

Python Reference

cs101: Unit 5 (includes Units 1-5)

Arithmetic Expressions

addition: $\langle \text{Number} \rangle + \langle \text{Number} \rangle \rightarrow \langle \text{Number} \rangle$

outputs the sum of the two input numbers

multiplication: $\langle \text{Number} \rangle * \langle \text{Number} \rangle \rightarrow \langle \text{Number} \rangle$

outputs the product of the two input numbers

subtraction: $\langle \text{Number} \rangle - \langle \text{Number} \rangle \rightarrow \langle \text{Number} \rangle$

outputs the difference between the two input numbers

division: $\langle \text{Number} \rangle / \langle \text{Number} \rangle \rightarrow \langle \text{Number} \rangle$

outputs the result of dividing the first number by the second

Note: if both numbers are whole numbers, the result is truncated to just the whole number part.

modulo: $\langle \text{Number} \rangle \% \langle \text{Number} \rangle \rightarrow \langle \text{Number} \rangle$

outputs the remainder of dividing the first number by the second

exponentiation: $\langle \text{Base} \rangle ** \langle \text{Power} \rangle \rightarrow \langle \text{Number} \rangle$

outputs the result of raising $\langle \text{Base} \rangle$ to the $\langle \text{Power} \rangle$ power (multiplying $\langle \text{Base} \rangle$ by itself $\langle \text{Power} \rangle$ number of times).

Comparisons

equality: $\langle \text{Value} \rangle == \langle \text{Value} \rangle \rightarrow \langle \text{Boolean} \rangle$

outputs **True** if the two input values are equal, **False** otherwise

inequality: $\langle \text{Value} \rangle != \langle \text{Value} \rangle \rightarrow \langle \text{Boolean} \rangle$

outputs **True** if the two input values are not equal, **False** otherwise

greater than: $\langle \text{Number}_1 \rangle > \langle \text{Number}_2 \rangle \rightarrow \langle \text{Boolean} \rangle$

outputs **True** if Number_1 is greater than Number_2

less than: $\langle \text{Number}_1 \rangle < \langle \text{Number}_2 \rangle \rightarrow \langle \text{Boolean} \rangle$

outputs **True** if Number_1 is less than Number_2

greater or equal to: $\langle \text{Number}_1 \rangle >= \langle \text{Number}_2 \rangle \rightarrow \langle \text{Boolean} \rangle$

outputs **True** if Number_1 is not less than Number_2

less than or equal to: $\langle \text{Number}_1 \rangle <= \langle \text{Number}_2 \rangle \rightarrow \langle \text{Boolean} \rangle$

outputs **True** if Number_1 is not greater than Number_2

Variables and Assignment

Names

A **<Name>** in Python can be any sequence of letters, numbers, and underscores (_) that does not start with a number. We usually use all lowercase letters for variable names, but capitalization must match exactly. Here are some valid examples of names in Python (but most of these would not be good choices to actually use in your programs):

```
my_name
one2one
Dorina
this_is_a_very_long_variable_name
```

Assignment Statement

An assignment statement assigns a value to a variable:

<Name> = <Expression>

After the assignment statement, the variable **<Name>** refers to the value of the **<Expression>** on the right side of the assignment. An **<Expression>** is any Python construct that has a value.

Multiple Assignment

We can put more than one name on the left side of an assignment statement, and a corresponding number of expressions on the right side:

<Name₁>, <Name₂>, ... = <Expression₁>, <Expression₂>, ...

All of the expressions on the right side are evaluated first. Then, each name on the left side is assigned to reference the value of the corresponding expression on the right side. This is handy for swapping variable values. For example,

```
s, t = t, s
```

would swap the values of **s** and **t** so after the assignment statement **s** now refers to the previous value of **t**, and **t** refers to the previous value of **s**.

Note: what is really going on here is a bit different. The multiple values are packed in a tuple (which is similar to the list data type introduced in Unit 3, but an immutable version of a list), and then unpacked into its components when there are multiple names on the left side. This distinction is not important for what we do in cs101, but does become important in some contexts.

Procedures

A **procedure** takes inputs and produces outputs. It is an abstraction that provides a way to use the same code to operate on different data by passing in that data as its inputs.

Defining a procedure:

```
def <Name>(<Parameters>):  
    <Block>
```

The **<Parameters>** are the inputs to the procedure. There is one **<Name>** for each input in order, separated by commas. There can be any number of parameters (including none).

To produce outputs:

```
return <Expression>, <Expression>, ...
```

There can be any number of expressions following the return (including none, in which case the output of the procedure is the special value **None**).

Using a procedure:

```
<Procedure>(<Input>, <Input>, ...)
```

The number of inputs must match the number of parameters. The value of each input is assigned to the value of each parameter name in order, and then the block is evaluated.

If Statements

The **if** statement provides a way to control what code executes based on the result of a test expression.

```
if <TestExpression>:  
    <Block>
```

The code in **<Block>** only executes if the **<TestExpression>** has a **True** value.

Alternate clauses. We can use an **else** clause in an **if** statement to provide code that will run when the **<TestExpression>** has a **False** value.

```
if <TestExpression>:  
    <BlockTrue>  
else:  
    <BlockFalse>
```

Logical Operators

The **and** and **or** operators behave similarly to logical conjunction (and) and disjunction (or). The important property they have which is different from other operators is that the second operand expression is evaluated only when necessary.

<Expression₁> and <Expression₂>

If **Expression₁** has a **False** value, the result is **False** and **Expression₂** is not evaluated (so even if it would produce an error it does not matter). If **Expression₁** has a **True** value, the result of the **and** is the value of **Expression₂**.

<Expression₁> or <Expression₂>

If **Expression₁** has a **True** value, the result is **True** and **Expression₂** is not evaluated (so even if it would produce an error it does not matter). If **Expression₁** has a **False** value, the result of the **or** is the value of **Expression₂**.

While Loops

A **while** loop provides a way to keep executing a block of code as long as a test expression is **True**.

```
while <TestExpression>:  
    <Block>
```

If the <TestExpression> evaluates to **False**, the **while** loop is done and execution continues with the following statement. If the <TestExpression> evaluates to **True**, the <Block> is executed. Then, the loop repeats, returning to the <TestExpression> and continuing to evaluate the <Block> as long as the <TestExpression> is **True**.

Break Statement

A **break** statement in the <Block> of a **while** loop, jumps out of the containing while loop, continuing execution at the following statement.

```
break
```

For Loops

A **for** loop provides a way to execute a block once for each element of a collection:

```
for <Name> in <Collection>:  
    <Block>
```

The loop goes through each element of the collection, assigning that element to the <Name> and evaluating the <Block>. The collection could be a String, in which case the elements are the characters of a string; a List, in which case the elements are the elements of the list; a Dictionary, in which case the elements are the keys in the dictionary; or many other types in Python that represent collections of objects.

Strings

A string is sequence of characters surrounded by quotes. The quotes can be either single or double quotes, but the quotes at both ends of the string must be the same type. Here are some examples of strings in Python:

```
"silly"  
'string'  
"I'm a valid string, even with a single quote in the middle!"
```

String Concatenation

We can use the + operator on strings, but it has a different meaning than when it is used on numbers.

string concatenation: $\langle String \rangle + \langle String \rangle \rightarrow \langle String \rangle$
outputs the concatenation of the two input strings (pasting the string together with no space between them)

We can also use the multiplication operator on strings:

string multiplication: $\langle String \rangle * \langle Number \rangle \rightarrow \langle String \rangle$
outputs a string that is $\langle Number \rangle$ copies of the input $\langle String \rangle$ pasted together

Indexing Strings

The indexing operator provides a way to extract subsequences of characters from a string.

string indexing: $\langle String \rangle[\langle Number \rangle] \rightarrow \langle String \rangle$
outputs a single-character string containing the character at position $\langle Number \rangle$ of the input $\langle String \rangle$. Positions in the string are counted starting from 0, so `s[1]` would output the second character in `s`. If the $\langle Number \rangle$ is negative, positions are counted from the end of the string: `s[-1]` is the last character in `s`.

string extraction: $\langle String \rangle[\langle Start Number \rangle:\langle Stop Number \rangle] \rightarrow \langle String \rangle$
outputs a string that is the subsequence of the input string starting from position $\langle Start Number \rangle$ and ending just before position $\langle Stop Number \rangle$. If $\langle Start Number \rangle$ is missing, starts from the beginning of the input string; if $\langle Stop Number \rangle$ is missing, goes to the end of the input string.

Length

length: $\text{len}(\langle String \rangle) \rightarrow \langle Number \rangle$
Outputs the number of characters in $\langle String \rangle$

find

The **find** method provides a way to find sub-sequences of characters in strings.

find: `<Search String>.find(<Target String>) → <Number>`

outputs a number giving the position in *<Search String>* where *<Target String>* first appears. If there is no occurrence of *<Target String>* in *<Search String>*, outputs -1.

To find later occurrences, we can also pass in a number to find:

find after: `<Search String>.find(<Target String>, <Start Number>) → <Number>`

outputs a number giving the position in *<Search String>* where *<Target String>* first appears that is at or after the position give by *<Start Number>*. If there is no occurrence of *<Target String>* in *<Search String>* at or after *<Start Number>*, outputs -1.

Converting between Numbers and Strings

str: `str(<Number>) → <String>`

outputs a string that represents the input number. For example, **str(23)** outputs the string '23'.

ord: `ord(<One-Character String>) → <Number>`

outputs the number corresponding to the input string.

chr: `chr(<Number>) → <One-Character String>`

outputs the one-character string corresponding to the number input. This function is the inverse of **ord**: **chr(ord(α)) = α** for any one-character string α .

Splitting Strings

split: `<String>.split() → [<String>, <String>, ...]`

outputs a list of strings that are (roughly) the words contained in the input string. The words are determined by whitespace (either spaces, tabs, or newlines) in the string. (We did not cover this in class, but split can also be used with an optional input that is a list of the separator characters, and a second optional input that controls the maximum number of elements in the output list.)

Looping through Strings

A **for** loop provides a way to execute a block once for each character in a string (just like looping through the elements of a list):

```
for <Name> in <String>:  
    <Block>
```

The loop goes through each character of the string in turn, assigning that element to the **<Name>** and evaluating the **<Block>**.

Lists

A list is a mutable collection of objects. The elements in a list can be of any type, including other lists.

Constructing a list. A list is a sequence of zero or more elements, surrounded by square brackets:

[<Element>, <Element>, ...]

Selecting elements: <List>[<Number>] → <Element>

Outputs the value of the element in <List> at position <Number>. Elements are indexed starting from 0.

Selecting sub-sequences: <List>[<Start> : <Stop>] → <List>

Outputs a sub-sequence of <List> starting from position <Start>, up to (but not including) position <Stop>.

Update: <List>[<Number>] = <Value>

Modifies the value of the element in <List> at position <Number> to be <Value>.

Length: len(<List>) → <Number>

Outputs the number of (top-level) elements in <List>.

Append: <List>.append(<Element>)

Mutates <List> by adding <Element> to the end of the list.

Concatenation: <List₁> + <List₂> → <List>

Outputs a new list that is the elements of <List₁> followed by the elements of <List₂>.

Popping: <List>.pop() → <Element>

Mutates <List> by removing its last element. Outputs the value of that element. If there are no elements in <List>, [].pop() produces an error.

Finding: <List>.index(<Value>) → <Number>

Outputs the position of the first occurrence of an element matching <Value> in <List>. If <Value> is not found in <List>, produces an error.

Membership: <Value> in <List> → <Boolean>

Outputs True if <Value> occurs in <List>. Otherwise, outputs False.

Non-membership: <Value> not in <List> → <Boolean>

Outputs False if <Value> occurs in <List>. Otherwise, outputs True.

Loops on Lists

A **for** loop provides a way to execute a block once for each element of a List:

for <Name> in <List>:
 <Block>

Dictionaries

A Dictionary provides a mapping between keys, which can be values of any immutable type, and values, which can be any value. Because a Dictionary is implemented using a hash table, the time to lookup a value does not increase (significantly) even when the number of keys increases.

Constructing a Dictionary. A Dictionary is a set of zero or more key-value pairs, surrounded by squiggly braces:

```
{ <Key>: <Value>, <Key>: <Value>, ... }
```

Looking up elements: `<Dictionary>[<Key>] → <Value>`

outputs the value associated with <Key> in the <Dictionary>. Produces an error if the <Key> is not a key in the <Dictionary>.

Updating elements: `<Dictionary>[<Key>] = <Value>`

updates the value associated with <Key> in the <Dictionary> to be <Value>. If <Key> is already a key in <Dictionary>, replaces the value associated with <Key>; if not, adds a new <Key>: <Value> pair to the <Dictionary>.

Membership: `<Key> in <Dictionary> → <Boolean>`

outputs **True** if <Key> is a key in <Dictionary>, **False** otherwise.

Loops on Dictionaries

A **for** loop provides a way to execute a block once for each key in a Dictionary:

```
for <Name> in <Dictionary>:  
    <Block>
```

Eval

The **eval** function provides a way to evaluate an input string as a Python expression:

eval(<String>) → <Value>

The input is a string that is a Python expression; the value is the value that string would evaluate to in Python.

Time

The time library provides functions for obtaining and measuring time.

import time

System time: **time.clock() → <Number>**

outputs the processor time in seconds (a real number, including fractional seconds with limited accuracy) (Note that what clock means depends on your platform, and it may not provide accurate timings on all platforms.)

Exceptions

(We introduced exceptions in Unit 4 because we needed them in our **get_page** procedure, but you are not expected to understand this in detail or be able to use exception handlers in your own code in cs101.)

try:

<Try Block>

except:

<Handler Block>

Execute the code in the *<Try Block>*. If it completes normally, skip the *<Handler Block>* and continue with the following statement. If code in the *<Try Block>* raises an error, jump to the code in the *<Handler Block>*.

The **except** can be followed by an exception type and a variable name:

except <Exception Type>, <Name>:

<Handler Block>

If the exception raised in the *<Try Block>* matches the type *<Exception Type>*, evaluate the *<Handler Block>* with the variable *<Name>* referring to the exception object.

Libraries

```
import <Library>
```

Imports the *<Library>* into the Python environment, enabling the following code to use the definitions provided in the *<Library>*. Python provides many libraries such as **urllib** that we use for downloading web pages in **get_page**, and you can also import your own code. As programs get larger, it is important to organize them well into separate files.