Tuples

Tuples are like lists in that they can contain objects of different types.

They are different from lists in that they are **immutable**.

Tuples are created if you write values separated by commas. You can also use curved brackets (parenthesis) `()`.

In [1]:
```
t = 0, 'apple', 2, 'cat', 'dog', 5, 6  # parentheses are not required to create a tuple
```

In [2]:
```
t
```

Out[2]:
```
(0, 'apple', 2, 'cat', 'dog', 5, 6)
```

In [3]:
```
t = (0, 'apple', 2, 'cat', 'dog', 5, 6) # you can use parentheses
```

In [4]:
```
t
```

Out[4]:
```
(0, 'apple', 2, 'cat', 'dog', 5, 6)
```

To create a tuple with one value, you need a comma

In [5]:
```
t1 = "a",
```

In [6]:
```
type(t1)
```

Out[6]:
```
tuple
```

using parentheses without a comma will not work

In [7]:
```
t2 = ("a")
```

In [8]:
```
type(t2)
```

Out[8]:
```
str
```

You can create an empty tuple with the `tuple()` function, similar to using the `list()` or `dict()` function

In [9]:
```
t3 = tuple()
```

In [10]:
```
t3
```

Out[10]:
```
()
```

You can use the `tuple()` function to turn other iterables into tuples.

In [11]:
```
tuple("hello")
```

Out[11]:
```
('h', 'e', 'l', 'l', 'o')
```

In [12]:
```
tuple(range(5))
```

Out[12]:
```
(0, 1, 2, 3, 4)
```

In [13]:
```
tuple([1,4,7])
```

Out[13]:
```
(1, 4, 7)
```

The usual indexing rules apply to tuples

In [14]:
```
t = 0, 'apple', 2, 'cat', 'dog', 5, 6
```

In [15]:
```
t[1]
```

Out[15]:
```
'apple'
```

In [16]:
```
t[2:5] # slicing
```

Out[16]:
```
(2, 'cat', 'dog')
```

Tuples are immutable. They cannot be modified.

List are mutable and can be modified

In [17]:
```
t = (0,'apple',2,'cat','dog',5,6) # tuple
l = [0,'apple',2,'cat','dog',5,6] # list
```

In [18]:
```
l[0] = 100  # we can change the value of the object at index 0
print(l)
```

```
[100, 'apple', 2, 'cat', 'dog', 5, 6]
```

In [19]:
```
t[0] = 100  # trying to modify the value in a tuple is not allowed
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-19-1315e91aabf3> in <module>
----> 1 t[0] = 100  # trying to modify the value in a tuple is not allowed

TypeError: 'tuple' object does not support item assignment
```

methods that modify lists in place (e.g. append, insert, pop, etc) do not work for tuples

In [20]:
```
l.append('x')
print(l)
```

```
[100, 'apple', 2, 'cat', 'dog', 5, 6, 'x']
```

In [21]:
```
t.append('x')
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-21-2bc04b290b67> in <module>
----> 1 t.append('x')

AttributeError: 'tuple' object has no attribute 'append'
```

Because tuples are immutable, you can't modify the elements. But you can replace one tuple with another:

In [22]:
```
t = ("A",) + t[1:]
t
```

Out[22]:
```
('A', 'apple', 2, 'cat', 'dog', 5, 6)
```

This creates an entirely new tuple, unrelated to the other one.

The relational operators work with tuples and other sequences; Python starts by comparing the first element from each sequence. If they are equal, it goes on to the next elements, and so on, until it finds elements that differ. Subsequent elements are not considered (even if they are really big).

In [23]:
```
(0, 1, 2) < (0, 3, 4)
```

Out[23]:
```
True
```

In [24]:
```
(0, 1, 2000000) < (0, 3, 4)
```

Out[24]:
```
True
```

Tuple assignment

This is a cool feature in python. You can switch value assignments via tuples

In [25]:
```
# old option without tuples
a = 5
b = 1

temp = a
a = b
b = temp
print(a, b)
```

```
1 5
```

In [26]:
```
# faster way with tuples
a = 5
b = 1

b, a = a, b
print(a, b)
```

```
1 5
```

You can take the results of a function and have the returned values assign to different elements in a tuple

In [27]:
```
addr = "monty@python.org"
uname, domain = addr.split("@")
```

In [28]:
```
uname
```

Out[28]:
```
'monty'
```

In [29]:
```
domain
```

Out[29]:
```
'python.org'
```

We saw this when we talked about functions. You can have functions return multiple values in the form of a tuple

In [30]:
```
def my_divide(x, y):
    integer = x // y
    remainder = x % y
    return integer, remainder
```

In [31]:
```
my_divide(23, 5)
```

Out[31]:
```
(4, 3)
```

In [32]:
```
a, b = my_divide(23, 5)
```

In [33]:
```
a
```

Out[33]:
```
4
```

In [34]:
```
b
```

Out[34]:
```
3
```

Tuple Methods

tuples only support two methods: `tuple.index()` and `tuple.count()` which return information about contents of the tuple but do not modify them

In [35]:
```
t = 0, 'apple', 2, 'cat', 'dog', 5, 6
```

In [36]:
```
t.index('dog')
```

Out[36]: 4

In [37]:
```
t.count(5)
```

Out[37]: 1

Functions that support lists and tuples as inputs

Even though tuples only have two methods, there are several functions that support tuples (and lists) as inputs

- `len()`
- `sum()`
- `sorted()`
- `min()`
- `max()`

None of these functions affect the list or tuple itself.

In [38]:
```
some_digits = (4,2,7,9,2,5,3)  # a tuple of numbers
some_words = ['dog','apple','cat','hat','hand']  # this is a list
```

In [39]:
```
len(some_digits)
```

Out[39]:
```
7
```

In [40]:
```
sum(some_digits)
```

Out[40]:
```
32
```

In [41]:
```
sum(some_words) # won't work on strings
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-41-7ad2d781cfbf> in <module>
----> 1 sum(some_words) # won't work on strings

TypeError: unsupported operand type(s) for +: 'int' and 'str'
```

In [42]:
```
sorted(some_digits)  # sorts the tuple, but does not affect the list or tuple itself.
# contrast to list.sort() which will sort the list in place
# but the object returned is a list
```

Out[42]:
```
[2, 2, 3, 4, 5, 7, 9]
```

In [43]:
```
print(some_digits)  # just to show the list is unchanged
```

```
(4, 2, 7, 9, 2, 5, 3)
```

In [44]:
```
sorted(some_words) # when applied to a list of strings, it will alphabetize them
```

Out[44]:
```
['apple', 'cat', 'dog', 'hand', 'hat']
```

In [45]:
```
min(some_digits)
```

Out[45]:
```
2
```

In [46]:
```
max(some_words)  # max returns the last word if alphabetized,
# min will return the first in an alphabetized list
```

Out[46]:
```
'hat'
```

Math operators and lists, tuples, strings

multiplication generally duplicates

addition generally appends

behaviors across lists, tuples, and strings are similar

In [47]:
```
L1 = ['a','b','c']
L2 = ['d','e','f']
```

In [48]:
```
L1 * 2 # multiplication extends duplicates
```

Out[48]:
```
['a', 'b', 'c', 'a', 'b', 'c']
```

In [49]:
```
L1 + L2 # addition appends list objects
```

Out[49]:
```
['a', 'b', 'c', 'd', 'e', 'f']
```

In [50]:
```
T1 = ('a','b','c')
T2 = ('d','e','f')
```

In [51]:
```
T1 * 2
```

Out[51]:
```
('a', 'b', 'c', 'a', 'b', 'c')
```

In [52]:
```
T1 + T2
```

Out[52]:
```
('a', 'b', 'c', 'd', 'e', 'f')
```

In [53]:
```
L1 + T2 # fails. you cannot add list and tuple
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-53-75bf80180df8> in <module>
----> 1 L1 + T2 # fails. you cannot add list and tuple

TypeError: can only concatenate list (not "tuple") to list
```

In [54]:
```
L1 + list(T2) # but you can easily convert a tuple to a list first
```

Out[54]:
```
['a', 'b', 'c', 'd', 'e', 'f']
```

Variable-length argument tuples

Functions can take a variable number of arguments. A parameter name that begins with `*` gathers arguments into a tuple.

The gather parameter can have any name you like, but args is conventional.

In [55]:
```
def printall(*args):
    print(args)
```

In [56]:
```
printall(1, 3.0, 5, "hi")
```

```
(1, 3.0, 5, 'hi')
```

The complement of gather is scatter. If you have a sequence of values and you want to pass it to a function as multiple arguments, you can use the `*` operator.

For example, the `my_divide` function from earlier takes exactly two arguments; it doesn't work with a tuple:

In [57]:
```
def my_divide(x, y):
    integer = x // y
    remainder = x % y
    return integer, remainder
```

In [58]:
```
t = (23, 5)
```

In [59]:
```
my_divide(t)
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-59-ea0afdae4ba1> in <module>
----> 1 my_divide(t)

TypeError: my_divide() missing 1 required positional argument: 'y'
```

In [60]:
```
my_divide(*t)
```

Out[60]:
```
(4, 3)
```

Lists, Tuples and Iterators

`zip()` is a built-in function that takes two or more sequences and interleaves them. The name of the function refers to a zipper, which interleaves two rows of teeth.

In [61]:
```
s = 'abc'
t = 0, 1, 2
zip(s, t)
```

Out[61]:
```
<zip at 0x26068019708>
```

In [62]:
```
for pair in zip(s, t):
    print(pair)
```

```
('a', 0)
('b', 1)
('c', 2)
```

A zip object is a kind of iterator, which is any object that iterates through a sequence. Iterators are similar to lists in some ways, but unlike lists, you can't use an index to select an element from an iterator.

If you want, you can put the zip object inside a list.

It will return a list of tuples

In [63]:
```
list(zip(s,t))
```

Out[63]:
```
[('a', 0), ('b', 1), ('c', 2)]
```

If the sequences are not the same length, the result has the length of the shorter one.

In [64]:
```
list(zip("Anne" , "Elk" ))
```

Out[64]:
```
[('A', 'E'), ('n', 'l'), ('n', 'k')]
```

If you have a list of tuples, you can iterate over them by unpacking the elements.

In [65]:
```
t = [('a', 0), ('b', 1), ('c', 2)]
for letter, number in t:
    print(number, letter)
```

```
0 a
1 b
2 c
```

A useful snippet of code that will traverse two iterables and see if there is a match between them.

In [66]:
```
def has_match(t1, t2):
    for x, y in zip(t1, t2):
        if x == y:
            return True
    return False
```

In [67]:
```
has_match("abc", "def")
```

Out[67]:
```
False
```

In [68]:
```
has_match("abc", "dec")
```

Out[68]:
```
True
```

`enumerate()`

The built-in function enumerate is useful. It takes an iterable and returns an iterator of the index paired with the elements

In [69]:
```
enumerate("abc")
```

Out[69]:
```
<enumerate at 0x26067f3ee10>
```

In [70]:
```
for index, value in enumerate("abc"):
    print(index, value)
```

```
0 a
1 b
2 c
```

In [71]:
```
list(enumerate("abc"))
```

Out[71]:
```
[(0, 'a'), (1, 'b'), (2, 'c')]
```

Dictionaries and Tuples

the dictionary view object, dict.items() is a sequence of tuples.

In [72]:
```
d = {'a':0, 'b':1, 'c':2}
```

In [73]:
```
d.items()
```

Out[73]:
```
dict_items([('a', 0), ('b', 1), ('c', 2)])
```

In [74]:
```
for key, value in d.items():
    print(key, value)
```

```
a 0
b 1
c 2
```

We can create dictionaries out of sequences of tuples and with zip objects

In [75]:
```
l = [('z', 25), ('y',24), ('x', 23)]
dict(l)
```

Out[75]:
```
{'z': 25, 'y': 24, 'x': 23}
```

In [76]:
```
z = zip('xyz',[23,24,25])
dict(z)
```

Out[76]:
```
{'x': 23, 'y': 24, 'z': 25}
```

Tuples as dictionary keys

Because tuples are immutable, they can be used as keys in a dictionary

For example, there might be a 2D function that is very expensive to compute. You can create a dictionary that will store all of the values that have been calculated for each 2D pair.

Let's say you have a function: $f(x, y) = x^2 + 2y$

In [77]:
```
# this dictionary contains values that are known solutions
known = {(0,0):0}
```

In [78]:
```
def f(x, y):
    t = (x,y)
    if t in known:
        print("value already exists dictionary")
        return known[t]
    print("value must be calculated")
    res = x ** 2 + 2 * y
    known[t] = res
    return res
```

In [79]:
```
f(0,0)
```

```
value already exists dictionary
```

Out[79]:
```
0
```

In [80]:
```
f(1,2)
```

```
value must be calculated
```

Out[80]:
```
5
```

In [81]:
```
f(1,2)
```

```
value already exists dictionary
```

Out[81]:
```
5
```

In [82]:
```
known
```

Out[82]:
```
{(0, 0): 0, (1, 2): 5}
```

In many contexts, the different kinds of sequences (strings, lists and tuples) can be used interchangeably.