, 9, 5, 6]
[0, 0, 1, 9, 5, 6]
[0, 9, 5, 6]
```

99



Nested lists

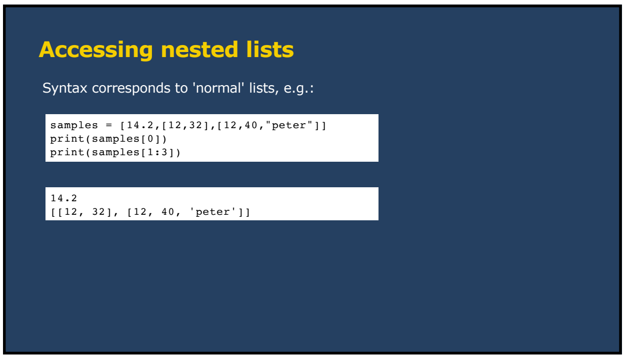
A list that is an element in another list, e.g,:

```
samples = [["x","y","z"],[12,32,7],[12,40,7]]
```

All combinations of length of lists and types are possible, e.g.:

```
aList = [14.2,[12,32],[12,40,"peter"]]
```

100



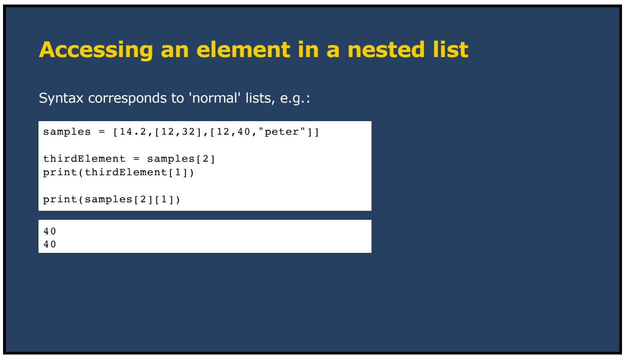
Accessing nested lists

Syntax corresponds to 'normal' lists, e.g.:

```
samples = [14.2,[12,32],[12,40,"peter"]]
print(samples[0])
print(samples[1:3])
```

```
14.2
[[12, 32], [12, 40, 'peter']]
```

101



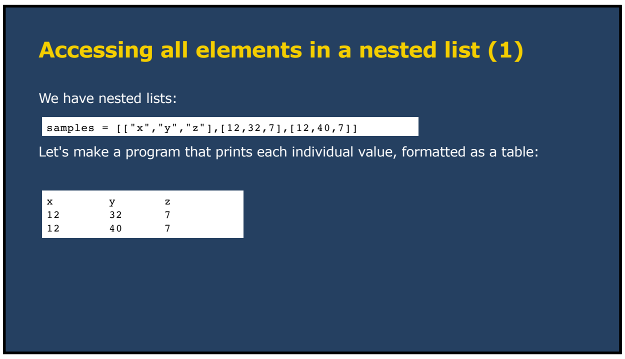
Accessing an element in a nested list

Syntax corresponds to 'normal' lists, e.g.:

```
samples = [14.2,[12,32],[12,40,"peter"]]

thirdElement = samples[2]
print(thirdElement[1])

print(samples[2][1])
```

```
40
40
```

102



Accessing all elements in a nested list (1)

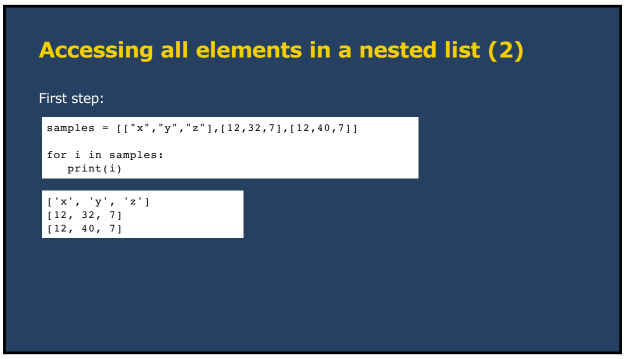
We have nested lists:

```
samples = [["x","y","z"],[12,32,7],[12,40,7]]
```

Let's make a program that prints each individual value, formatted as a table:

```
x        y        z
12       32       7
12       40       7
```

103



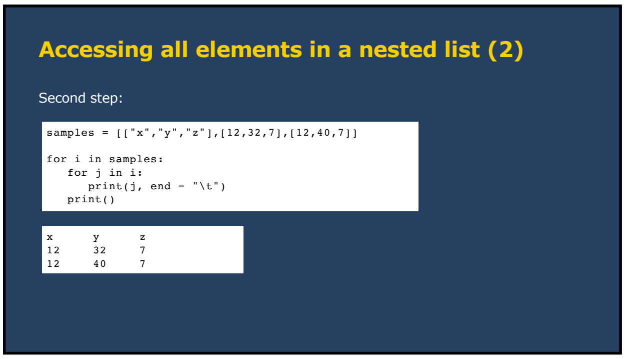
Accessing all elements in a nested list (2)

First step:

```
samples = [["x","y","z"],[12,32,7],[12,40,7]]

for i in samples:
   print(i)
```

```
['x', 'y', 'z']
[12, 32, 7]
[12, 40, 7]
```

104



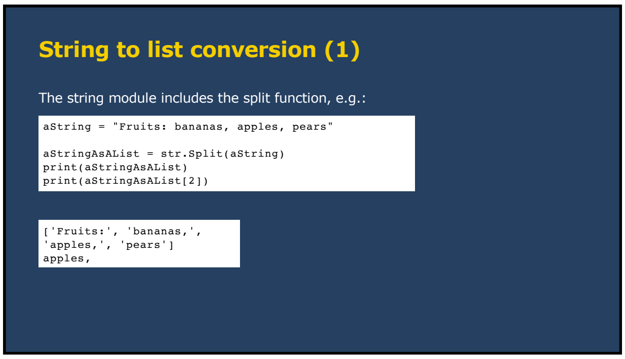
Accessing all elements in a nested list (2)

Second step:

```
samples = [["x","y","z"],[12,32,7],[12,40,7]]

for i in samples:
   for j in i:
      print(j, end = "\t")
   print()
```

```
x      y      z
12     32     7
12     40     7
```

105



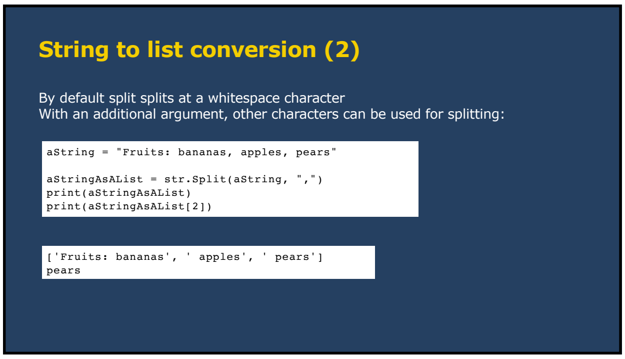
String to list conversion (1)

The string module includes the split function, e.g.:

```
aString = "Fruits: bananas, apples, pears"

aStringAsAList = str.Split(aString)
print(aStringAsAList)
print(aStringAsAList[2])
```

```
['Fruits:', 'bananas,',
'apples,', 'pears']
apples,
```

106



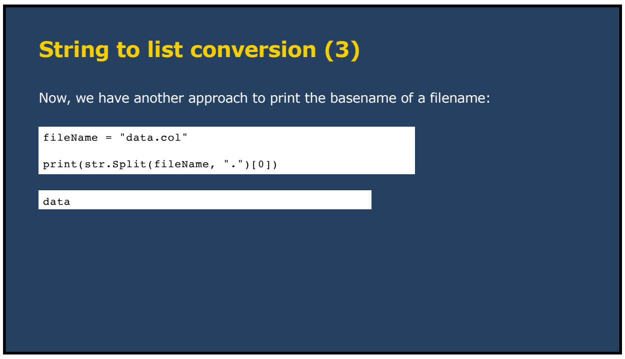
String to list conversion (2)

By default split splits at a whitespace character
With an additional argument, other characters can be used for splitting:

```
aString = "Fruits: bananas, apples, pears"

aStringAsAList = str.Split(aString, ",")
print(aStringAsAList)
print(aStringAsAList[2])
```

```
['Fruits: bananas', ' apples', ' pears']
pears
```

107



String to list conversion (3)

Now, we have another approach to print the basename of a filename:

```
fileName = "data.col"

print(str.Split(fileName, ".")[0])
```

```
data
```

108

109

Files

110

Computer memory and files

Computer memory

- is used by the program to store data (e.g. variables) while running the program
- disappears when the program ends or the computer shuts down
- is mainly managed by Python (you don't need to do that)

Files

- can be used in a program to open or store specified data
- data are stored permanently
- storage and manipulation needs to be defined in the program (explicitly)

111

Files: opening and closing

Like with a book, you need to do the following steps to read/write from/to a file:

- open the file
- read from the file
- or write to the file
- close the file

```
f = open("file.txt", "r")  # open an existing file,
                           # "r" indicates opening
                           # for reading


   # read here from the file ....

f.close()                   # close the file
                            # for reading

   # do something without the file or
   # do something else with the file
   # e.g. writing to the file
```

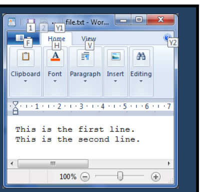
112

Files: example reading

read() returns a string with all contents of the file

```
aFile = open("file.txt", "r") # open

aString = aFile.read()         # read from it

aFile.close()                  # close

print aString
```

```
This is the first line.
This is the second line.
```



```
This is the first line.
This is the second line.
```

113

Files: example reading

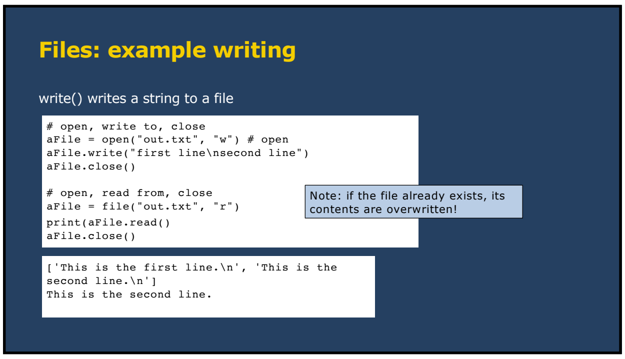
readlines()

- returns a list
- each element is a string with the content of one line from the file

```
aFile = open("file.txt", "r") # open

aList = aFile.readlines()    # read from it

aFile.close()                 # close

print aList
print aList[1]
```

```
['This is the first line.\n', 'This is the
second line.\n']
This is the second line.
```

114



Files: example writing

write() writes a string to a file

```
# open, write to, close
aFile = open("out.txt", "w") # open
aFile.write("first line\nsecond line")
aFile.close()

# open, read from, close
aFile = file("out.txt", "r")
print(aFile.read()
aFile.close()
```

Note: if the file already exists, its contents are overwritten!

```
['This is the first line.\n', 'This is the
second line.\n']
This is the second line.
```

115

116