# Introduction to the Python language



#### **CS111 Computer Programming**

Department of Computer Science Wellesley College

# **Python Intro Overview**

o Values: 10 (integer),

**3.1415** (decimal number or float), **'wellesley'** (text or string)

• Types: numbers and text: int, float, str type(10) type('wellesley') Knowing the **type** of a **value** allows us to choose the right **operator** when creating **expressions**.

- Operators: + \* /  $\frac{1}{0}$  =
- Expressions: (they always produce a value as a result)

'abc' + 'def' -> `abcdef'

Simple Ex	pressions:
Python as	calculator

**Concepts in this slide**: numerical values, math operators, expressions.

Input Expressions In []	Output Values Out […]	
1+2	3	
3*4	12	
3 * 4	12	# Spaces don't matter
3.4 * 5.67	19.278	# Floating point (decimal) operations
2 + 3 * 4	14	# Precedence: * binds more tightly than +
(2 + 3) * 4	20	# Overriding precedence with parentheses
11 / 4	2.75	# Floating point (decimal) division
11 // 4	2	# Integer division
11 % 4	3	# Remainder (often called modulus)
5 - 3.4	1.6 🦳	
3.25 * 4	13.0	
11.0 // 2	5.0 -	-# output is float if at least one input is float
5 // 2.25	2.0	
5 % 2.25	0.5	Python Intro 3

# Strings and concatenation

**Concepts in this slide**: string values, string operators, TypeError

A string is just a sequence of characters that we write between a pair of double quotes or a pair of single quotes. Strings are usually displayed with single quotes. **The same string value is created regardless of which quotes are used.** 

<pre>"CS111" 'CS111' 'rocks!' 'rocks!' 'You say "Hi!"' 'You say "Hi!"' # Characters in a string "No, I didn't" "No, I didn't" # can include spaces, # punctuation, quotes</pre>	
<pre>'rocks!' 'rocks!' 'You say "Hi!"' 'You say "Hi!"' # Characters in a string "No, I didn't" "No, I didn't" # can include spaces, # punctuation, quotes</pre>	
<pre>'You say "Hi!"' 'You say "Hi!"' # Characters in a string "No, I didn't" "No, I didn't" # can include spaces, # punctuation, quotes</pre>	
"CS111 " + 'rocks!' 'CS111 rocks!' # String concatenation	
<b>'123' + '4' '1234' # Strings and numbers</b>	
123 + 4 127 # are very different!	
'123' + 4 TypeError # Can't concatenate strings & nu	m.
'123123123123' # Repeated concatenation	
'123' * '4' TypeError	4



**Concepts in this slide**: variables, assignment statement, memory diagram model, NameError

- A variable is a way to remember a value for later in the computer's memory.
- A variable is created by an **assignment statement**, whose form is

```
varName = expression
```

**Example:** ans = 42 # ans is the varName, 42 is the expression saved in ans

This line of code is executed in two steps:

- 1. Evaluate **expression** to its value **val**
- If there is no variable box already labeled with *varName*, create a new box labeled with *varName* and store *val* in it; otherwise, change the contents of the existing box labeled *varName* to *val*.





• How does the memory diagram change if we evaluate the following expression?

```
ans = 2*ans+27
ans 111
```

- The expression checks the most recent *val* of **ans** (42), reevaluates the new expression based on that value, and reassigns the value of **ans** accordingly.
- $\circ$  ans = 2\*42+27
- $\circ$  ans = 111

# Variable summary

A variable names a value that we want to use later in a program.

In the memory diagram model, an assignment statement var = exp stores the value of exp in a box labeled by the variable name.

Later assignments can change the value in a variable box.

**Note**: The symbol **=** is pronounced "gets" not "equals"!

# Variable Examples

**Concepts in this slide**: variables, assignment statement, memory

In []	Memory Diagram	Out []	Notes
fav = 17	fav 17		Assignment statements makes box, no output
fav		17	Returns current contents of fav
fav + fav		34	The contents of fav are unchanged
lucky = 8	lucky 8		Makes new box, has no output
fav + lucky		25	Variable contents unchanged
aSum = fav + lucky	aSum 25		Makes new box, has no output
aSum * aSum		625	Variable contents unchanged

# Variable Examples

**Concepts in this slide**: variables, assignment statement, memory

How does the memory diagram change when we change the values of our existing variables? How are strings stored in memory?

In []	Memory Diagram	Out []	Notes
fav = 11	fav 11		Change contents of fav box to 11
fav = fav - lucky	fav 3		Change contents of fav box to 3
name = 'CS111'	name		Makes new box containing string. Strings are drawn *outside* box with arrow pointing to them (b/c they're often "too big" to fit inside box
name*fav		'CS111CS111CS111 '	string*int will repeat the string int # of times

## **Built-in functions:**

Built-in function	Result
max	Returns the largest item in an iterable (an iterable is an object we can loop over, like a list of numbers. We will learn about them soon!)
min	Returns the smallest item in an iterable
id	Returns memory address of a value
type	Returns the type of a value
len	Returns the length of a sequence value (strings are an example)
str	Converts and returns the input as a string
int	Converts and returns the input as an integer number
float	Converts and returns the input as a floating point number
round	Rounds a number to nearest integer or decimal point
print	Prints a specified message on the screen/output device,, and returns the None value.
input	Asks user for input, converts input to a string, returns the string

Python Intro 10

# Built-in functions: max and min

**Concepts in this slide**: built-in functions, arguments, function calls.

Python has many <u>built-in functions</u> that we can use. Built-in functions and userdefined variable and function names names are highlighted with different colors in both Thonny and Jupyter Notebooks.

Out [...] In [...] min(7, 3)3 max(7, 3)7 min(7, 3, 2, 8.19)2 # can take any num. of arguments max(7, 3, 2, 8.19)8.19 # smallest gets -5 smallest = min(-5, 2)# largest gets -3.4 largest = max(-3.4, -10)max(smallest, largest, -1) -1

The inputs to a function are called its **arguments** and the function is said to be **called** on its arguments. In Python, the arguments in a function call are delimited by parentheses and separated by commas.

# Understanding variable and function names

#### **Concepts in this slide**: Values can have multiple names. Functions are also values.

One value can have multiple names. These names refer to the same value in the computer memory. See the examples below for variables and functions.



# Built-in functions: id

**Concepts in this slide**:

Values can have multiple names. Functions are also values.

>>> id(oneValue)
4526040688
>>> id(otherValue)
4526040688

#### Built-in function id:

This function displays the memory address where a value is stored.

Different names can refer to the same value in memory. >>> id(max)
4525077120
>>> id(myMaxFunction)
4525077120

# Built-in functions: type

**Concepts in this slide**: types, the function **type**.

**Each Python value has a type**. It can be queried with the built-in **type** function. Types are special kinds of values that display as **<class** '*typeName*'> Knowing the type of a value is important for reasoning about expressions containing the value.

ln []	Out […]	
type (123)	int ]	Jupyter notebooks display these
type (3.141)	float 🧲	type names. Thonny actually
type(4 + 5.0)	float	displays <class 'int'="">,</class>
type('CS111')	str	<class 'float'="">, etc., but</class>
type('111')	str	we'll often abbreviate these
type (11/4)	float	using the Jupyter notebook
type (11//4)	int	types int, float, etc.
type (11%4)	int	
<b>type(11.0%4)</b>	float	
type(max(7, 3.4))	int	
x = min(7, 3.4)	<b># x g</b> ets	3.4
type(x)	float	
<pre>type('Hi,' + 'you!')</pre>	str	
type (type (111) )	type <b>#</b> S	pecial type for types!

Python Intro 14

# Using type with different values

**Concepts in this slide**: Every value in Python has a type, which can be queried with **type**.

Below are some examples of using **type** in Thonny, with different values:

```
>>> type(10)
<class 'int'>
>>> type('abc')
<class 'str'>
>>> type(10/3)
<class 'float'>
>>> type(max)
<class 'builtin_function_or_method'>
                                          Functions are values
>>> type(len)
                                          with this type
<class 'builtin_function_or_method'>
>>> type(True)
<class 'bool'>
                       Other types we will
>>> type([1,2,3])
                       learn about later in
<class 'list'>
                       the semester
>>> type((10,5))
<class 'tuple'>
```

# Built-in functions: len

#### **Concepts in this slide**: length of a string, the function **len**, TypeError

When applied to a **string**, the built-in **len** function returns the number of characters in the string.

**len** raises a **TypeError** if used on values (like numbers) that are not sequences. (We'll learn about sequences later in the course.)

In [...] Out [...] 5 len('CS111') 12 len('CS111 rocks!') 8 len('com' + 'puter') course = 'computer programming' len(course) 20 TypeError len(111) 3 len('111') TypeError len(3.141) 5 len('3.141')

# Built-in functions: str

The **str** built-in function returns a string representation of its argument. It is used to create string values from **int**s and **float**s (and other types of values we will meet later) to use in expressions with other string values.

ln []	Out []
str('CS111')	'CS111'
str(17)	'17'
str(4.0)	'4.0'
' <mark>CS'</mark> + 111	TypeError
' <mark>CS'</mark> + str(111)	'CS111'
len(str(111))	3
	_

# Built-in functions: int

#### **Concepts in this slide**: **int** function, TypeError, ValueError.

- When given a string that's a sequence of digits, optionally ValueError.
   preceded by +/-, int returns the corresponding integer. On any other string it raises a ValueError (correct type, but wrong value of that type).
- When given a float, **int** return the integer the results by truncating it toward zero.
- When given an integer, **int** returns that integer.

ln []	Out []
int('42')	42
int('-273')	-273
123 + '42'	TypeError
123 + int('42')	165
<pre>int('3.141')</pre>	ValueError # strings are not sequence
<pre>int('five')</pre>	ValueError # of chars denoting integer
int(3.141)	3
int(98.6)	98 - # Truncate floats toward 0
int(-2.978)	-2
int(42)	42
Int(-273)	-273 Python Intro 18

# Built-in functions: float

**Concepts in this slide**: **float** function, ValueError

- When given a string that's a sequence of digits, optionally preceded by +/-, and optionally including one decimal point, **float** returns the corresponding floating point number. On any other string it raises a **ValueError**.
- When given an integer, **float** converts it to floating point number.
- When given a floating point number, **float** returns that number.

In []	Out []
float(' <mark>3.141</mark> ')	3.141
float('-273.15')	-273.15
float(' <mark>3</mark> ')	3.0
float(' <mark>3.1.4</mark> ')	ValueError
float(' <mark>pi</mark> ')	ValueError
float(42)	42.0
float(98.6)	98.6

# **Oddities of floating point numbers**

#### **Concepts in this slide**: floating point numbers are only approximations, so don't always behave exactly like math

In computer languages, floating point numbers (numbers with decimal points) don't always behave like you might expect from mathematics. This is a consequence of their fixedsized internal representations, which permit only approximations in many cases.

#### In [...]

- 2.1 2.02.2 - 2.02.3 - 2.0
- 1.3 1.0
- 100.3 100.0
- 10.0/3.0
- 1.414\*(3.14159/1.414)

#### Out [...]

- 0.1000000000000000
- 0.2000000000000018
- 0.29999999999999998
- 0.300000000000004
- 0.29999999999999716
- 3.33333333333333333
- 3.141590000000003

# Built-in functions: round

#### Concepts in this slide:

the **round** function, called with varying number of arguments.

- When given one numeric argument, **round** returns the **integer** it's closest to.
- When given **two** arguments (a numeric argument and an integer number of decimal places), **round** returns **floating point** result of rounding the first argument to the number of places specified by the second.
- In other cases, **round** raises a **TypeError**

In [...] Out [...] round(3.14156) 3 99 round(98.6)round(-98.6)-99 round(3.5)# always rounds up for 0.5 5 round(4.5)round(2.718, 2) 2.72 round(2.718, 1) 2.7 round(2.718, 0) 3.0 round  $(1.3 - 1.0, 1) \quad 0.3$ Compare to previous slide  $round(2.3 - 2.0, 1) \quad 0.3$ Python Intro 21

# Built-in functions: print

**print** displays a character-based representation of its argument(s) on the screen and **returns** a special **None** value (not displayed).

```
Characters displayed in
Input statements
                                         console (*not* the output
In [...]
                                         value of the expression!)
print(7)
                                          7
                                          CS111
print('CS111')
print(len(str('CS111')) * min(17,3)) 15
college = 'Wellesley'
                                          I go to Wellesley
print('I go to ' + college)
dollars = 10
                                          The movie costs $10.
print('The movie costs $'
        + str(dollars) + '.')
```

# The newline character '\n'

'\n' is a single special newline character. Printing it causes the console to shift to the next line.

In [...]
print('one\ntwo\nthree')

**Concepts in this slide**: The '\n' newline character.

Console

one two

three

Python Intro 23

# print with multiple arguments

#### **Concepts in this slide**: **print** can take more than one argument

When **print** is given more than one argument, it prints all arguments, separated by one space by default. This is helpful for avoiding concatenating the parts of the printed string using **+** and using **str** to convert nonstrings to strings.

# print with the sep keyword argument

#### **Concepts in this slide**:

The optional **sep** keyword argument overrides the default space between values

print can take an optional so-called keyword argument of the form sep=stringValue
that uses stringValue to replace the default space string between multiple values.
In [...]
Console

<pre>print(6, '*',7, '=',6*7)</pre>	6 * 7 = 42
<pre># replace space by \$ print(6,'*',7,'=',6*7,sep='\$')</pre>	6\$*\$7\$=\$42
<pre># replace space by two spaces print(6,'*',7,'=',6*7,sep=' ')</pre>	6 * 7 = 42
<pre># replace space by zero spaces print(6, '*',7,'=',6*7,sep='')</pre>	6*7=42
<pre># replace space by newline print(6,'*',7,'=',6*7,sep='\n')</pre>	6 * 7

=

42

# print returns None!

**Concepts in this slide**:

The optional **sep** keyword argument overrides the default space between values

In addition to printing characters in the console, **print** also **returns** the special value **None**. Confusingly, but Thonny and Jupyter notebooks do not explicitly display this **None**. value, but there are still ways to see that it's really there.

```
In [1]: str(print('Hi!'))
    Hi! # printed by print
Out [1]: 'None' # string value returned by str
In [2]: print(print(6*7))
    42 # printed by 2<sup>nd</sup> print
    None # printed by 1<sup>st</sup> print
    # No Out [2] shown when result is None
```

```
In [3]: type(print(print('CS'), print(111)))
CS # printed by 2<sup>nd</sup> print
111 # printed by 3<sup>rd</sup> print
None None # printed by 1<sup>st</sup> print
Out [3]: NoneType # The type of None is NoneType
```

Python Intro 26

```
Concepts in this slide:
                                                 The '\n' newline
 More print examples
                                                 character; print returns
                                                 the None value, which is
                                                 normally hidden.
                                      # '\n' is a single special
In [8]: print('one\ntwo\nthree')
                                      # newline character.
one
                                      # Printing it causes the
two
                                      # display to shift to the
three
                                      # next line.
In [9]: print('one', 'two', 'three', sep='\n')
one
                                      # Like previous example,
                                      # but use sep keyword arg
two
                                      # for newlines
three
In [10]: str(print(print('CS'), print(111)))
CS # printed by 2<sup>nd</sup> print.
111 # printed by 3<sup>rd</sup> print.
None None # printed by 1<sup>st</sup> print; shows that print returns None
Out[10]: 'None' # Output of str; shows that print returns None
```

# Built-in functions: input

**Concepts in this slide**: The **input** function; converting from string returned by **input**.

**input** displays its single argument as a prompt on the screen and waits for the user to input text, followed by Enter/Return. It returns the entered value as a **string**.



Out [1]: 'Olivia Rodrigo'

# Built-in functions: input

#### **Concepts in this slide**:

The **input** function; converting from string returned by **input**.

# Built-in functions: input

#### **Concepts in this slide**:

The **input** function; converting from string returned by **input**.



# **Complex Expression Evaluation**

**Concepts in this slide**: complex expressions ; subexpressions; expression evaluation

An **expression** is a programming language phrase that denotes a value. Smaller **sub-expressions** can be combined to form arbitrarily large expressions.

Complex expressions are evaluated from "inside out", first finding the value of smaller expressions, and then combining those to yield the values of larger expressions. See how the expression below evaluates to '35':



**Concepts in this slide**: Expressions, statements

# Expressions

They always **produce a value**:

10
10 \* 20 - 100/25
max(10, 20)
int("100") + 200
fav
fav
fav + 3
"pie" + " in the sky"

Expressions are composed of any combination of values, variables operations, and function calls.

#### VS.

### **Statements**

They **perform an action** (that can be visible, invisible, or both):

print(10)
age = 19
teleport(0, 150)

Statements may contain expressions, which are evaluated **before** the action is performed.

print('She is ' + str(age)
+ ' years old.')

**Some** statements return a **None** value that is not normally displayed in Thonny or Jupyter notebooks.

# Expressions, statements, and console printing in Jupyter

In [1]: max(10,20) Out[1]: 20 ← -In [2]: 10 + 20 Out[2]: 30 -In [3]: message = "Welcome to CS 111" In [4]: message Out[4]: 'Welcome to CS 111' In [5]: print(message) Welcome to CS 111 In [6]: print(max(10,20)) 20 In [7]: print(10 + 20) 30

#### Concepts in this slide:

Jupyter displays **Out[]** for expressions, but not statements. Non-**Out[]** chars come from **print** 

Notice the **Out[]** field for the result when the input is an expression.

Expressions, statements, and console printing in Jupyter

```
In [1]: max(10,20)
Out[1]: 20
In [2]: 10 + 20
Out[2]: 30
In [3]: message = "Welcome to CS 111"
In [4]: message
Out[4]: 'Welcome to CS 111'
In [5]: print(message) 
Welcome to CS 111
In [6]: print(max(10,20))
20
In [7]: print(10 + 20)
30
```

#### Concepts in this slide:

Jupyter displays **Out[]** for expressions, but not statements. Non-**Out[]** chars come from **print** 

An assignment is a statement without any outputs

The **print** function returns a **None** value that is not displayed as an output in Jupyter. Any function or method call that returns **None** is treated as a statement in Python. Expressions, statements, and console printing in Jupyter

```
In [1]: max(10,20)
Out[1]: 20
In [2]: 10 + 20
Out[2]: 30
In [3]: message = "Welcome to CS 111"
In [4]: message
Out[4]: 'Welcome to CS 111'
In [5]: print(message)
Welcome to CS 111
In [6]: print(max(10,20))
20 🛶
In [7]: print(10 + 20)
30 🔦
```

#### Concepts in this slide:

Jupyter displays **Out[]** for expressions, but not statements. Non-**Out[]** chars come from **print** 

These are characters displayed by **print** in the "console", which is interleaved with **In[]/Out[]** 

Expressions, statements, and console printing in Thonny

>>> message = "Welcome to 65 111"

#### Concepts in this slide:

Thonny displays expressions, but not statements. Expressions are distinguished from printed output by text size and indentation.

Notice no **Out[]** field for the result when the input is an expression for Thonny. Text is bigger and has no indent!

>>> print(message)
Welcome to CS 111
>>> print(max(10, 20))
20
>>> print(10 + 20)

'Welcome to CS 111'

>>> max(10, 20)

>>> 10 + 20

>>> message

20

30

30

Expressions, statements, and console printing in Thonny

```
>>> max(10, 20)
20
>>> 10 + 20
30
>>> message = "Welcome to CS 111" -
>>> message
'Welcome to CS 111'
>>> print(message) 
  Welcome to CS 111
>>> print(max(10, 20))
  20
>>> print(10 + 20) 4
  30
```

#### Concepts in this slide:

Thonny displays expressions, but not statements. Expressions are distinguished from printed output by text size and indentation.

An assignment is a statement without any outputs

The **print** function returns a **None** value that is not displayed as an output in Thonny. The text is displayed as smaller and indented! Expressions, statements, and console printing in Thonny

```
>>> max(10, 20)
20
>>> 10 + 20
30
>>> message = "Welcome to CS 111"
>>> message
'Welcome to CS 111'
>>> print(message)
  Welcome to CS 111 🔨
>>> print(max(10, 20))
  20
>>> print(10 + 20)
  30
```

#### Concepts in this slide:

Thonny displays expressions, but not statements. Expressions are distinguished from printed output by text size and indentation.

These are characters displayed by **print** in the "console", which is interleaved with expressions

# Putting Python code in a .py file

#### **Concepts in this slide**: Editor pane. .py Python

program file, running a program.

Rather than interactively entering code into the **Python Shell**, we can enter it in the **Editor Pane**, where we can edit it and save it away as a file with the **.py** extension (a Python program). Here is a **nameage.py** program. Lines beginning with **#** are comments We run the program by pressing the triangular "run"/play button.



# **Code Styling Advice**

**Concepts in this slide**: the 80-character limit, coding advice.

Thonny - /Users/andrewdavis/Desktop/nameage.py @ 8:10 🗋 💕 📓 🜔 🚸 👁 R. R 🕨 👳 nameage.py × 1 # Filename: nameage.py # Created: 08-31-2020 # Author: Andrew Davis # Purpose: A simple script for lecture 6 # Part 1: Gather input from the user interactively and store it for later reuse. 7 name = input("Enter your name: ") age = int(input("Enter your age: ")) 10 # Part 2: Output results by concatenating strings with variable values 11 # that store user data. 12 print("Hello, " + name + ".") 13 print("In 4 years, you will be " + str(age + 4) + " years old.")

- 1. Lines should not be longer than 80 characters
- 2. Give meaningful names to variables.
- 3. Use space around operators (e.g, =, +)
- 4. Use comments at the top of file
- 5. Organize code in "blocks" of related statements preceded by comments for block.
- 6. Use space between blocks to improve readability.
- 7. For CS111 coding style guidelines, see http://cs111.wellesley.edu/reference/styleguide

Python Intro 40

# Error messages in Python

#### **Concepts in this slide**: Error types, Error messages.

Type Lifers			
'111' + 5	<b>TypeError</b> : ca	annot concatenate 'str' and 'int' values	5
len(111)	<b>TypeError</b> : ol	bject of type 'int' has no len()	
Value Errors			
int('3.142	) ValueErro	<b>r</b> : invalid literal for int() with base 10:	: '3.142'
float('pi')	) ValueErro	<b>r</b> : could not convert string to float: pi	1
Name Errors			
CS + '111'	NameError	: name 'CS' is not defined	
CS + '111' Syntax Errors	NameError A syntax error ind the rules of the Py a statement, and va	: name 'CS' is not defined icates a phrase is not well formed acc ython language. E.g. a number can't b ariable names can't begin with digits.	cording to e added to
CS + '111' Syntax Errors 1 + (ans=42) ^	NameError A syntax error ind the rules of the Py a statement, and van 2)	name 'CS' is not defined icates a phrase is not well formed acc whon language. E.g. a number can't b ariable names can't begin with digits. <b>2ndValue = 25</b> ^	cording to e added to

# Test your knowledge

- 1. Create simple **expressions** that combine **values** of different **types** and math **operators**.
- 2. Which operators can be used with **string values**? Give examples of expressions involving them. What happens when you use other operators?
- 3. Write a few **assignment statements**, using as assigned values either **literals** or expressions. Experiment with different **variable names** that start with different characters to learn what is allowed and what not.
- Perform different function calls of the built-in functions: max, min, id, type, len, str, int, float, round.
- 5. Create **complex expressions** that combine variables, function calls, operators, and literal values.
- 6. Use the function **print** to display the result of expressions involving string and numerical values.
- 7. Write simple examples that use **input** to collect values from a user and use them in simple expressions. Remember to **convert** numerical values.
- 8. Create situations that raise different kinds of errors: TypeError, ValueError, NameError, and SyntaxError.