Lecture 3-3

Tuples

Week 4 Monday

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Adapted from Chapter 12 of Think Python by Allen B Downey

Additional content on Dictionaries adapted from "Whirlwind Tour of Python" by Jake VanderPlas

Tuples

Tuples are like lists in that they can contain objects of different types. Tuples are ordered and preserve their order.

Tuples are different from lists in that they are **immutable**. You cannot append to a tuple or modify values in a tuple.

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

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

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

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

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

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```
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
```

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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)
```

You can create a tuple with one value by having a trailing comma

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

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

In [6]:
```python
t1
```

Out[6]:
```python
('a',)
```

You can create a tuple with one value by having a trailing comma

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

```
In [6]:  t1
```

```
Out[6]:  ('a',)
```

```
In [7]:  type(t1)
```

```
Out[7]:  tuple
```

You can create a tuple with one value by having a trailing comma

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

```
In [6]:   t1
```

```
Out[6]:   ('a',)
```

```
In [7]:   type(t1)
```

```
Out[7]:   tuple
```

```
In [8]:   len(t1)
```

```
Out[8]:   1
```

using parentheses without a comma will not work

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```python
t2 = ("a")
```

using parentheses without a comma will not work

In [9]:
```python
t2 = ("a")
```

In [10]:
```python
type(t2)
```

Out[10]:
str

using parentheses without a comma will not work

In [9]:
```python
t2 = ("a")
```

In [10]:
```python
type(t2)
```

Out[10]:   str

In [11]:
```python
t2 = ("a",)
```

using parentheses without a comma will not work

In [9]:
```python
t2 = ("a")
```

In [10]:
```python
type(t2)
```

Out[10]: str

In [11]:
```python
t2 = ("a",)
```

In [12]:
```python
type(t2)
```

Out[12]: tuple

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

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```python
t3 = tuple()
```

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

In [13]:
```python
t3 = tuple()
```

In [14]:
```python
t3
```

Out[14]:
```
()
```

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

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

In [15]:
```python
tuple("hello")
```

Out[15]: `('h', 'e', 'l', 'l', 'o')`

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

```
In [15]:   tuple("hello")

Out[15]:   ('h', 'e', 'l', 'l', 'o')

In [16]:   tuple(range(5))

Out[16]:   (0, 1, 2, 3, 4)
```

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

```
In [15]:   tuple("hello")

Out[15]:   ('h', 'e', 'l', 'l', 'o')

In [16]:   tuple(range(5))

Out[16]:   (0, 1, 2, 3, 4)

In [17]:   tuple([1,4,7])

Out[17]:   (1, 4, 7)
```

The usual indexing rules apply to tuples

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In [18]:
```python
t = 0, 'apple', 2, 'cat', 'dog', 5, 6
```

The usual indexing rules apply to tuples

In [18]:
```python
t = 0, 'apple', 2, 'cat', 'dog', 5, 6
```

In [19]:
```python
t[1]
```

Out[19]:
```
'apple'
```

The usual indexing rules apply to tuples

```
In [18]:  t = 0, 'apple', 2, 'cat', 'dog', 5, 6
```

```
In [19]:  t[1]
```

```
Out[19]:  'apple'
```

```
In [20]:  t[2:5] # slicing
```

```
Out[20]:  (2, 'cat', 'dog')
```

Tuples are immutable. They cannot be modified.

List are mutable and can be modified

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List are mutable and can be modified

In [21]:

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

Tuples are immutable. They cannot be modified.

List are mutable and can be modified

In [21]:
```python
t = (0,'apple',2,'cat','dog',5,6) # tuple
l = [0,'apple',2,'cat','dog',5,6] # list
```

In [22]:
```python
l[0] = 100   # we can change the value of the object at index 0
print(l)
```

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

Tuples are immutable. They cannot be modified.

List are mutable and can be modified

In [21]:
```python
t = (0,'apple',2,'cat','dog',5,6) # tuple
l = [0,'apple',2,'cat','dog',5,6] # list
```

In [22]:
```python
l[0] = 100  # we can change the value of the object at index 0
print(l)
```

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

In [23]:
```python
t[0] = 100  # trying to modify the value in a tuple is not allowed
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
~\AppData\Local\Temp/ipykernel_17316/3323244693.py 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

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In [24]:
```python
l.append('x')
print(l)
```

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

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

In [24]:
```python
l.append('x')
print(l)
```

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

In [25]:
```python
t.append('x')
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
~\AppData\Local\Temp/ipykernel_17316/4157613306.py 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:

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In [26]:
```python
t = ("A",) + t[1:]
t
```

Out[26]: ('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).

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```
In [27]:  (0, 1, 2) < (0, 3, 4)
```

```
Out[27]:  True
```

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In [27]:
```
(0, 1, 2) < (0, 3, 4)
```

Out[27]: True

In [28]:
```
(0, 1, 2000000) < (0, 3, 4)
```

Out[28]: True

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 [27]:
```python
(0, 1, 2) < (0, 3, 4)
```

Out[27]: True

In [28]:
```python
(0, 1, 2000000) < (0, 3, 4)
```

Out[28]: True

In [29]:
```python
(0, 500, 2) < (0, 3, 4)
```

Out[29]: False

In [30]:
```python
# abbbb
# abc
# abcd
tuple("abc") <= tuple("abcd")
```

Out[30]: True

Tuple assignment

A common and useful tuple idiom: You can switch value assignments via tuples

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In [31]:

```python
# old option without tuples
a = 5
b = 1

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

1 5

Tuple assignment

A common and useful tuple idiom: You can switch value assignments via tuples

In [31]:
```python
# old option without tuples
a = 5
b = 1

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

1 5

In [32]:
```python
# 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

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In [33]:
```python
addr = "mileschen@stat.ucla.edu"
addr.split("@") # string.split() normally returns two elements in a list
```

Out[33]:
```
['mileschen', 'stat.ucla.edu']
```

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addr = "mileschen@stat.ucla.edu"
addr.split("@") # string.split() normally returns two elements in a list
```

Out[33]:
```
['mileschen', 'stat.ucla.edu']
```

In [34]:
```python
addr = "mileschen@stat.ucla.edu"
uname, domain = addr.split("@") # we can assign the results of str.split() to a tuple
```

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

In [33]:
```python
addr = "mileschen@stat.ucla.edu"
addr.split("@") # string.split() normally returns two elements in a list
```

Out[33]: ['mileschen', 'stat.ucla.edu']

In [34]:
```python
addr = "mileschen@stat.ucla.edu"
uname, domain = addr.split("@") # we can assign the results of str.split() to a tuple
```

In [35]:
```python
uname
```

Out[35]: 'mileschen'

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

In [33]:
```python
addr = "mileschen@stat.ucla.edu"
addr.split("@") # string.split() normally returns two elements in a list
```

Out[33]: ['mileschen', 'stat.ucla.edu']

In [34]:
```python
addr = "mileschen@stat.ucla.edu"
uname, domain = addr.split("@") # we can assign the results of str.split() to a tuple
```

In [35]:
```python
uname
```

Out[35]: 'mileschen'

In [36]:
```python
domain
```

Out[36]: 'stat.ucla.edu'

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

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In [37]:
```python
def my_divide(x, y):
    integer = x // y
    remainder = x % y
    return integer, remainder
```

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

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def my_divide(x, y):
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In [38]:
```python
a, b = my_divide(23, 5)
```

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def my_divide(x, y):
    integer = x // y
    remainder = x % y
    return integer, remainder
```

In [38]:
```python
a, b = my_divide(23, 5)
```

In [39]:
```python
a, b
```

Out[39]:
```
(4, 3)
```

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

```
In [37]:  def my_divide(x, y):
              integer = x // y
              remainder = x % y
              return integer, remainder
```

```
In [38]:  a, b = my_divide(23, 5)
```

```
In [39]:  a, b
```

Out[39]: (4, 3)

```
In [40]:  divmod(23, 5)  # divmod() is a built-in function that does exactly this.
```

Out[40]: (4, 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

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In [41]:
```python
t = 0, 'apple', 2, 'cat', 'dog', 5, 6
```

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 [41]:
```python
t = 0, 'apple', 2, 'cat', 'dog', 5, 6
```

In [42]:
```python
t.index('dog')
```

Out[42]:
```
4
```

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

```
In [42]:  t.index('dog')
```

Out[42]: 4

```
In [43]:  t.count(5)
```

Out[43]: 1

Functions that support tuples and other iterables as inputs

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

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

None of these functions affect the list or tuple itself.

```
In [44]:  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 [44]:   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 [45]:   len(some_digits)
```

Out[45]:   7

```
In [44]: 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 [45]: len(some_digits)
```

Out[45]: 7

```
In [46]: sum(some_digits)
```

Out[46]: 32

```
In [44]:  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 [45]:  len(some_digits)
```

Out[45]: 7

```
In [46]:  sum(some_digits)
```

Out[46]: 32

```
In [47]:  sum(some_words) # won't work on strings
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
~\AppData\Local\Temp/ipykernel_17316/3741811082.py in <module>
----> 1 sum(some_words) # won't work on strings

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

```python
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
```

```
[2, 2, 3, 4, 5, 7, 9]
```

```
In [48]:  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[48]: [2, 2, 3, 4, 5, 7, 9]

```
In [49]:  print(some_digits)  # just to show the list is unchanged
```

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

In [48]:
```python
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[48]:
```
[2, 2, 3, 4, 5, 7, 9]
```

In [49]:
```python
print(some_digits)  # just to show the list is unchanged
```

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

In [50]:
```python
sorted(some_words) # when applied to a list of strings, it will alphabetize them
```

Out[50]:
```
['apple', 'cat', 'dog', 'hand', 'hat']
```

```
In [48]:    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[48]:   [2, 2, 3, 4, 5, 7, 9]

```
In [49]:    print(some_digits)  # just to show the list is unchanged
```

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

```
In [50]:    sorted(some_words) # when applied to a list of strings, it will alphabetize them
```

Out[50]:   ['apple', 'cat', 'dog', 'hand', 'hat']

```
In [51]:    min(some_digits)
```

Out[51]:   2

```
In [48]: 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[48]: [2, 2, 3, 4, 5, 7, 9]

```
In [49]: print(some_digits)  # just to show the list is unchanged
```

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

```
In [50]: sorted(some_words) # when applied to a list of strings, it will alphabetize them
```

Out[50]: ['apple', 'cat', 'dog', 'hand', 'hat']

```
In [51]: min(some_digits)
```

Out[51]: 2

```
In [52]: max(some_words)  # max returns the last word if alphabetized,
         # min will return the first in an alphabetized list
```

Out[52]: 'hat'

```python
dict_num = {1: "a", 2: "b", 3: "c"}
dict_alpha = {"a":1, "b":2, "c":3}
```

```
In [53]:  dict_num = {1: "a", 2: "b", 3: "c"}
          dict_alpha = {"a":1, "b":2, "c":3}

In [54]:  len(dict_num) # number of items in the dictionary

Out[54]:  3
```

```
In [53]:  dict_num = {1: "a", 2: "b", 3: "c"}
          dict_alpha = {"a":1, "b":2, "c":3}
```

```
In [54]:  len(dict_num) # number of items in the dictionary
```

Out[54]: 3

```
In [55]:  sorted(dict_num) # a list of the keys sorted
```

Out[55]: [1, 2, 3]

```
In [53]:    dict_num = {1: "a", 2: "b", 3: "c"}
            dict_alpha = {"a":1, "b":2, "c":3}
```

```
In [54]:    len(dict_num) # number of items in the dictionary
```

Out[54]:   3

```
In [55]:    sorted(dict_num) # a list of the keys sorted
```

Out[55]:   [1, 2, 3]

```
In [56]:    sorted(dict_alpha)
```

Out[56]:   ['a', 'b', 'c']

```
In [53]:  dict_num = {1: "a", 2: "b", 3: "c"}
          dict_alpha = {"a":1, "b":2, "c":3}
```

```
In [54]:  len(dict_num) # number of items in the dictionary
```

Out[54]: 3

```
In [55]:  sorted(dict_num) # a list of the keys sorted
```

Out[55]: [1, 2, 3]

```
In [56]:  sorted(dict_alpha)
```

Out[56]: ['a', 'b', 'c']

```
In [57]:  max(dict_num) # the "maximum" key
```

Out[57]: 3

Math operators and lists, tuples, strings

multiplication generally duplicates

addition generally appends

behaviors across lists, tuples, and strings are similar

Math operators and lists, tuples, strings

multiplication generally duplicates

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behaviors across lists, tuples, and strings are similar

In [58]:
```python
L1 = ['a','b','c']
L2 = ['d','e','f']
```

Math operators and lists, tuples, strings

multiplication generally duplicates

addition generally appends

behaviors across lists, tuples, and strings are similar

In [58]:
```python
L1 = ['a','b','c']
L2 = ['d','e','f']
```

In [59]:
```python
L1 * 2 # multiplication extends duplicates
```

Out[59]:
```
['a', 'b', 'c', 'a', 'b', 'c']
```

Math operators and lists, tuples, strings

multiplication generally duplicates

addition generally appends

behaviors across lists, tuples, and strings are similar

In [58]:
```python
L1 = ['a','b','c']
L2 = ['d','e','f']
```

In [59]:
```python
L1 * 2 # multiplication extends duplicates
```

Out[59]:
```
['a', 'b', 'c', 'a', 'b', 'c']
```

In [60]:
```python
L1 + L2 # addition appends list objects
```

Out[60]:
```
['a', 'b', 'c', 'd', 'e', 'f']
```

```
In [61]:  T1 = ('a','b','c')
          T2 = ('d','e','f')
```

```
In [61]:   T1 = ('a','b','c')
           T2 = ('d','e','f')

In [62]:   T1 * 2

Out[62]:   ('a', 'b', 'c', 'a', 'b', 'c')

In [63]:   T1 + T2

Out[63]:   ('a', 'b', 'c', 'd', 'e', 'f')
```

```
In [64]:  L1 + T2 # fails. you cannot add list and tuple
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
~\AppData\Local\Temp/ipykernel_17316/2067178384.py in <module>
----> 1 L1 + T2 # fails. you cannot add list and tuple

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

```
In [65]:  L1 + list(T2) # but you can easily convert a tuple to a list first
```

```
Out[65]:  ['a', 'b', 'c', 'd', 'e', 'f']
```

Variable-length argument tuples

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def printall(args):
    print(args)
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In [67]:
```python
printall(1, 3.0, 5, "hi")
```

```
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In [70]: def print_lines(*args):
             for element in args:
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In [70]:  def print_lines(*args):
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```
In [71]:  print_lines("hi", "goodbye")
```

```
hi
goodbye
```

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In [70]:    def print_lines(*args):
                for element in args:
                    print(element)
```

```
In [71]:    print_lines("hi", "goodbye")
```

hi
goodbye

```
In [72]:    print_lines(1, 5, 7, 9, 10)
```

1
5
7
9
10

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:

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```python
def my_divide(x, y):
    integer = x // y
    remainder = x % y
    return integer, remainder
```

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In [74]:
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t = (23, 5)
```

In [75]:
```python
my_divide(t)
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
~\AppData\Local\Temp/ipykernel_17316/1954193532.py in <module>
----> 1 my_divide(t)

TypeError: my_divide() missing 1 required positional argument: 'y'
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----> 1 my_divide(t)

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

In [76]:
```python
my_divide(*t)
```

Out[76]:   (4, 3)

Lists, Tuples and Iterators

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In [77]:
```python
s = 'abc'
t = 0, 1, 2
zip(s, t)
```

Out[77]: `<zip at 0x27e215f5288>`

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In [77]:    s = 'abc'
            t = 0, 1, 2
            zip(s, t)
```

```
Out[77]:    <zip at 0x27e215f5288>
```

```
In [78]:    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.

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In [79]:
```python
list(zip(s,t))
```

Out[79]: `[('a', 0), ('b', 1), ('c', 2)]`

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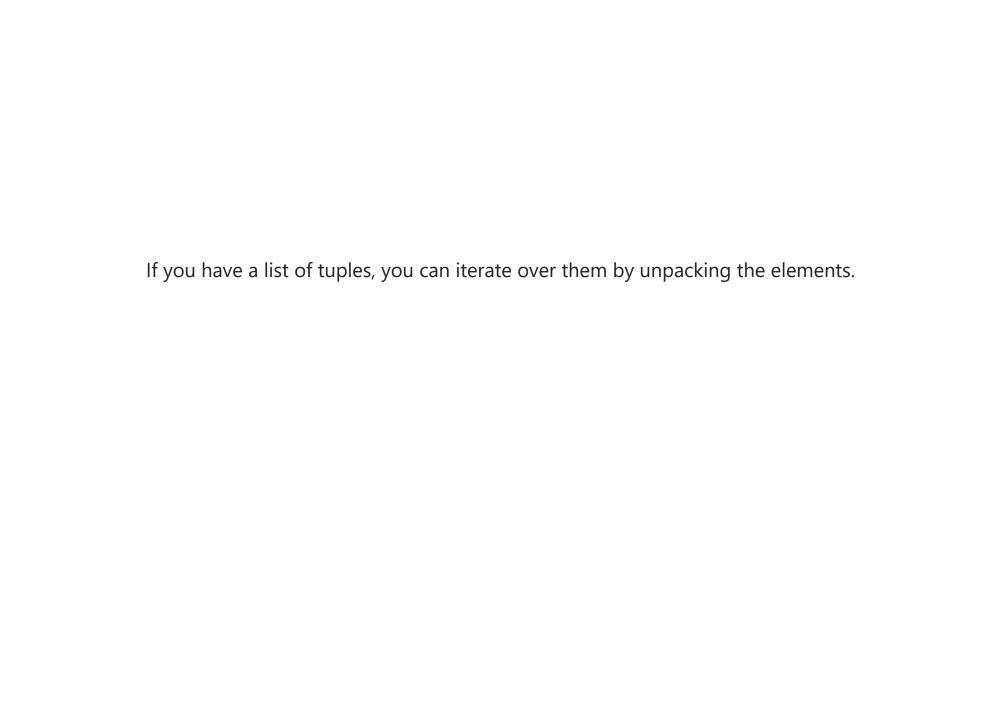
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In [79]:
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Out[79]: [('a', 0), ('b', 1), ('c', 2)]

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

In [80]:
```python
list(zip("Anne" , "Elk" ))
```

Out[80]: [('A', 'E'), ('n', 'l'), ('n', 'k')]

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

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In [81]:
```python
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 both share a certain element in the same position.

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In [82]:

```python
def has_match(t1, t2):
    for x, y in zip(t1, t2):
        if x == y:
            return True
    return False
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In [83]:
```python
has_match(('a', 'b', 'c'), ('d', 'e', 'f'))
```

Out[83]:
```
False
```

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In [83]:
```python
has_match(('a', 'b', 'c'), ('d', 'e', 'f'))
```

Out[83]:   False

In [84]:
```python
has_match(('a', 'b', 'c'), ('d', 'e', 'c'))
```

Out[84]:   True

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In [82]:
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def has_match(t1, t2):
    for x, y in zip(t1, t2):
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In [83]:
```python
has_match(('a', 'b', 'c'), ('d', 'e', 'f'))
```

Out[83]: False

In [84]:
```python
has_match(('a', 'b', 'c'), ('d', 'e', 'c'))
```

Out[84]: True

In [85]:
```python
has_match(('a', 'b', 'c', 'd'), ('d', 'c', 'b', 'a'))
```

Out[85]: False

`enumerate()`

The built-in function enumerate is useful. It takes an iterable and returns an iterator of the index paired with the elements You can think of `enumerate()` as zipping a range object of the same length with the iterable.

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In [86]:
```python
enumerate("morning")
```

Out[86]:
```
<enumerate at 0x27e215fb1d8>
```

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In [86]:
```python
enumerate("morning")
```

Out[86]: `<enumerate at 0x27e215fb1d8>`

In [87]:
```python
for index, value in enumerate("morning"):
    print(index, value)
```

```
0 m
1 o
2 r
3 n
4 i
5 n
6 g
```

```
In [88]:  list(enumerate(['a','b','c','d']))

Out[88]:  [(0, 'a'), (1, 'b'), (2, 'c'), (3, 'd')]
```

```python
In [88]: list(enumerate(['a','b','c','d']))

Out[88]: [(0, 'a'), (1, 'b'), (2, 'c'), (3, 'd')]

In [89]: list(zip(range(4),['a','b','c','d']))  # zipping a range object with a list

Out[89]: [(0, 'a'), (1, 'b'), (2, 'c'), (3, 'd')]
```

Dictionaries and Tuples

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In [90]:
```python
d = {'a':0, 'b':1, 'c':2}
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In [90]:
```python
d = {'a':0, 'b':1, 'c':2}
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In [91]:
```python
d.items()
```

Out[91]:
```
dict_items([('a', 0), ('b', 1), ('c', 2)])
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```
In [90]:   d = {'a':0, 'b':1, 'c':2}
```

```
In [91]:   d.items()
```

```
Out[91]:   dict_items([('a', 0), ('b', 1), ('c', 2)])
```

```
In [92]:   for key, value in d.items():
               print(key, value)
```

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

```
In [93]:    d = dict(enumerate("efg"))
```

```
In [93]:    d = dict(enumerate("efg"))

In [94]:    d

Out[94]:    {0: 'e', 1: 'f', 2: 'g'}
```

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```
In [94]:  d
```

```
Out[94]:  {0: 'e', 1: 'f', 2: 'g'}
```

Swap the keys and elements in a dictionary

In [93]:
```python
d = dict(enumerate("efg"))
```

In [94]:
```python
d
```

Out[94]:
```
{0: 'e', 1: 'f', 2: 'g'}
```

Swap the keys and elements in a dictionary

In [95]:
```python
swapped = {}
for key, value in d.items():
    swapped[value] = key
```

```
In [93]:   d = dict(enumerate("efg"))
```

```
In [94]:   d
```

```
Out[94]:   {0: 'e', 1: 'f', 2: 'g'}
```

Swap the keys and elements in a dictionary

```
In [95]:   swapped = {}
           for key, value in d.items():
               swapped[value] = key
```

```
In [96]:   swapped
```

```
Out[96]:   {'e': 0, 'f': 1, 'g': 2}
```

```
In [97]:   dict(zip("efg", range(3)))
```

```
Out[97]:   {'e': 0, 'f': 1, 'g': 2}
```

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

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In [98]:
```python
l = [('z', 25), ('y', 24), ('x', 23)]
dict(l)
```

Out[98]: `{'z': 25, 'y': 24, 'x': 23}`

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In [98]:
```python
l = [('z', 25), ('y', 24), ('x', 23)]
dict(l)
```

Out[98]: `{'z': 25, 'y': 24, 'x': 23}`

In [99]:
```python
z = zip('xyz', [23, 24, 25])
dict(z)
```

Out[99]: `{'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 for coordinates. 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: $f(x, y) = x^2 + 2y$

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In [100]:
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# this dictionary contains values that are known solutions
known = {(0, 0): 0}
```

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

In [100]:
```python
# this dictionary contains values that are known solutions
known = {(0, 0): 0}
```

In [101]:
```python
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 [102]:   f(0, 0)

            value already exists dictionary

Out[102]:   0
```

```
In [102]:  f(0, 0)
```

value already exists dictionary

Out[102]: 0

```
In [103]:  f(1, 2)
```

value must be calculated

Out[103]: 5

```
In [102]: f(0, 0)
```

value already exists dictionary

Out[102]: 0

```
In [103]: f(1, 2)
```

value must be calculated

Out[103]: 5

```
In [104]: f(1, 2)
```

value already exists dictionary

Out[104]: 5

```
In [102]:    f(0, 0)

             value already exists dictionary

Out[102]:    0

In [103]:    f(1, 2)

             value must be calculated

Out[103]:    5

In [104]:    f(1, 2)

             value already exists dictionary

Out[104]:    5

In [105]:    known

Out[105]:    {(0, 0): 0, (1, 2): 5}
```