Lecture 5-2

Pandas: Indexing, Arithmetic, Missing Values

Week 5 Wednesday

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Based on Wes McKinney's Python for Data Analysis and the Pandas Documentation

In [1]:

```
import numpy as np
import pandas as pd
```

Series that we will use as examples

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```
In [2]:
# note that the value after the decimal place corresponds to the letter position.
# i.e. 1.4 corresponds to d, the fourth letter.
original1 = pd.Series([1.4, 2.3, 3.1, 4.2], index = ['d','c','a','b'])
original2 = pd.Series([2.2, 3.1, 1.3, 4.4], index = ['b','a','c','d'])
```

```
In [3]:
original1 # when you create a series, the original order of the index is preserved
```

```
Out[3]:
d    1.4
c    2.3
a    3.1
b    4.2
dtype: float64
```

Series that we will use as examples

In [2]:

```
# note that the value after the decimal place corresponds to the letter position.
# i.e. 1.4 corresponds to d, the fourth letter.
original1 = pd.Series([1.4, 2.3, 3.1, 4.2], index = ['d','c','a','b'])
original2 = pd.Series([2.2, 3.1, 1.3, 4.4], index = ['b','a','c','d'])
```

In [3]:

```
original1 # when you create a series, the original order of the index is preserved
```

Out[3]:

```
d    1.4
c    2.3
a    3.1
b    4.2
dtype: float64
```

In [4]:

```
# making a DataFrame with multiple series with the same index preserves the index order
pd.DataFrame({"x":original1, "x2": original1 * 2})
```

Out[4]:

	x	x2
d	1.4	2.8
c	2.3	4.6
a	3.1	6.2
b	4.2	8.4

In [5]:

```
original2 # note that original1 and original2 have different index orders
```

Out[5]:

```
b    2.2
a    3.1
c    1.3
d    4.4
dtype: float64
```

In [5]:

```
original2 # note that original1 and original2 have different index orders
```

Out[5]:

```
b    2.2
a    3.1
c    1.3
d    4.4
dtype: float64
```

In [6]:

```
# because original1 and original2 have index in different order, Pandas will sort the index before p
df = pd.DataFrame({"x":original1, "y": original2})
df
```

Out[6]:

	x	y
a	3.1	3.1
b	4.2	2.2
c	2.3	1.3
d	1.4	4.4

```
In [7]: original1.index # the index of original1 is the letters d, c, a, b in a tuple-like object
```

```
Out[7]: Index(['d', 'c', 'a', 'b'], dtype='object')
```

```
In [8]: original1['d':'a'] # when slicing pandas uses the index order or original1
```

```
Out[8]: d    1.4
        c    2.3
        a    3.1
        dtype: float64
```

In [7]:

```
original1.index # the index of original1 is the letters d, c, a, b in a tuple-like object
```

Out[7]:

```
Index(['d', 'c', 'a', 'b'], dtype='object')
```

In [8]:

```
original1['d':'a'] # when slicing pandas uses the index order or original1
```

Out[8]:

```
d    1.4
c    2.3
a    3.1
dtype: float64
```

In [9]:

```
df.index  # the index of df are the letters abcd in order
```

Out[9]:

```
Index(['a', 'b', 'c', 'd'], dtype='object')
```

In [10]:

```
df['a':'c'] # when slicing Pandas uses the index order of the DataFrame, which has been sorted
```

Out[10]:

	x	y
a	3.1	3.1
b	4.2	2.2
c	2.3	1.3

Rearranging value

Both Series and DataFrames have the `.sort_index()` and `.sort_values()` methods which can be used to rearrange the value.

Rearranging value

Both Series and DataFrames have the `.sort_index()` and `.sort_values()` methods which can be used to rearrange the value.

In [11]:

```
original2
```

Out[11]:

```
b    2.2
a    3.1
c    1.3
d    4.4
dtype: float64
```

Rearranging value

Both Series and DataFrames have the `.sort_index()` and `.sort_values()` methods which can be used to rearrange the value.

In [11]:

```
original2
```

Out[11]:

```
b    2.2
a    3.1
c    1.3
d    4.4
dtype: float64
```

In [12]:

```
original2.sort_index()
```

Out[12]:

```
a    3.1
b    2.2
c    1.3
d    4.4
dtype: float64
```

Rearranging value

Both Series and DataFrames have the `.sort_index()` and `.sort_values()` methods which can be used to rearrange the value.

```
In [11]: original2
```

```
Out[11]: b    2.2
         a    3.1
         c    1.3
         d    4.4
         dtype: float64
```

```
In [12]: original2.sort_index()
```

```
Out[12]: a    3.1
         b    2.2
         c    1.3
         d    4.4
         dtype: float64
```

```
In [13]: original2.sort_values()
```

```
Out[13]: c    1.3
         b    2.2
         a    3.1
         d    4.4
         dtype: float64
```

In [14]:

```
df
```

Out[14]:

	x	y
a	3.1	3.1
b	4.2	2.2
c	2.3	1.3
d	1.4	4.4

In [14]:

```
df
```

Out[14]:

	x	y
a	3.1	3.1
b	4.2	2.2
c	2.3	1.3
d	1.4	4.4

In [15]:

```
df.sort_values(by = "x", ascending = False)
```

Out[15]:

	x	y
b	4.2	2.2
a	3.1	3.1
c	2.3	1.3
d	1.4	4.4

Changing the Index

The index of a Pandas Series or Pandas DataFrame is immutable and cannot be modified.

However, if you want to change the index of a series or dataframe, you can define a new index and replace the existing index of the series/DataFrame.

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In [16]:

```
original1.index = range(4) # I replace the index of the series with this range object.
```

Changing the Index

The index of a Pandas Series or Pandas DataFrame is immutable and cannot be modified.

However, if you want to change the index of a series or dataframe, you can define a new index and replace the existing index of the series/DataFrame.

```
In [16]: original1.index = range(4) # I replace the index of the series with this range object.
```

```
In [17]: original1
```

```
Out[17]: 0    1.4
         1    2.3
         2    3.1
         3    4.2
         dtype: float64
```

Changing the Index

The index of a Pandas Series or Pandas DataFrame is immutable and cannot be modified.

However, if you want to change the index of a series or dataframe, you can define a new index and replace the existing index of the series/DataFrame.

In [16]:

```
original1.index = range(4) # I replace the index of the series with this range object.
```

In [17]:

```
original1
```

Out[17]:

```
0    1.4
1    2.3
2    3.1
3    4.2
dtype: float64
```

In [18]:

```
original1.index # We can see this has automatically become a RangeIndex object
```

Out[18]:

```
RangeIndex(start=0, stop=4, step=1)
```

In [19]:

```
original1[1]
```

Out[19]:

```
2.3
```

```
In [19]: original1[1]
```

```
Out[19]: 2.3
```

```
In [20]: original1.loc[1] # behaves the same as above
```

```
Out[20]: 2.3
```

```
In [19]: original1[1]
```

```
Out[19]: 2.3
```

```
In [20]: original1.loc[1] # behaves the same as above
```

```
Out[20]: 2.3
```

```
In [21]: original1.iloc[1] # behaves the same as above because the range index starts at 0
```

```
Out[21]: 2.3
```

In [22]:

```
original1.index = range(1,5)
```

In [22]:

```
original1.index = range(1,5)
```

In [23]:

```
original1
```

Out[23]:

```
1    1.4
2    2.3
3    3.1
4    4.2
dtype: float64
```

```
In [22]: original1.index = range(1,5)
```

```
In [23]: original1
```

```
Out[23]: 1    1.4
         2    2.3
         3    3.1
         4    4.2
         dtype: float64
```

```
In [24]: original1[1]
```

```
Out[24]: 1.4
```

```
In [22]:  original1.index = range(1,5)
```

```
In [23]:  original1
```

```
Out[23]:  1    1.4
          2    2.3
          3    3.1
          4    4.2
          dtype: float64
```

```
In [24]:  original1[1]
```

```
Out[24]:  1.4
```

```
In [25]:  original1.loc[1]
```

```
Out[25]:  1.4
```

In [22]:

```
original1.index = range(1,5)
```

In [23]:

```
original1
```

Out[23]:

```
1    1.4
2    2.3
3    3.1
4    4.2
dtype: float64
```

In [24]:

```
original1[1]
```

Out[24]:

```
1.4
```

In [25]:

```
original1.loc[1]
```

Out[25]:

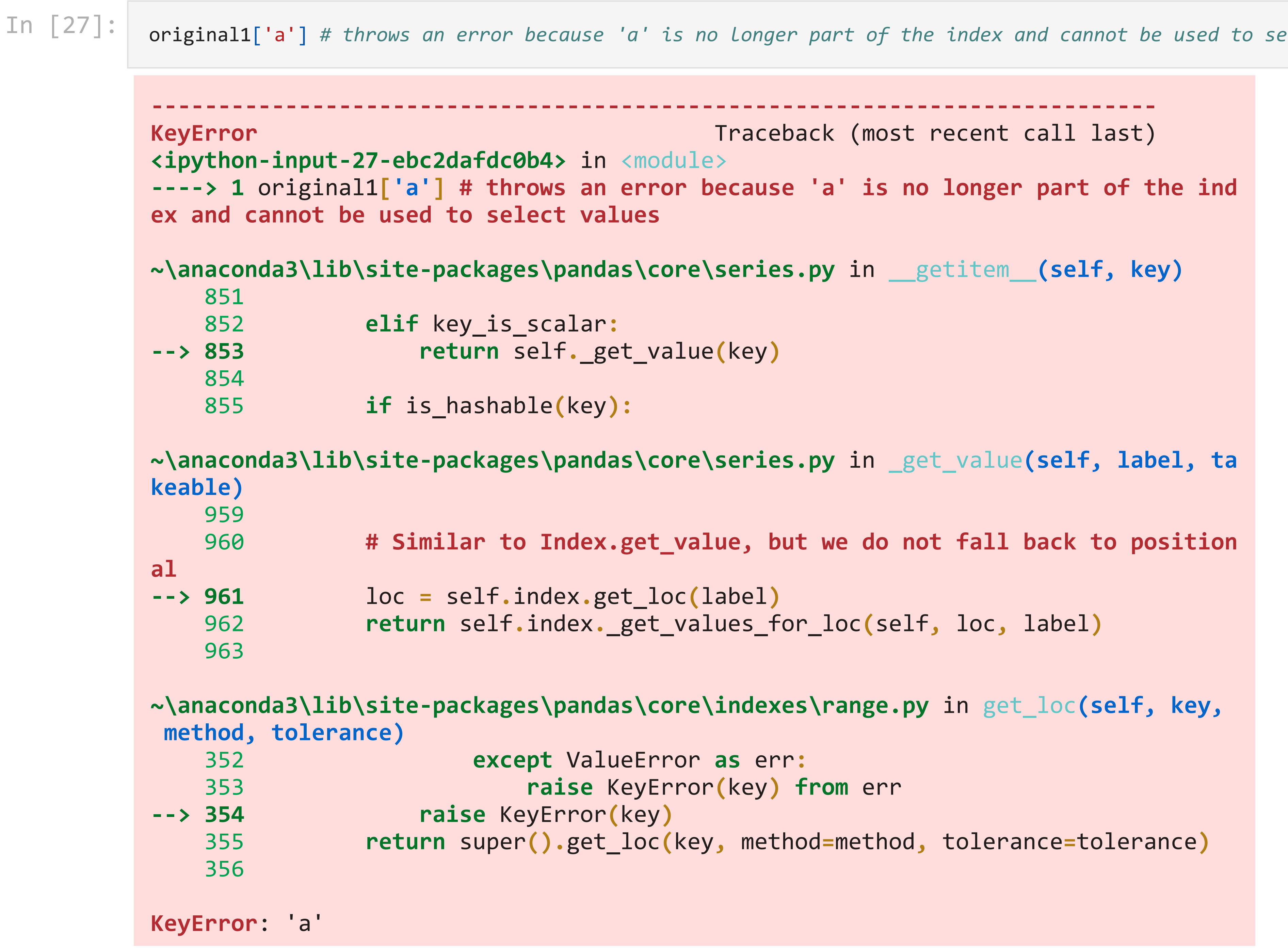
```
1.4
```

In [26]:

```
original1.iloc[1] # behavior is different because range index starts at 1
```

Out[26]:

```
2.3
```



```
In [27]: original1['a'] # throws an error because 'a' is no longer part of the index and cannot be used to se
```

```
---------------------------------------------------------------------------
KeyError                                  Traceback (most recent call last)
<ipython-input-27-ebc2dafdc0b4> in <module>
----> 1 original1['a'] # throws an error because 'a' is no longer part of the ind
ex and cannot be used to select values

~\anaconda3\lib\site-packages\pandas\core\series.py in __getitem__(self, key)
    851 
    852         elif key_is_scalar:
--> 853             return self._get_value(key)
    854 
    855         if is_hashable(key):

~\anaconda3\lib\site-packages\pandas\core\series.py in _get_value(self, label, ta
keable)
    959 
    960         # Similar to Index.get_value, but we do not fall back to position
al
--> 961         loc = self.index.get_loc(label)
    962         return self.index._get_values_for_loc(self, loc, label)
    963 

~\anaconda3\lib\site-packages\pandas\core\indexes\range.py in get_loc(self, key,
 method, tolerance)
    352                 except ValueError as err:
    353                     raise KeyError(key) from err
--> 354             raise KeyError(key)
    355         return super().get_loc(key, method=method, tolerance=tolerance)
    356 

KeyError: 'a'
```

In [28]:

```
original1.index = ['a','b','c','d'] # be careful as no restrictions regarding the meaning of the ind
# in the original 'a' was associated with 3.1. This index will associate it with 1.4
```

In [28]:

```
original1.index = ['a','b','c','d'] # be careful as no restrictions regarding the meaning of the ind
# in the original 'a' was associated with 3.1. This index will associate it with 1.4
```

In [29]:

```
original1
```

Out[29]:

```
a    1.4
b    2.3
c    3.1
d    4.2
dtype: float64
```

In [28]:

```
original1.index = ['a','b','c','d'] # be careful as no restrictions regarding the meaning of the ind
# in the original 'a' was associated with 3.1. This index will associate it with 1.4
```

In [29]:

```
original1
```

Out[29]:

```
a    1.4
b    2.3
c    3.1
d    4.2
dtype: float64
```

In [30]:

```
original1['a']
```

Out[30]:

```
1.4
```

In [28]:

```
original1.index = ['a','b','c','d'] # be careful as no restrictions regarding the meaning of the ind
# in the original 'a' was associated with 3.1. This index will associate it with 1.4
```

In [29]:

```
original1
```

Out[29]:

```
a    1.4
b    2.3
c    3.1
d    4.2
dtype: float64
```

In [30]:

```
original1['a']
```

Out[30]:

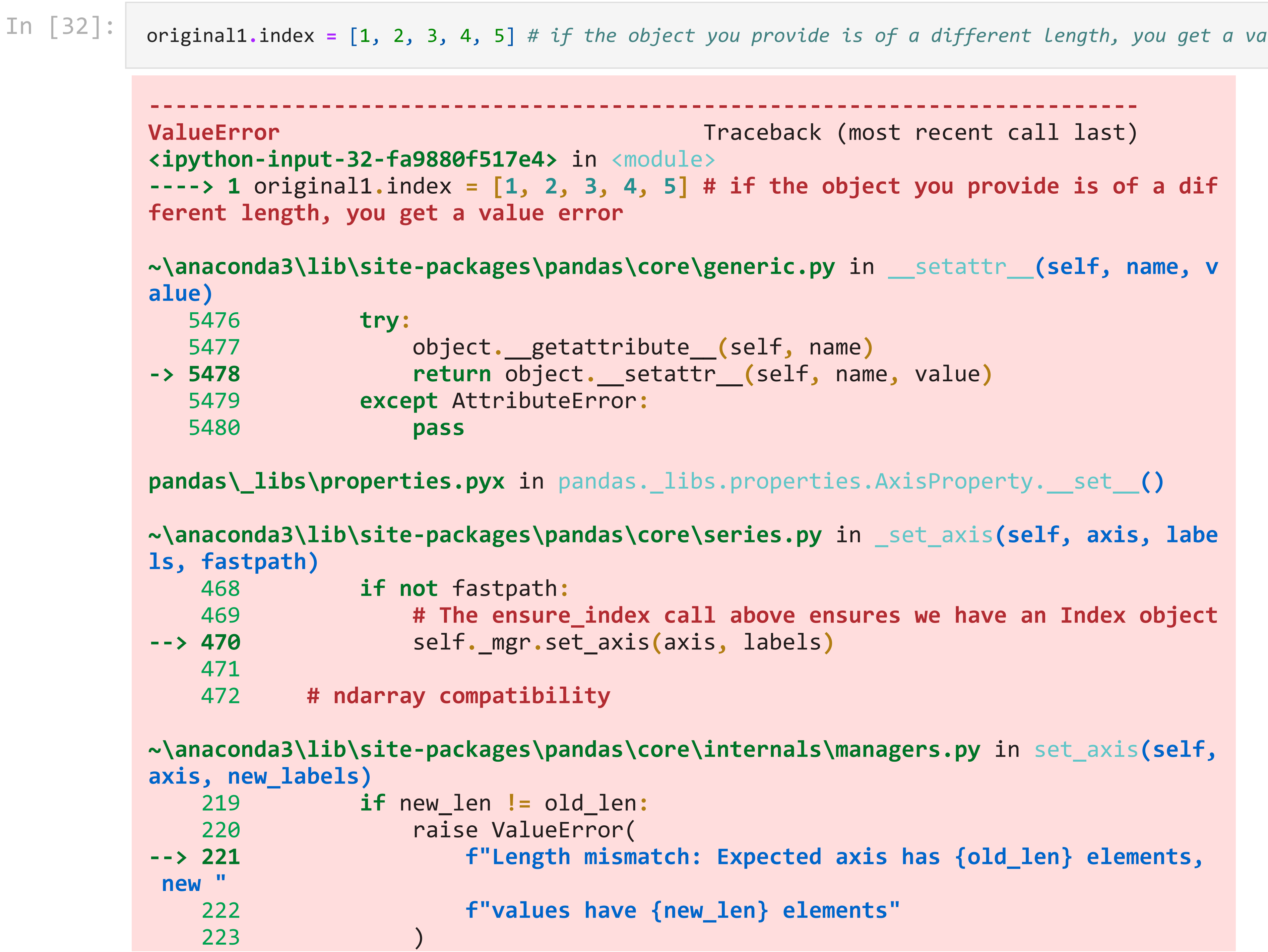
```
1.4
```

In [31]:

```
original1[0] # now that the index uses strings, you can index by position
```

Out[31]:

```
1.4
```



```
In [32]:  original1.index = [1, 2, 3, 4, 5] # if the object you provide is of a different length, you get a va
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-32-fa9880f517e4> in <module>
----> 1 original1.index = [1, 2, 3, 4, 5] # if the object you provide is of a dif
ferent length, you get a value error

~\anaconda3\lib\site-packages\pandas\core\generic.py in __setattr__(self, name, v
alue)
   5476         try:
   5477             object.__getattribute__(self, name)
-> 5478             return object.__setattr__(self, name, value)
   5479         except AttributeError:
   5480             pass

pandas\_libs\properties.pyx in pandas._libs.properties.AxisProperty.__set__()

~\anaconda3\lib\site-packages\pandas\core\series.py in _set_axis(self, axis, labe
ls, fastpath)
    468         if not fastpath:
    469             # The ensure_index call above ensures we have an Index object
--> 470             self._mgr.set_axis(axis, labels)
    471 
    472     # ndarray compatibility

~\anaconda3\lib\site-packages\pandas\core\internals\managers.py in set_axis(self,
axis, new_labels)
    219         if new_len != old_len:
    220             raise ValueError(
--> 221                 f"Length mismatch: Expected axis has {old_len} elements,
 new "
    222                 f"values have {new_len} elements"
    223             )
```

```
ValueError: Length mismatch: Expected axis has 4 elements, new values have 5 elem
ents
```

In [33]:

```
# similarly you can change the index of a DataFrame by defining a new object and assigning it to the
df.index = ['j','k','l','m']
df
```

Out[33]:

```
     x    y
j  3.1  3.1
k  4.2  2.2
l  2.3  1.3
m  1.4  4.4
```

Reindexing

Reindexing is different from just defining a new index.

Reindexing takes a current Pandas object and creates a *new* Pandas object that *conforms* to the specified index.

Do not confuse reindexing with creating a new index for a dataframe object.

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Reindexing is different from just defining a new index.

Reindexing takes a current Pandas object and creates a *new* Pandas object that *conforms* to the specified index.

Do not confuse reindexing with creating a new index for a dataframe object.

In [34]:

```
original = pd.Series([1.4, 2.3, 3.1, 4.2], index = ['d','c','a','b'])
```

In [35]:

```
original
```

Out[35]:

```
d    1.4
c    2.3
a    3.1
b    4.2
dtype: float64
```

In [35]:

```
original
```

Out[35]:

```
d    1.4
c    2.3
a    3.1
b    4.2
dtype: float64
```

In [36]:

```
newobj = original.reindex(['a','b','c','d','e']) # note this has an index value that doesn't exist i
```

In [35]:

```
original
```

Out[35]:

```
d    1.4
c    2.3
a    3.1
b    4.2
dtype: float64
```

In [36]:

```
newobj = original.reindex(['a','b','c','d','e']) # note this has an index value that doesn't exist i
```

In [37]:

```
newobj  # takes the data in orignal and moves it so it conforms to the specified index
# values that do not exist for the new index get NaN
```

Out[37]:

```
a    3.1
b    4.2
c    2.3
d    1.4
e    NaN
dtype: float64
```

In [38]:

```
# if you don't want NaN, you can specify a fill_value
newobj2 = original.reindex(['a','b','c','d','e'], fill_value = 0)
newobj2
```

Out[38]:

```
a    3.1
b    4.2
c    2.3
d    1.4
e    0.0
dtype: float64
```

For ordered data like a time series, it might be desirable to fill values when reindexing

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In [39]:

```
obj3 = pd.Series(['blue', 'purple', 'yellow'], index=[0, 3, 6])
obj3
```

Out[39]:

```
0      blue
3    purple
6    yellow
dtype: object
```

For ordered data like a time series, it might be desirable to fill values when reindexing

In [39]:

```
obj3 = pd.Series(['blue', 'purple', 'yellow'], index=[0, 3, 6])
obj3
```

Out[39]:

```
0      blue
3    purple
6    yellow
dtype: object
```

In [40]:

```
obj3.reindex(range(9))  # without any optional arguments, lots of missing values
```

Out[40]:

```
0      blue
1       NaN
2       NaN
3    purple
4       NaN
5       NaN
6    yellow
7       NaN
8       NaN
dtype: object
```

In [41]:

```
obj3.reindex(range(9), method='ffill')
# forward-fill pushes values 'forward' until a new value is encountered
```

Out[41]:

```
0       blue
1       blue
2       blue
3     purple
4     purple
5     purple
6     yellow
7     yellow
8     yellow
dtype: object
```

In [41]:

```
obj3.reindex(range(9), method='ffill')
# forward-fill pushes values 'forward' until a new value is encountered
```

Out[41]:

```
0      blue
1      blue
2      blue
3    purple
4    purple
5    purple
6    yellow
7    yellow
8    yellow
dtype: object
```

In [42]:

```
obj3.reindex(range(9), method='bfill')
# back-fill works in the opposite direction
# there was no value at index 8 so, NaNs get filled in
```

Out[42]:

```
0      blue
1    purple
2    purple
3    purple
4    yellow
5    yellow
6    yellow
7       NaN
8       NaN
dtype: object
```

Date Ranges as Index

Date Ranges as Index

In [43]:

```
# we specify the creation of a date_index using the date_range function
# freq = 'D' creates Daily values
date_index = pd.date_range('1/1/2010', periods=6, freq='D')
date_index
```

Out[43]:

```
DatetimeIndex(['2010-01-01', '2010-01-02', '2010-01-03', '2010-01-04',
               '2010-01-05', '2010-01-06'],
              dtype='datetime64[ns]', freq='D')
```

Date Ranges as Index

In [43]:

```
# we specify the creation of a date_index using the date_range function
# freq = 'D' creates Daily values
date_index = pd.date_range('1/1/2010', periods=6, freq='D')
date_index
```

Out[43]:

```
DatetimeIndex(['2010-01-01', '2010-01-02', '2010-01-03', '2010-01-04',
               '2010-01-05', '2010-01-06'],
              dtype='datetime64[ns]', freq='D')
```

In [44]:

```
# we create a DataFrame with the date index
df2 = pd.DataFrame({"prices": [100, 101, np.nan, 100, 89, 88]}, index=date_index)
df2
```

Out[44]:

	prices
2010-01-01	100.0
2010-01-02	101.0
2010-01-03	NaN
2010-01-04	100.0
2010-01-05	89.0
2010-01-06	88.0

In [45]:

```
# we create a DataFrame with the date index
df2 = pd.DataFrame({"prices": [100, 101, np.nan, 100, 89, 88]}, index=date_index)
df2
```

Out[45]:

```
            prices
2010-01-01   100.0
2010-01-02   101.0
2010-01-03     NaN
2010-01-04   100.0
2010-01-05    89.0
2010-01-06    88.0
```

In [45]:

```
# we create a DataFrame with the date index
df2 = pd.DataFrame({"prices": [100, 101, np.nan, 100, 89, 88]}, index=date_index)
df2
```

Out[45]:

	prices
2010-01-01	100.0
2010-01-02	101.0
2010-01-03	NaN
2010-01-04	100.0
2010-01-05	89.0
2010-01-06	88.0

In [46]:

```
date_index2 = pd.date_range('12/29/2009', periods=10, freq='D')  # a new date index
df2.reindex(date_index2)
```

Out[46]:

	prices
2009-12-29	NaN
2009-12-30	NaN
2009-12-31	NaN
2010-01-01	100.0
2010-01-02	101.0
2010-01-03	NaN
2010-01-04	100.0
2010-01-05	89.0
2010-01-06	88.0
2010-01-07	NaN

In [47]:

```
df2.reindex(date_index2, method = 'bfill')
# The value for Jan 3 isn't filled in because that NaN was not created by the reindexing process
# The NaN already existed in the data.
```

Out[47]:

	prices
2009-12-29	100.0
2009-12-30	100.0
2009-12-31	100.0
2010-01-01	100.0
2010-01-02	101.0
2010-01-03	NaN
2010-01-04	100.0
2010-01-05	89.0
2010-01-06	88.0
2010-01-07	NaN

`.reindex()` vs `.loc()`

If you don't need to fill in any missing info, then `.reindex()` and `.loc()` work very similarly. If the new index will have values that don't exist in the current index, you need to use `reindex`.

`.reindex()` vs `.loc()`

If you don't need to fill in any missing info, then `.reindex()` and `.loc()` work very similarly. If the new index will have values that don't exist in the current index, you need to use `reindex`.

In [48]:

```
obj5 = pd.DataFrame({'val':[1.4, 2.3, 3.1, 4.2]}, index = ['d','c','a','b'])
obj5
```

Out[48]:

	val
d	1.4
c	2.3
a	3.1
b	4.2

In [49]:

```
obj5.reindex(['a','b','c','d'])
```

Out[49]:

	val
a	3.1
b	4.2
c	2.3
d	1.4

In [49]:

```
obj5.reindex(['a','b','c','d'])
```

Out[49]:

	val
a	3.1
b	4.2
c	2.3
d	1.4

In [50]:

```
obj5.loc[['a','b','c','d']] # works the same as reindex
```

Out[50]:

	val
a	3.1
b	4.2
c	2.3
d	1.4

In [49]:

```
obj5.reindex(['a','b','c','d'])
```

Out[49]:

	val
a	3.1
b	4.2
c	2.3
d	1.4

In [50]:

```
obj5.loc[['a','b','c','d']] # works the same as reindex
```

Out[50]:

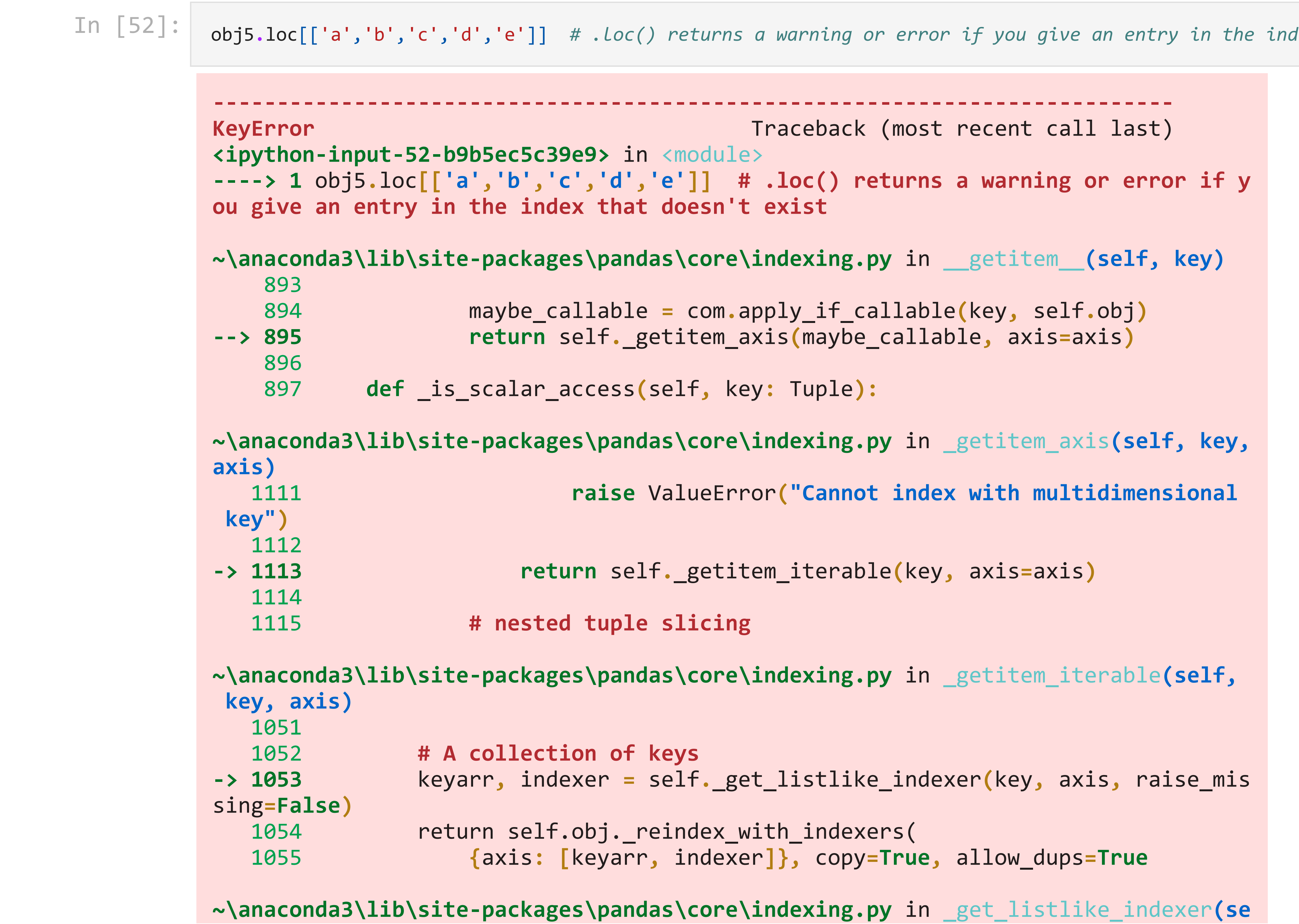
	val
a	3.1
b	4.2
c	2.3
d	1.4

In [51]:

```
obj5.reindex(['a','b','c','d','e'])
```

Out[51]:

	val
a	3.1
b	4.2
c	2.3
d	1.4
e	NaN



```
In [52]: obj5.loc[['a','b','c','d','e']]  # .loc() returns a warning or error if you give an entry in the ind
```

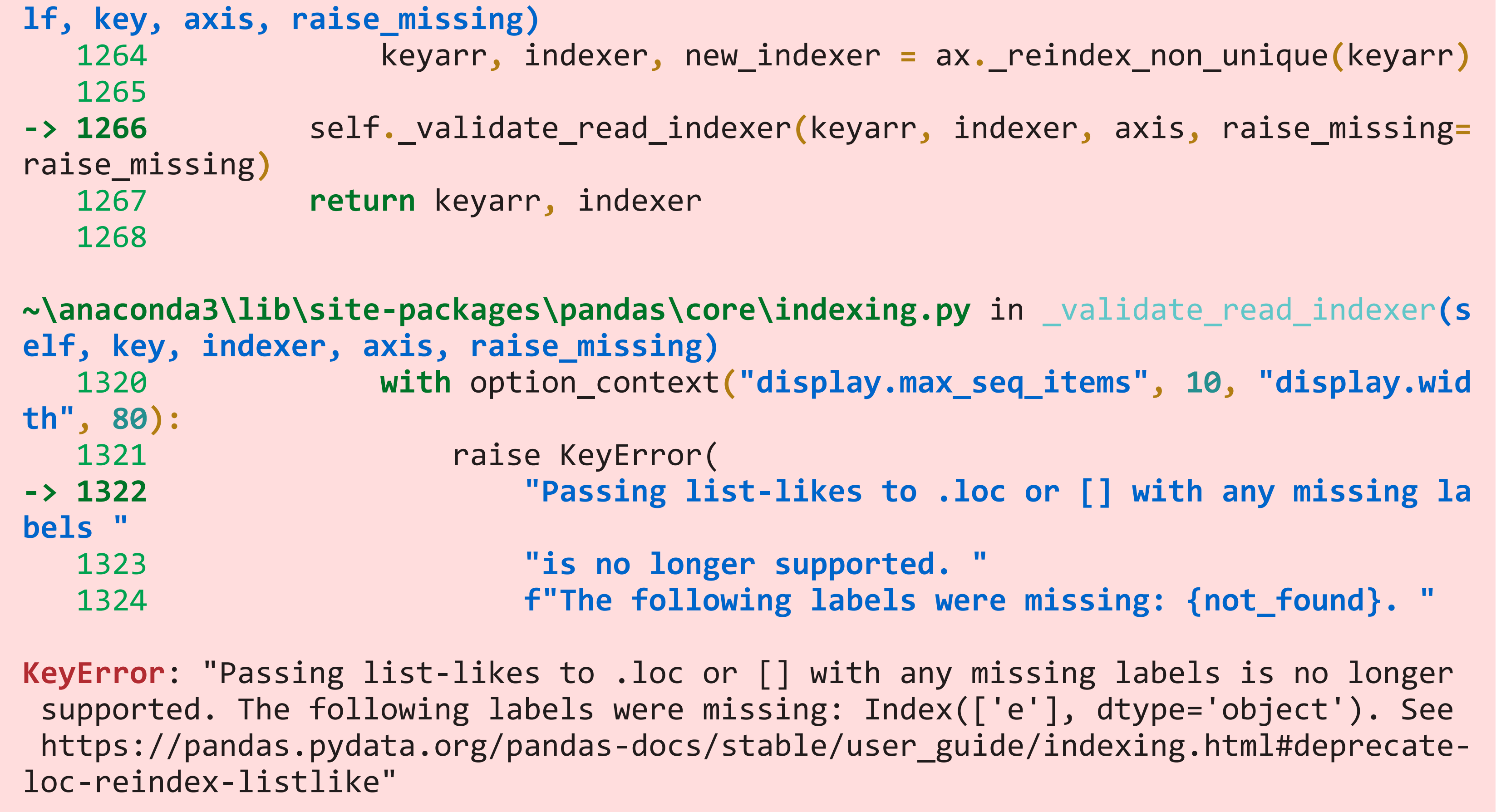
```
---------------------------------------------------------------------------
KeyError                                  Traceback (most recent call last)
<ipython-input-52-b9b5ec5c39e9> in <module>
----> 1 obj5.loc[['a','b','c','d','e']]  # .loc() returns a warning or error if y
ou give an entry in the index that doesn't exist

~\anaconda3\lib\site-packages\pandas\core\indexing.py in __getitem__(self, key)
    893 
    894             maybe_callable = com.apply_if_callable(key, self.obj)
--> 895             return self._getitem_axis(maybe_callable, axis=axis)
    896 
    897     def _is_scalar_access(self, key: Tuple):

~\anaconda3\lib\site-packages\pandas\core\indexing.py in _getitem_axis(self, key,
axis)
   1111                     raise ValueError("Cannot index with multidimensional
 key")
   1112 
-> 1113                 return self._getitem_iterable(key, axis=axis)
   1114 
   1115             # nested tuple slicing

~\anaconda3\lib\site-packages\pandas\core\indexing.py in _getitem_iterable(self,
 key, axis)
   1051 
   1052         # A collection of keys
-> 1053         keyarr, indexer = self._get_listlike_indexer(key, axis, raise_mis
sing=False)
   1054         return self.obj._reindex_with_indexers(
   1055             {axis: [keyarr, indexer]}, copy=True, allow_dups=True

~\anaconda3\lib\site-packages\pandas\core\indexing.py in _get_listlike_indexer(se
```



```
lf, key, axis, raise_missing)
   1264                 keyarr, indexer, new_indexer = ax._reindex_non_unique(keyarr)
   1265
-> 1266             self._validate_read_indexer(keyarr, indexer, axis, raise_missing=
raise_missing)
   1267             return keyarr, indexer
   1268

~\anaconda3\lib\site-packages\pandas\core\indexing.py in _validate_read_indexer(s
elf, key, indexer, axis, raise_missing)
   1320                 with option_context("display.max_seq_items", 10, "display.wid
th", 80):
   1321                     raise KeyError(
-> 1322                         "Passing list-likes to .loc or [] with any missing la
bels "
   1323                         "is no longer supported. "
   1324                         f"The following labels were missing: {not_found}. "

KeyError: "Passing list-likes to .loc or [] with any missing labels is no longer
 supported. The following labels were missing: Index(['e'], dtype='object'). See
 https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#deprecate-
loc-reindex-listlike"
```

Dropping rows or columns

you can use `df.drop()` to remove rows (default) or columns (specify axis = 1) at certain index locations.

Dropping rows or columns

you can use `df.drop()` to remove rows (default) or columns (specify axis = 1) at certain index locations.

In [53]:

```
df = pd.DataFrame(np.arange(12).reshape(3,4), columns=['A', 'B', 'C', 'D'], index = ['x','y','z'])
df
```

Out[53]:

	A	B	C	D
x	0	1	2	3
y	4	5	6	7
z	8	9	10	11

Dropping rows or columns

you can use `df.drop()` to remove rows (default) or columns (specify axis = 1) at certain index locations.

In [53]:

```
df = pd.DataFrame(np.arange(12).reshape(3,4), columns=['A', 'B', 'C', 'D'], index = ['x','y','z'])
df
```

Out[53]:

	A	B	C	D
x	0	1	2	3
y	4	5	6	7
z	8	9	10	11

In [54]:

```
# drop rows
df.drop(['x', 'z'])
```

Out[54]:

	A	B	C	D
y	4	5	6	7

Dropping rows or columns

you can use `df.drop()` to remove rows (default) or columns (specify axis = 1) at certain index locations.

In [53]:

```
df = pd.DataFrame(np.arange(12).reshape(3,4), columns=['A', 'B', 'C', 'D'], index = ['x','y','z'])
df
```

Out[53]:

	A	B	C	D
x	0	1	2	3
y	4	5	6	7
z	8	9	10	11

In [54]:

```
# drop rows
df.drop(['x', 'z'])
```

Out[54]:

	A	B	C	D
y	4	5	6	7

In [55]:

```
# drop columns
df.drop(['B', 'C'], axis = 1) # we must specify axis = 1 otherwise Pandas will look for "B" and "C"
```

Out[55]:

	A	D
x	0	3
y	4	7
z	8	11

In [56]:

```
# df.drop returns a new object and leaves df unchanged
# you can change this behavior with the argument inplace = True
df
```

Out[56]:

	A	B	C	D
x	0	1	2	3
y	4	5	6	7
z	8	9	10	11

Data Alignment

When performing element-wise arithmetic, Pandas will align the index values before doing the computation

Data Alignment

When performing element-wise arithmetic, Pandas will align the index values before doing the computation

In [57]:

```
s1 = pd.Series([7.3, -2.5, 3.4, 1.5], index=['a', 'c', 'd', 'e'])
s1
```

Out[57]:

```
a    7.3
c   -2.5
d    3.4
e    1.5
dtype: float64
```

Data Alignment

When performing element-wise arithmetic, Pandas will align the index values before doing the computation

In [57]:

```
s1 = pd.Series([7.3, -2.5, 3.4, 1.5], index=['a', 'c', 'd', 'e'])
s1
```

Out[57]:

```
a    7.3
c   -2.5
d    3.4
e    1.5
dtype: float64
```

In [58]:

```
s2 = pd.Series([-2.1, 3.6, -1.5, 4, 3.1],
               index=['a', 'c', 'e', 'f', 'g'])
s2
```

Out[58]:

```
a   -2.1
c    3.6
e   -1.5
f    4.0
g    3.1
dtype: float64
```

In [59]:

```
pd.DataFrame({'s1':s1,'s2':s2}) # for reference
```

Out[59]:

	s1	s2
a	7.3	-2.1
c	-2.5	3.6
d	3.4	NaN
e	1.5	-1.5
f	NaN	4.0
g	NaN	3.1

In [59]:

```
pd.DataFrame({'s1':s1,'s2':s2}) # for reference
```

Out[59]:

	s1	s2
a	7.3	-2.1
c	-2.5	3.6
d	3.4	NaN
e	1.5	-1.5
f	NaN	4.0
g	NaN	3.1

In [60]:

```
s1 + s2  # returns a new series, where the indexes are the union of the indexes of s1 and s2
```

Out[60]:

```
a    5.2
c    1.1
d    NaN
e    0.0
f    NaN
g    NaN
dtype: float64
```

In [59]:

```
pd.DataFrame({'s1':s1,'s2':s2}) # for reference
```

Out[59]:

	s1	s2
a	7.3	-2.1
c	-2.5	3.6
d	3.4	NaN
e	1.5	-1.5
f	NaN	4.0
g	NaN	3.1

In [60]:

```
s1 + s2  # returns a new series, where the indexes are the union of the indexes of s1 and s2
```

Out[60]:

```
a    5.2
c    1.1
d    NaN
e    0.0
f    NaN
g    NaN
dtype: float64
```

In [61]:

```
s1.add(s2)
```

Out[61]:

```
a    5.2
c    1.1
d    NaN
e    0.0
f    NaN
g    NaN
dtype: float64
```

In [62]:

```
pd.DataFrame({'s1':s1,'s2':s2})
```

Out[62]:

	s1	s2
a	7.3	-2.1
c	-2.5	3.6
d	3.4	NaN
e	1.5	-1.5
f	NaN	4.0
g	NaN	3.1

In [62]:

```
pd.DataFrame({'s1':s1,'s2':s2})
```

Out[62]:

	s1	s2
a	7.3	-2.1
c	-2.5	3.6
d	3.4	NaN
e	1.5	-1.5
f	NaN	4.0
g	NaN	3.1

In [63]:

```
s1.sub(s2, fill_value = 0)
```

Out[63]:

```
a    9.4
c   -6.1
d    3.4
e    3.0
f   -4.0
g   -3.1
dtype: float64
```

In [62]:

```
pd.DataFrame({'s1':s1,'s2':s2})
```

Out[62]:

	s1	s2
a	7.3	-2.1
c	-2.5	3.6
d	3.4	NaN
e	1.5	-1.5
f	NaN	4.0
g	NaN	3.1

In [63]:

```
s1.sub(s2, fill_value = 0)
```

Out[63]:

```
a    9.4
c   -6.1
d    3.4
e    3.0
f   -4.0
g   -3.1
dtype: float64
```

In [64]:

```
s1.rsub(s2, fill_value = 0) # .rsub means 'right hand subtract' sets the series in the argument as t
```

Out[64]:

```
a   -9.4
c    6.1
d   -3.4
e   -3.0
f    4.0
g    3.1
dtype: float64
```

In [65]:

```
s1 * s2
```

Out[65]:

```
a   -15.33
c    -9.00
d      NaN
e    -2.25
f      NaN
g      NaN
dtype: float64
```

In [65]:

```
s1 * s2
```

Out[65]:

```
a   -15.33
c    -9.00
d      NaN
e    -2.25
f      NaN
g      NaN
dtype: float64
```

In [66]:

```
s1.multiply(s2, fill_value = 1)
```

Out[66]:

```
a   -15.33
c    -9.00
d     3.40
e    -2.25
f     4.00
g     3.10
dtype: float64
```

For data frames with different columns, the rows and columns will be aligned

For data frames with different columns, the rows and columns will be aligned

In [67]:

```
df1 = pd.DataFrame(np.arange(9.).reshape((3, 3)), columns=list('bcd'),
                   index=['Ohio', 'Texas', 'Colorado'])
df1
```

Out[67]:

	b	c	d
Ohio	0.0	1.0	2.0
Texas	3.0	4.0	5.0
Colorado	6.0	7.0	8.0

For data frames with different columns, the rows and columns will be aligned

In [67]:

```
df1 = pd.DataFrame(np.arange(9.).reshape((3, 3)), columns=list('bcd'),
                   index=['Ohio', 'Texas', 'Colorado'])
df1
```

Out[67]:

	b	c	d
Ohio	0.0	1.0	2.0
Texas	3.0	4.0	5.0
Colorado	6.0	7.0	8.0

In [68]:

```
df2 = pd.DataFrame(np.arange(12.).reshape((4, 3)), columns=list('bde'),
                   index=['Utah', 'Ohio', 'Texas', 'Oregon'])
df2
```

Out[68]:

	b	d	e
Utah	0.0	1.0	2.0
Ohio	3.0	4.0	5.0
Texas	6.0	7.0	8.0
Oregon	9.0	10.0	11.0

In [69]:

```python
df1 + df2
# c is in df1, but not df2
# e is in df2, but not df1
# the result returns the union of columns, but will fill in NaN for elements that do not exist in bo
```

Out[69]:

	b	c	d	e
Colorado	NaN	NaN	NaN	NaN
Ohio	3.0	NaN	6.0	NaN
Oregon	NaN	NaN	NaN	NaN
Texas	9.0	NaN	12.0	NaN
Utah	NaN	NaN	NaN	NaN

In [69]:

```
df1 + df2
# c is in df1, but not df2
# e is in df2, but not df1
# the result returns the union of columns, but will fill in NaN for elements that do not exist in bo
```

Out[69]:

	b	c	d	e
Colorado	NaN	NaN	NaN	NaN
Ohio	3.0	NaN	6.0	NaN
Oregon	NaN	NaN	NaN	NaN
Texas	9.0	NaN	12.0	NaN
Utah	NaN	NaN	NaN	NaN

In [70]:

```
# if you want to fill in values that are missing, you can use df.add() and specify the fill_value
# this will perform the above operation, but instead of using NaN when it can't find a value
# (which will return NaN),
# it will use the fill_value
df1.add(df2, fill_value = 0)
# you still get NaN if the value does not exist in either DataFrame
```

Out[70]:

	b	c	d	e
Colorado	6.0	7.0	8.0	NaN
Ohio	3.0	1.0	6.0	5.0
Oregon	9.0	NaN	10.0	11.0
Texas	9.0	4.0	12.0	8.0
Utah	0.0	NaN	1.0	2.0

Arithmetic operations that can be called on DataFrames and Series are:

- `.add()`, `.radd()` and `.sub()`, `.rsub()`
- `.mul()`, `.rmul()` and `.div()`, `.rdiv()`
- `.floordiv()`, `.rfloordiv()` (floor division `//`)
- `.pow()`, `.rpow()` (exponentiation `**`)

Summary Stats of a DataFrame

Summary Stats of a DataFrame

In [71]:

```
df = pd.DataFrame({'one':[1.5,6.0,np.nan, 1.5,4,6, np.nan],
                   'two':[np.nan, -4.5, np.nan, -1.5, 0, -4.5, 4]},
                  index=['a', 'b', 'c', 'd','e','f','g'])
df
```

Out[71]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

Summary Stats of a DataFrame

In [71]:

```
df = pd.DataFrame({'one':[1.5,6.0,np.nan, 1.5,4,6, np.nan],
                   'two':[np.nan, -4.5, np.nan, -1.5, 0, -4.5, 4]},
                  index=['a', 'b', 'c', 'd','e','f','g'])
df
```

Out[71]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [72]:

```
df.sum()  # default behavior returns column sums and skips missing values
# default behavior sums across axis 0 (sums the row)
```

Out[72]:

```
one     19.0
two     -6.5
dtype: float64
```

In [73]:

```
df # for reference
```

Out[73]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [73]:

```
df # for reference
```

Out[73]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [74]:

```
df.sum(axis = 1) # sum across axis=1, sum across the columns and give row sums
```

Out[74]:

```
a    1.5
b    1.5
c    0.0
d    0.0
e    4.0
f    1.5
g    4.0
dtype: float64
```

In [73]:

```
df # for reference
```

Out[73]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [74]:

```
df.sum(axis = 1) # sum across axis=1, sum across the columns and give row sums
```

Out[74]:

```
a    1.5
b    1.5
c    0.0
d    0.0
e    4.0
f    1.5
g    4.0
dtype: float64
```

In [75]:

```
df.sum(skipna = False)
```

Out[75]:

```
one    NaN
two    NaN
dtype: float64
```

In [76]:

```
df.mean()
```

Out[76]:

```
one    3.8
two   -1.3
dtype: float64
```

In [76]:

```
df.mean()
```

Out[76]:

```
one     3.8
two    -1.3
dtype: float64
```

In [77]:

```
df.mean(axis = 1)
```

Out[77]:

```
a    1.50
b    0.75
c     NaN
d    0.00
e    2.00
f    0.75
g    4.00
dtype: float64
```

```
In [78]: df # for reference
```

```
Out[78]:
     one   two
a    1.5   NaN
b    6.0  -4.5
c    NaN   NaN
d    1.5  -1.5
e    4.0   0.0
f    6.0  -4.5
g    NaN   4.0
```

In [78]:

```
df # for reference
```

Out[78]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [79]:

```
df.min()
```

Out[79]:

```
one     1.5
two    -4.5
dtype: float64
```

In [78]:

```
df # for reference
```

Out[78]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [79]:

```
df.min()
```

Out[79]:

```
one     1.5
two    -4.5
dtype: float64
```

In [80]:

```
df.idxmin()  # which row has the minimum value, also .idxmax()
# returns the first minimum, if there are multiple
# you can also specify axis
```

Out[80]:

```
one     a
two     b
dtype: object
```

Summary stats available for dataframes and series

- `count()` - number of non NA values
- `quantile()`
- `sum()`
- `mean()`
- `median()`
- `mad()` - mean absolute deviation
- `prod()`
- `var()`, `std()`

https://pandas.pydata.org/pandas-docs/stable/reference/series.html#computations-descriptive-stats

Unique values

Unique values

In [81]:

```
df # for reference
```

Out[81]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

Unique values

In [81]:

```
df # for reference
```

Out[81]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [82]:

```
df.one.unique()  # shows the unique values in the order observed
```

Out[82]:

```
array([1.5, 6. , nan, 4. ])
```

Unique values

In [81]:

```
df # for reference
```

Out[81]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [82]:

```
df.one.unique()  # shows the unique values in the order observed
```

Out[82]:

```
array([1.5, 6. , nan, 4. ])
```

In [83]:

```
df.two.unique()
```

Out[83]:

```
array([ nan, -4.5, -1.5,  0. ,  4. ])
```

Unique values

```
In [81]: df # for reference
```

Out[81]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

```
In [82]: df.one.unique()  # shows the unique values in the order observed
```

```
Out[82]: array([1.5, 6. , nan, 4. ])
```

```
In [83]: df.two.unique()
```

```
Out[83]: array([ nan, -4.5, -1.5,  0. ,  4. ])
```

```
In [84]: df.unique()  # unique can only be applied to a series (a column in a dataframe)
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-84-02a393eeccfb> in <module>
----> 1 df.unique()  # unique can only be applied to a series (a column in a data
frame)
```

```
~\anaconda3\lib\site-packages\pandas\core\generic.py in __getattr__(self, name)
   5463             if self._info_axis._can_hold_identifiers_and_holds_name(name)
:
   5464                 return self[name]
-> 5465             return object.__getattribute__(self, name)
   5466 
   5467     def __setattr__(self, name: str, value) -> None:

AttributeError: 'DataFrame' object has no attribute 'unique'
```

In [85]:

```python
df # for reference
```

Out[85]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [85]:

```
df # for reference
```

Out[85]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [86]:

```
df.one.nunique()  # number of non-missing unique values exist
```

Out[86]:

```
3
```

In [85]:

```
df # for reference
```

Out[85]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [86]:

```
df.one.nunique()  # number of non-missing unique values exist
```

Out[86]:

```
3
```

In [87]:

```
df.one.value_counts()  # tally up counts of each value
# returns a series. the index are the unique values observed, the values are the frequencies.
# they appear in descending order of frequency
```

Out[87]:

```
6.0    2
1.5    2
4.0    1
Name: one, dtype: int64
```

In [88]:

```
df.one.isin([1.5, 4.0]) # checks to see if the value has membership in a particular list
# returns a series with boolean values
```

Out[88]:

```
a     True
b    False
c    False
d     True
e     True
f    False
g    False
Name: one, dtype: bool
```

In [88]:

```
df.one.isin([1.5, 4.0]) # checks to see if the value has membership in a particular list
# returns a series with boolean values
```

Out[88]:

```
a     True
b    False
c    False
d     True
e     True
f    False
g    False
Name: one, dtype: bool
```

In [89]:

```
(df.one == 1.5) | (df.one == 4.0)  # must use bitwise or. .isin() is much prefered
```

Out[89]:

```
a     True
b    False
c    False
d     True
e     True
f    False
g    False
Name: one, dtype: bool
```

In [90]:

```
df.loc[  df.one.isin([1.5,4.0]),  ]  # can filter rows based on the .isin() membership
```

Out[90]:

	one	two
a	1.5	NaN
d	1.5	-1.5
e	4.0	0.0

filtering out missing values

filtering out missing values

In [91]:

```
df
```

Out[91]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

filtering out missing values

In [91]:

```
df
```

Out[91]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [92]:

```
df.dropna() # gets rid of any row that is not complete
```

Out[92]:

	one	two
b	6.0	-4.5
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5

In [93]:

```python
df.dropna(how = 'all')  # only drops rows that are entirely NaN
```

Out[93]:

	one	two
a	1.5	NaN
b	6.0	-4.5
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [93]:

```
df.dropna(how = 'all')  # only drops rows that are entirely NaN
```

Out[93]:

	one	two
a	1.5	NaN
b	6.0	-4.5
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [94]:

```
# you can also use .notnull(), which is True for values that are not missing
df[df.two.notnull()]  # You can use this in conjuntion with specifying the column
```

Out[94]:

	one	two
b	6.0	-4.5
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

Filling in Missing Values

Filling in Missing Values

```
In [95]: df
```

```
Out[95]:
   one  two
a  1.5  NaN
b  6.0 -4.5
c  NaN  NaN
d  1.5 -1.5
e  4.0  0.0
f  6.0 -4.5
g  NaN  4.0
```

Filling in Missing Values

In [95]:

```
df
```

Out[95]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [96]:

```
df.fillna(0) # fill in missing values with a constant
```

Out[96]:

	one	two
a	1.5	0.0
b	6.0	-4.5
c	0.0	0.0
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	0.0	4.0

In [97]:

```
df.fillna({'one': 1000, 'two': 0})  # use a dictionary to specify values to use for each column
```

Out[97]:

	one	two
a	1.5	0.0
b	6.0	-4.5
c	1000.0	0.0
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	1000.0	4.0

In [98]:

```
df.fillna(method = 'bfill')  # backfills. You can also use ffill
```

Out[98]:

	one	two
a	1.5	-4.5
b	6.0	-4.5
c	1.5	-1.5
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [99]:

```
df.mean()
```

Out[99]:

```
one      3.8
two     -1.3
dtype: float64
```

In [99]:

```
df.mean()
```

Out[99]:

```
one     3.8
two    -1.3
dtype: float64
```

In [100]:

```
df.fillna(df.mean())  # fill na with df.mean() will fill in the column means
```

Out[100]:

	one	two
a	1.5	-1.3
b	6.0	-4.5
c	3.8	-1.3
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	3.8	4.0

In [99]:

```
df.mean()
```

Out[99]:

```
one      3.8
two     -1.3
dtype: float64
```

In [100]:

```
df.fillna(df.mean())  # fill na with df.mean() will fill in the column means
```

Out[100]:

	one	two
a	1.5	-1.3
b	6.0	-4.5
c	3.8	-1.3
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	3.8	4.0

all of the above fillna methods have created new DataFrame objects. If you want to modify the current DataFrame, you can use the optional argument `inplace = True`

```
In [101]: df.T
```

```
Out[101]:
        a     b    c     d    e     f    g
one   1.5   6.0  NaN   1.5  4.0   6.0  NaN
two   NaN  -4.5  NaN  -1.5  0.0  -4.5  4.0
```

In [101]:

```
df.T
```

Out[101]:

	a	b	c	d	e	f	g
one	1.5	6.0	NaN	1.5	4.0	6.0	NaN
two	NaN	-4.5	NaN	-1.5	0.0	-4.5	4.0

In [102]:

```
# apparently you can only fill missing values with dictionaries/series over a column
# so we have to do some Transpose magic
df.T.fillna(df.T.mean()).T
```

Out[102]:

	one	two
a	1.5	1.5
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	4.0	4.0

dealing with duplicates

dealing with duplicates

In [103]:

```
df
```

Out[103]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

dealing with duplicates

In [103]:

```
df
```

Out[103]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
f	6.0	-4.5
g	NaN	4.0

In [104]:

```
df.duplicated()  # sees if any of the rows are a duplicate of an earlier row
```

Out[104]:

```
a    False
b    False
c    False
d    False
e    False
f     True
g    False
dtype: bool
```

In [105]:

```
df[~df.duplicated()]  # gets rid of the duplicated rows
```

Out[105]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
g	NaN	4.0

In [105]:

```
df[~df.duplicated()]  # gets rid of the duplicated rows
```

Out[105]:

	one	two
a	1.5	NaN
b	6.0	-4.5
c	NaN	NaN
d	1.5	-1.5
e	4.0	0.0
g	NaN	4.0

In [106]:

```
df.one.duplicated()
```

Out[106]:

```
a    False
b    False
c    False
d     True
e    False
f     True
g     True
Name: one, dtype: bool
```