Module 8: Working with Dates and Times Module

Working with datetime type enables us to extract a lot of information. For example, the quarters of a year (Q1,Q2,Q3,Q4)

But first, let's explore on Python built-in date and time.

In [1]:

```
import pandas as pd
import datetime as dt
```

Datetime is a built-in module. This module is not imported automatically for every python file to conserve/save memory. Hence, we need to import the module when we want to use it. Datetime module has unique object, attributes, and method. We will learn the basics of Python Datetime before we learn Pandas Datetime format.

1. Review of Python's datetime Module

- An internal library that Python loads on demand. This is to conserve memory.
- Date() method creates an object to store a date. It can be year, month, day and etc.

date() method

Let's create a datetime object. The arguments are in order of year, month, and day.

Hint : Shift + Tab to read about the method

In [2]:

```
someday = dt.date(2016,4,12)
someday
```

Out[2]:

```
datetime.date(2016, 4, 12)
```

We can directly call the following attributes from the object.

In [3]:

```
someday.day , someday.month , someday.year
```

Out[3]:

```
(12, 4, 2016)
```

datetime() method

It is the same as date() method but with additional time parameter. The default values for the time (hours and seconds) are (0000h) which is midnight.

In [4]:

```
dt.datetime(2016,4,12)
```

Out[4]:

```
datetime.datetime(2016, 4, 12, 0, 0)
```

In [5]:

```
sometime = dt.datetime(2016,4,12, 8, 15)
sometime
```

Out[5]:

```
datetime.datetime(2016, 4, 12, 8, 15)
```

Casting or changing the datetime object to string will give a readable date format.

In [6]:

```
str(someday)
```

Out[6]:

```
'2016-04-12'
```

2. Pandas Timestamp Object

- Pandas version of Datetime
- If the user does not provide the specific time, the default values will be midnight (0000H)
- Pandas Datetime or Timestamp can do more analysis than Python Datetime module.

pd.Timestamp()

- argument can be Pandas Series or string.
- For string argument, Pandas can recognize separator which are either dash (-) , comma (,) or slash (/)

In [7]:

```
pd.Timestamp("2016-4-12")
```

Out[7]:

```
Timestamp('2016-04-12 00:00:00')
```

In [8]:

```
pd.Timestamp("4.12.2016")
```

Out[8]:

```
Timestamp('2016-04-12 00:00:00')
```

In [9]:

```
pd.Timestamp("2016/4/12 12:12")
```

Out[9]:

```
Timestamp('2016-04-12 12:12:00')
```

Pandas Datetime can also read Python Datetime objects.

In [10]:

```
someday
```

Out[10]:

```
datetime.date(2016, 4, 12)
```

In [11]:

```
pd.Timestamp(someday)
```

Out[11]:

```
Timestamp('2016-04-12 00:00:00')
```

3. The Pandas DateTimeIndex Object

- create dateTimeIndex object using DateTimeIndex() method
- Change string type into datetime data type

In [12]:

```
dates = ["2015-10-5", "2016-5-10", "2019-1-20"]
```

In [13]:

```
dtIndex = pd.DatetimeIndex(dates)
dtIndex
```

Out[13]:

```
DatetimeIndex(['2015-10-05', '2016-05-10', '2019-01-20'], dtype='datetime64
[ns]', freq=None)
```

We can also pass the Python Date/Datetime object to Pandas Datetime format.

In [14]:

```
dates2 = [dt.date(2015,10,5), dt.date(2016,5,10), dt.date(2019,1,20)]
pd.DatetimeIndex(dates2)
```

Out[14]:

```
DatetimeIndex(['2015-10-05', '2016-05-10', '2019-01-20'], dtype='datetime64
[ns]', freq=None)
```

Let's create a Pandas Series with Datetime as index.

In [15]:

```
values = [100,200,300]
pd.Series(values, dtIndex)
```

Out[15]:

```
2015-10-05    100
2016-05-10    200
2019-01-20    300
dtype: int64
```

4. pd.to_datetime() method

- Converts existing data object into Pandas Datetime object.
- to_datetime() can convert strings, Python Date object and Pandas Series.

In [16]:

```
pd.to_datetime("2016-5-10")
```

Out[16]:

```
Timestamp('2016-05-10 00:00:00')
```

In [17]:

```
pd.to_datetime(dt.date(2015,10,5))
```

Out[17]:

```
Timestamp('2015-10-05 00:00:00')
```

In [18]:

```
pd.to_datetime(["2016-5-10", "2019-1-20", "July 12th 1998"])
```

Out[18]:

```
DatetimeIndex(['2016-05-10', '2019-01-20', '1998-07-12'], dtype='datetime64
[ns]', freq=None)
```

Convert Pandas Series into Pandas Datetime object

In [19]:

```
s = pd.Series(["2019-1-20", "July 12th 1998", "2016"])
s
```

Out[19]:

```
0          2019-1-20
1     July 12th 1998
2               2016
dtype: object
```

In [20]:

```
pd.to_datetime(s)
```

Out[20]:

```
0   2019-01-20
1   1998-07-12
2   2016-01-01
dtype: datetime64[ns]
```

If we pass wrong format string to the method, it will prompt error.

However, we can fix the error by replacing it with NaT data, which means missing data. This can be done using the errors parameter by setting it to "coerce".

In [21]:

```
s = pd.Series(["2019-1-20", "July 12th 1998", "2016", "Hello World"])
```

In [22]:

```
pd.to_datetime(s)
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
~\Anaconda3\lib\site-packages\pandas\core\arrays\datetimes.py in objects_to_
datetime64ns(data, dayfirst, yearfirst, utc, errors, require_iso8601, allow_
object)
   1978         try:
-> 1979             values, tz_parsed = conversion.datetime_to_datetime64(da
ta)
   1980             # If tzaware, these values represent unix timestamps, so
we

pandas\_libs\tslibs\conversion.pyx in pandas._libs.tslibs.conversion.datetim
e_to_datetime64()

TypeError: Unrecognized value type: <class 'str'>

During handling of the above exception, another exception occurred:

ValueError                                Traceback (most recent call last)
<ipython-input-22-db78efd4cda4> in <module>
----> 1 pd.to_datetime(s)

~\Anaconda3\lib\site-packages\pandas\util\_decorators.py in wrapper(*args, *
*kwargs)
    206                 else:
    207                     kwargs[new_arg_name] = new_arg_value
--> 208             return func(*args, **kwargs)
    209 
    210         return wrapper

~\Anaconda3\lib\site-packages\pandas\core\tools\datetimes.py in to_datetime
(arg, errors, dayfirst, yearfirst, utc, box, format, exact, unit, infer_date
time_format, origin, cache)
    776             result = arg.map(cache_array)
    777         else:
--> 778             values = convert_listlike(arg._values, True, format)
    779             result = arg._constructor(values, index=arg.index, name=
arg.name)
    780     elif isinstance(arg, (ABCDataFrame, abc.MutableMapping)):

~\Anaconda3\lib\site-packages\pandas\core\tools\datetimes.py in _convert_lis
tlike_datetimes(arg, box, format, name, tz, unit, errors, infer_datetime_for
mat, dayfirst, yearfirst, exact)
    461             errors=errors,
    462             require_iso8601=require_iso8601,
--> 463             allow_object=True,
    464         )
    465 

~\Anaconda3\lib\site-packages\pandas\core\arrays\datetimes.py in objects_to_
datetime64ns(data, dayfirst, yearfirst, utc, errors, require_iso8601, allow_
object)
   1982             return values.view("i8"), tz_parsed
   1983         except (ValueError, TypeError):
-> 1984             raise e
   1985 
   1986     if tz_parsed is not None:
```

```
~\Anaconda3\lib\site-packages\pandas\core\arrays\datetimes.py in objects_to_
datetime64ns(data, dayfirst, yearfirst, utc, errors, require_iso8601, allow_
object)
   1973             dayfirst=dayfirst,
   1974             yearfirst=yearfirst,
-> 1975             require_iso8601=require_iso8601,
   1976         )
   1977     except ValueError as e:

pandas\_libs\tslib.pyx in pandas._libs.tslib.array_to_datetime()

pandas\_libs\tslib.pyx in pandas._libs.tslib.array_to_datetime()

pandas\_libs\tslib.pyx in pandas._libs.tslib.array_to_datetime_object()

pandas\_libs\tslib.pyx in pandas._libs.tslib.array_to_datetime_object()

pandas\_libs\tslibs\parsing.pyx in pandas._libs.tslibs.parsing.parse_datetim
e_string()

~\Anaconda3\lib\site-packages\dateutil\parser\_parser.py in parse(timestr, p
arserinfo, **kwargs)
   1356         return parser(parserinfo).parse(timestr, **kwargs)
   1357     else:
-> 1358         return DEFAULTPARSER.parse(timestr, **kwargs)
   1359
   1360

~\Anaconda3\lib\site-packages\dateutil\parser\_parser.py in parse(self, time
str, default, ignoretz, tzinfos, **kwargs)
    647
    648         if res is None:
--> 649             raise ValueError("Unknown string format:", timestr)
    650
    651         if len(res) == 0:

ValueError: ('Unknown string format:', 'Hello World')
```

In [23]:

```
pd.to_datetime(s, errors="coerce")
```

Out[23]:

```
0   2019-01-20
1   1998-07-12
2   2016-01-01
3          NaT
dtype: datetime64[ns]
```

UNIX time

Pandas can also read UNIX Time. Unix time (also known as POSIX time or UNIX Epoch time) is a system for describing a point in time. It is the number of seconds that have elapsed since 00:00:00 Thursday, 1 January 1970, Coordinated Universal Time (UTC), minus leap seconds.

Try:[https://www.epochconverter.com/ (https://www.epochconverter.com/)](https://www.epochconverter.com/)

In [24]:

```
pd.to_datetime(1564880922, unit="s")
```

Out[24]:

```
Timestamp('2019-08-04 01:08:42')
```

5. Create Range of Dates with the pd.date_range() Method

Requires at least 2 parameters, start and end:

- start : starting day
- end : upper bound for the day generated
- freq : how the internal is calculated. The default value is "D" which stands for Day. "2D" stands for 2 Days.

For full list of freq : [https://pandas.pydata.org/pandas-docs/stable/user_guide/timeseries.html#timeseries-offset-aliases (https://pandas.pydata.org/pandas-docs/stable/user_guide/timeseries.html#timeseries-offset-aliases)](https://pandas.pydata.org/pandas-docs/stable/user_guide/timeseries.html#timeseries-offset-aliases)

START + END + FREQ

In [25]:

```
pd.date_range(start="2019-1-2", end="2019-1-10", freq="2D")
```

Out[25]:

```
DatetimeIndex(['2019-01-02', '2019-01-04', '2019-01-06', '2019-01-08',
               '2019-01-10'],
              dtype='datetime64[ns]', freq='2D')
```

We can also generate days on weekdays or business days. This can be done by specifying freq= "B“.

In [26]:

```
pd.date_range(start="2019-1-2", end="2019-1-10", freq="B")
```

Out[26]:

```
DatetimeIndex(['2019-01-02', '2019-01-03', '2019-01-04', '2019-01-07',
               '2019-01-08', '2019-01-09', '2019-01-10'],
              dtype='datetime64[ns]', freq='B')
```

Let's generate the dates of all Fridays on February 2020.

In [27]:

```
pd.date_range(start="1 Feb 2020", end="28 Feb 2020", freq="W-FRI")
```

Out[27]:

```
DatetimeIndex(['2020-02-07', '2020-02-14', '2020-02-21', '2020-02-28'], dtyp
e='datetime64[ns]', freq='W-FRI')
```

Generate ten days with 6 Hours interval.

In [28]:

```
pd.date_range(start="1 Feb 2020", end="10 Feb 2020", freq="6H")
```

Out[28]:

```
DatetimeIndex(['2020-02-01 00:00:00', '2020-02-01 06:00:00',
               '2020-02-01 12:00:00', '2020-02-01 18:00:00',
               '2020-02-02 00:00:00', '2020-02-02 06:00:00',
               '2020-02-02 12:00:00', '2020-02-02 18:00:00',
               '2020-02-03 00:00:00', '2020-02-03 06:00:00',
               '2020-02-03 12:00:00', '2020-02-03 18:00:00',
               '2020-02-04 00:00:00', '2020-02-04 06:00:00',
               '2020-02-04 12:00:00', '2020-02-04 18:00:00',
               '2020-02-05 00:00:00', '2020-02-05 06:00:00',
               '2020-02-05 12:00:00', '2020-02-05 18:00:00',
               '2020-02-06 00:00:00', '2020-02-06 06:00:00',
               '2020-02-06 12:00:00', '2020-02-06 18:00:00',
               '2020-02-07 00:00:00', '2020-02-07 06:00:00',
               '2020-02-07 12:00:00', '2020-02-07 18:00:00',
               '2020-02-08 00:00:00', '2020-02-08 06:00:00',
               '2020-02-08 12:00:00', '2020-02-08 18:00:00',
               '2020-02-09 00:00:00', '2020-02-09 06:00:00',
               '2020-02-09 12:00:00', '2020-02-09 18:00:00',
               '2020-02-10 00:00:00'],
              dtype='datetime64[ns]', freq='6H')
```

Generating last day of every month in the year 2020.

freq="M" stands for Month.

In [29]:

```
pd.date_range(start="1 Jan 2020", end="31 Dec 2020", freq="M")
```

Out[29]:

```
DatetimeIndex(['2020-01-31', '2020-02-29', '2020-03-31', '2020-04-30',
               '2020-05-31', '2020-06-30', '2020-07-31', '2020-08-31',
               '2020-09-30', '2020-10-31', '2020-11-30', '2020-12-31'],
              dtype='datetime64[ns]', freq='M')
```

START + PERIODS + FREQ

periods parameter : Number of dates we want to generate from starting date

For example, if we want to generate **25 days** from 12 July 1998, we need to specify the start parameter as "12 July 1998" and set ** periods parameter to 25.

In [30]:

```
pd.date_range(start="12 July 1998", periods=25, freq="D")
```

Out[30]:

```
DatetimeIndex(['1998-07-12', '1998-07-13', '1998-07-14', '1998-07-15',
               '1998-07-16', '1998-07-17', '1998-07-18', '1998-07-19',
               '1998-07-20', '1998-07-21', '1998-07-22', '1998-07-23',
               '1998-07-24', '1998-07-25', '1998-07-26', '1998-07-27',
               '1998-07-28', '1998-07-29', '1998-07-30', '1998-07-31',
               '1998-08-01', '1998-08-02', '1998-08-03', '1998-08-04',
               '1998-08-05'],
              dtype='datetime64[ns]', freq='D')
```

We can also generate **25 Business days** (Weekdays) from 12 July 1998.

Since 12 July is Sunday, the dates will start counting on 13 July.

In [31]:

```
pd.date_range(start="12 July 1998", periods=25, freq="B")
```

Out[31]:

```
DatetimeIndex(['1998-07-13', '1998-07-14', '1998-07-15', '1998-07-16',
               '1998-07-17', '1998-07-20', '1998-07-21', '1998-07-22',
               '1998-07-23', '1998-07-24', '1998-07-27', '1998-07-28',
               '1998-07-29', '1998-07-30', '1998-07-31', '1998-08-03',
               '1998-08-04', '1998-08-05', '1998-08-06', '1998-08-07',
               '1998-08-10', '1998-08-11', '1998-08-12', '1998-08-13',
               '1998-08-14'],
              dtype='datetime64[ns]', freq='B')
```

To generate 25 dates of the last days of every month, we use parameter freq="M".

In [32]:

```
pd.date_range(start="12 July 1998" , periods=25, freq="M")
```

Out[32]:

```
DatetimeIndex(['1998-07-31', '1998-08-31', '1998-09-30', '1998-10-31',
               '1998-11-30', '1998-12-31', '1999-01-31', '1999-02-28',
               '1999-03-31', '1999-04-30', '1999-05-31', '1999-06-30',
               '1999-07-31', '1999-08-31', '1999-09-30', '1999-10-31',
               '1999-11-30', '1999-12-31', '2000-01-31', '2000-02-29',
               '2000-03-31', '2000-04-30', '2000-05-31', '2000-06-30',
               '2000-07-31'],
              dtype='datetime64[ns]', freq='M')
```

Generate 25 dates with interval of 12 Hours.

In [33]:

```
pd.date_range(start="12/7/1998", periods=25, freq="12H")
```

Out[33]:

```
DatetimeIndex(['1998-12-07 00:00:00', '1998-12-07 12:00:00',
               '1998-12-08 00:00:00', '1998-12-08 12:00:00',
               '1998-12-09 00:00:00', '1998-12-09 12:00:00',
               '1998-12-10 00:00:00', '1998-12-10 12:00:00',
               '1998-12-11 00:00:00', '1998-12-11 12:00:00',
               '1998-12-12 00:00:00', '1998-12-12 12:00:00',
               '1998-12-13 00:00:00', '1998-12-13 12:00:00',
               '1998-12-14 00:00:00', '1998-12-14 12:00:00',
               '1998-12-15 00:00:00', '1998-12-15 12:00:00',
               '1998-12-16 00:00:00', '1998-12-16 12:00:00',
               '1998-12-17 00:00:00', '1998-12-17 12:00:00',
               '1998-12-18 00:00:00', '1998-12-18 12:00:00',
               '1998-12-19 00:00:00'],
              dtype='datetime64[ns]', freq='12H')
```

In [34]:

```
pd.date_range(start="12 July 1998" , periods=25, freq="M" )
```

Out[34]:

```
DatetimeIndex(['1998-07-31', '1998-08-31', '1998-09-30', '1998-10-31',
               '1998-11-30', '1998-12-31', '1999-01-31', '1999-02-28',
               '1999-03-31', '1999-04-30', '1999-05-31', '1999-06-30',
               '1999-07-31', '1999-08-31', '1999-09-30', '1999-10-31',
               '1999-11-30', '1999-12-31', '2000-01-31', '2000-02-29',
               '2000-03-31', '2000-04-30', '2000-05-31', '2000-06-30',
               '2000-07-31'],
              dtype='datetime64[ns]', freq='M')
```

END + PERIODS + FREQ

We can specify the end dates and the number of periods we want, then it will generate a list of dates which will end before the end date.

For example, the code below will generate 10 dates with an interval of 1 day. The end date is 31 Dec 2019. Hence, the calculated starting date is 22 Dec 2019.

In [35]:

```
pd.date_range(end="31 Dec 2019", periods=10, freq="D")
```

Out[35]:

```
DatetimeIndex(['2019-12-22', '2019-12-23', '2019-12-24', '2019-12-25',
               '2019-12-26', '2019-12-27', '2019-12-28', '2019-12-29',
               '2019-12-30', '2019-12-31'],
              dtype='datetime64[ns]', freq='D')
```

Freq="MS" means start of each months

Notice the last date is 1 Dec 2019, because our end date is 31 Dec 2019. Hence, dates after the end date will not be generated.

In [36]:

```
pd.date_range(end="31 Dec 2019", periods=10, freq="MS")
```

Out[36]:

```
DatetimeIndex(['2019-03-01', '2019-04-01', '2019-05-01', '2019-06-01',
               '2019-07-01', '2019-08-01', '2019-09-01', '2019-10-01',
               '2019-11-01', '2019-12-01'],
              dtype='datetime64[ns]', freq='MS')
```

6 .dt Accessor

In the previous chapter, we learned how to change a columns' data type from string to datetime. This is to enable us to do more operations on the date.

Let's generate a list of dates and pass it into Pandas Series.

In [37]:

```
list_dates = pd.date_range(start="1-1-2019", end="10-1-2019", freq="B")
```

In [38]:

```
s = pd.Series(list_dates)
s.head()
```

Out[38]:

```
0   2019-01-01
1   2019-01-02
2   2019-01-03
3   2019-01-04
4   2019-01-07
dtype: datetime64[ns]
```

In [39]:

```
len(s)
```

Out[39]:

```
196
```

Now we have a list of dates in Pandas Series. We need to use **.dt** to access some of the attributes

s.dt.day will return the days from the Series. Since the Series is already in datetime type, we do not need to do additional operations.

In [40]:

```
s.dt.day.head()
```

Out[40]:

```
0    1
1    2
2    3
3    4
4    7
dtype: int64
```

s.dt.is_quater_start will return a list of Booleans. It will return TRUE if the date is the first day of a quarter.

In [41]:

```
mask = s.dt.is_quarter_start
s[mask]
```

Out[41]:

```
0     2019-01-01
64    2019-04-01
129   2019-07-01
195   2019-10-01
dtype: datetime64[ns]
```

Generating Business days/Weekday, will gives us the days from Monday to Friday.

In [42]:

```
s.dt.day_name()
```

Out[42]:

```
0        Tuesday
1      Wednesday
2       Thursday
3         Friday
4         Monday
         ...
191    Wednesday
192     Thursday
193       Friday
194       Monday
195      Tuesday
Length: 196, dtype: object
```

7. Install Pandas-datareader library

pandas_datareader provides a consistent, simple API for you to collect data from these platforms. We can get stock prices for many companies.

- Open Anaconda Command Prompt
- Run command - **conda install pandas-datareader**
- wait until it is done

8. Import Financial Datasets with Pandas Data Reader Library

- Unfortunately, Google finance and Morningstar have been deprecated due to massive changes in their API and there has been no stable replacement.
- Full documentation : https://pydata.github.io/pandas-datareader/stable (https://pydata.github.io/pandas-datareader/stable)

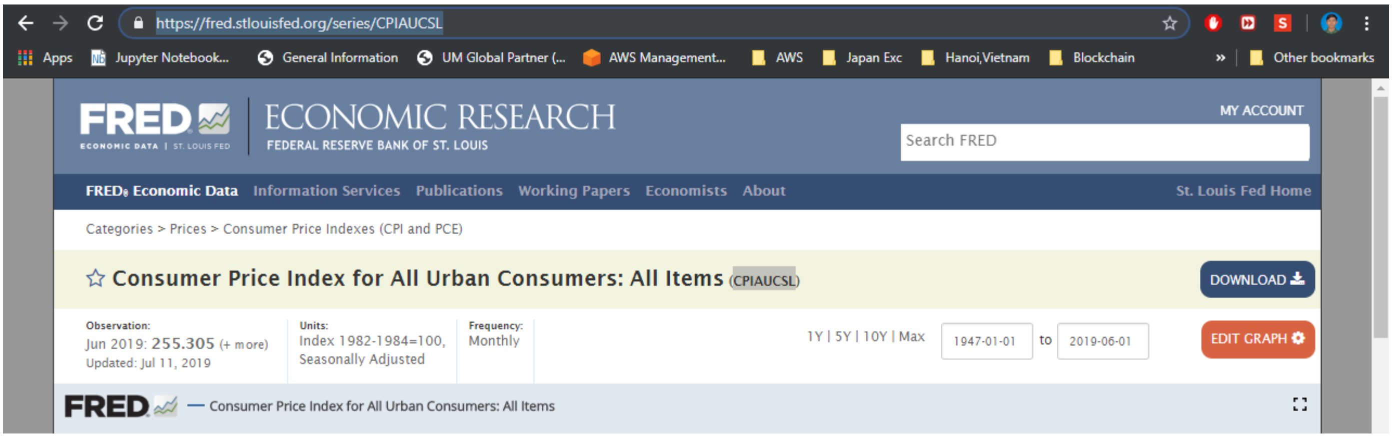
In [43]:

```
import pandas as pd
import datetime as dt
from pandas_datareader import data
```

FRED (Federal Reserve Economic Data)

source : https://pydata.github.io/pandas-datareader/stable/remote_data.html#fred (https://pydata.github.io/pandas-datareader/stable/remote_data.html#fred)

From FRED Official WEbsite, https://fred.stlouisfed.org/series/CPIAUCSL (https://fred.stlouisfed.org/series/CPIAUCSL)



We can see the code on the right of the topic. To retrieve the data using Pandas DataReader, we need to use the code.

In [44]:

```
data.get_data_fred('CPIAUCSL')
```

Out[44]:

DATE	CPIAUCSL
2014-11-01	236.983
2014-12-01	236.252
2015-01-01	234.718
2015-02-01	235.236
2015-03-01	236.005
2015-04-01	236.156
2015-05-01	236.974
2015-06-01	237.684
2015-07-01	238.053
2015-08-01	238.028
2015-09-01	237.506
2015-10-01	237.781
2015-11-01	238.016
2015-12-01	237.817
2016-01-01	237.833
2016-02-01	237.469
2016-03-01	238.038
2016-04-01	238.827
2016-05-01	239.464
2016-06-01	240.167
2016-07-01	240.150
2016-08-01	240.602
2016-09-01	241.051
2016-10-01	241.691
2016-11-01	242.029
2016-12-01	242.772
2017-01-01	243.780
2017-02-01	243.961
2017-03-01	243.749
2017-04-01	244.051
2017-05-01	243.962
2017-06-01	244.182
2017-07-01	244.390

DATE	CPIAUCSL
2017-08-01	245.297
2017-09-01	246.418
2017-10-01	246.587
2017-11-01	247.332
2017-12-01	247.901
2018-01-01	248.884
2018-02-01	249.369
2018-03-01	249.498
2018-04-01	249.956
2018-05-01	250.646
2018-06-01	251.134
2018-07-01	251.597
2018-08-01	251.879
2018-09-01	252.010
2018-10-01	252.794
2018-11-01	252.760
2018-12-01	252.723
2019-01-01	252.673
2019-02-01	253.113
2019-03-01	254.148
2019-04-01	254.958
2019-05-01	255.155
2019-06-01	255.305
2019-07-01	256.161
2019-08-01	256.300
2019-09-01	256.358

In [45]:

```
from pandas_datareader import data
start="1990-1-2"
end="2019-1-10"
gdp = data.DataReader('GDP', 'fred', start, end)
gdp
```

Out[45]:

	GDP
DATE	
1990-04-01	5960.028
1990-07-01	6015.116
1990-10-01	6004.733
1991-01-01	6035.178
1991-04-01	6126.862
...	...
2018-01-01	20163.159
2018-04-01	20510.177
2018-07-01	20749.752
2018-10-01	20897.804
2019-01-01	21098.827

116 rows × 1 columns

Fama/French

source : https://pydata.github.io/pandas-datareader/stable/remote_data.html#fama-french (https://pydata.github.io/pandas-datareader/stable/remote_data.html#fama-french)

In [46]:

```python
from pandas_datareader import data
ds = data.DataReader('5_Industry_Portfolios', 'famafrench')
ds
```

Out[46]:

```
{0:          Cnsmr  Manuf  HiTec  Hlth   Other
 Date
 2014-11   6.26  -2.04   4.00   2.66   2.73
 2014-12   0.08   0.35  -1.38  -0.88   1.13
 2015-01  -0.72  -3.11  -3.63   1.56  -6.19
 2015-02   5.57   3.83   8.44   4.31   6.89
 2015-03  -0.49  -1.91  -2.40   0.84  -0.77
 2015-04  -1.05   1.79   1.77  -1.40   0.48
 2015-05   1.14  -1.16   1.79   4.88   1.73
 2015-06  -0.92  -3.07  -2.88   0.08  -0.32
 2015-07   4.20  -3.28   2.19   3.66   2.02
 2015-08  -5.00  -4.74  -6.40  -8.34  -6.18
 2015-09  -1.51  -3.96  -1.70  -7.29  -3.07
 2015-10   5.43   8.69   9.80   7.72   6.51
 2015-11   0.29  -0.08   0.57   0.72   1.20
 2015-12   0.13  -4.66  -2.59   0.38  -2.67
 2016-01  -3.30  -3.46  -5.05  -9.40  -8.23
 2016-02   0.51   1.39  -0.51  -1.06  -0.07
```

In [47]:

```python
ds.keys()
```

Out[47]:

```
dict_keys([0, 1, 2, 3, 4, 5, 6, 7, 'DESCR'])
```

In [48]:

```python
ds["DESCR"]
```

Out[48]:

```
'5 Industry Portfolios\n---------------------\n\nThis file was created by CM
PT_IND_RETS using the 201909 CRSP database. It contains value- and equal-wei
ghted returns for 5 industry portfolios. The portfolios are constructed at t
he end of June. The annual returns are from January to December. Missing dat
a are indicated by -99.99 or -999. Copyright 2019 Kenneth R. French\n\n  0 :
Average Value Weighted Returns -- Monthly (59 rows x 5 cols)\n  1 : Average
Equal Weighted Returns -- Monthly (59 rows x 5 cols)\n  2 : Average Value We
ighted Returns -- Annual (5 rows x 5 cols)\n  3 : Average Equal Weighted Ret
urns -- Annual (5 rows x 5 cols)\n  4 : Number of Firms in Portfolios (59 ro
ws x 5 cols)\n  5 : Average Firm Size (59 rows x 5 cols)\n  6 : Sum of BE /
Sum of ME (6 rows x 5 cols)\n  7 : Value-Weighted Average of BE/ME (6 rows x
5 cols)'
```

World Bank

- Using wb.search, we can search any data that we want.
- To use it, we need to specify the keyword in a string. If we have multiple keywords, we can separate them with **"."** .
- Then, we can download the data using the ID column as a reference.

In [52]:

```
from pandas_datareader import wb
matches = wb.search('gdp')
matches
```

Out[52]:

	id	name	unit	source	sourceNote	sourceOrganizat
641	5.51.01.10.gdp	Per capita GDP growth		Statistical Capacity Indicators	GDP per capita is the sum of gross value added...	b'Wo Developm Indicator (W databank
643	6.0.GDP_current	GDP (current $)		LAC Equity Lab	GDP is the sum of gross value added by all res...	b'Wo Developm Indicators (Wo Ba
644	6.0.GDP_growth	GDP growth (annual %)		LAC Equity Lab	Annual percentage growth rate of GDP at market...	b'Wo Developm Indicators (Wo Ba
645	6.0.GDP_usd	GDP (constant 2005 $)		LAC Equity Lab	GDP is the sum of gross value added by all res...	b'Wo Developm Indicators (Wo Ba
646	6.0.GDPpc_constant	GDP per capita, PPP (constant 2011 internation...		LAC Equity Lab	GDP per capita based on purchasing power parit...	b'Wo Developm Indicators (Wo Ba
...	...	...	...	...	...	
13449	UIS.XUNIT.GDPCAP.23.FSGOV	Initial government funding per secondary stude...		Education Statistics		
13450	UIS.XUNIT.GDPCAP.23.FSHH	Initial household funding per secondary studen...		Education Statistics		
13451	UIS.XUNIT.GDPCAP.3.FSGOV	Initial government funding per upper secondary...		Education Statistics	Average total (current, capital and transfers)...	b'UNESCO Instit for Statist
13452	UIS.XUNIT.GDPCAP.5T8.FSGOV	Initial government funding per tertiary studen...		Education Statistics		
13453	UIS.XUNIT.GDPCAP.5T8.FSHH	Initial household funding per tertiary student...		Education Statistics		

494 rows × 7 columns

In [53]:

```
data = wb.download(indicator='6.0.GDP_usd',  start=1995, end=2010)
```

In [54]:

```
data
```

Out[54]:

		6.0.GDP_usd
country	year	
Mexico	2010	9.534405e+11
	2009	9.063198e+11
	2008	9.514536e+11
	2007	9.385028e+11
	2006	9.091831e+11
	2005	8.663465e+11
	2004	8.408472e+11
	2003	8.062145e+11
	2002	7.949056e+11
	2001	7.938584e+11
	2000	7.986944e+11

Historical data — Moscow Exchange

In [55]:

```
from pandas_datareader import data
f = data.DataReader('USD000UTSTOM', 'moex', start='2017-07-01', end='2017-07-31')
f.head()
```

Out[55]:

	BOARDID	SHORTNAME	SECID	OPEN	LOW	HIGH	CLOSE	NUM
TRADEDATE								
2017-07-03	CNGD	USDRUB_TOM	USD000UTSTOM	58.98	58.840	59.4250	59.3600	
2017-07-04	CETS	USDRUB_TOM	USD000UTSTOM	59.30	59.135	59.4575	59.4125	
2017-07-04	CNGD	USDRUB_TOM	USD000UTSTOM	59.36	58.930	59.3600	59.3575	
2017-07-05	CETS	USDRUB_TOM	USD000UTSTOM	59.30	59.300	60.2600	59.9825	
2017-07-05	CNGD	USDRUB_TOM	USD000UTSTOM	59.34	59.265	60.1800	60.1800	

9. Selecting DataFrame with DataTimeIndex

Let's use the data from Moscow Exchange.

In [56]:

```
from pandas_datareader import data
gdp = data.DataReader('GDP', 'fred', start="1990-01-01", end="2018-12-01")
gdp.head()
```

Out[56]:

	GDP
DATE	
1990-01-01	5872.701
1990-04-01	5960.028
1990-07-01	6015.116
1990-10-01	6004.733
1991-01-01	6035.178

Extracting specific data/row

In [57]:

```
gdp.loc["1990-01-01"]
```

Out[57]:

```
GDP    5872.701
Name: 1990-01-01 00:00:00, dtype: float64
```

Extracting a range of data

In [58]:

```
gdp.loc["1998-01-01" : "2011-04-01"]
```

Out[58]:

	GDP
DATE	
1998-01-01	8866.480
1998-04-01	8969.699
1998-07-01	9121.097
1998-10-01	9293.991
1999-01-01	9417.264
1999-04-01	9524.152
1999-07-01	9681.856
1999-10-01	9899.378
2000-01-01	10002.857
2000-04-01	10247.679
2000-07-01	10319.825
2000-10-01	10439.025
2001-01-01	10472.879
2001-04-01	10597.822
2001-07-01	10596.294
2001-10-01	10660.294
2002-01-01	10788.952
2002-04-01	10893.207
2002-07-01	10992.051
2002-10-01	11071.463
2003-01-01	11183.507
2003-04-01	11312.875
2003-07-01	11567.326
2003-10-01	11769.275
2004-01-01	11920.169
2004-04-01	12108.987
2004-07-01	12303.340
2004-10-01	12522.425
2005-01-01	12761.337
2005-04-01	12910.022
2005-07-01	13142.873
2005-10-01	13332.316
2006-01-01	13603.933

	GDP
DATE	
2006-04-01	13749.806
2006-07-01	13867.469
2006-10-01	14037.228
2007-01-01	14208.569
2007-04-01	14382.363
2007-07-01	14535.003
2007-10-01	14681.501
2008-01-01	14651.039
2008-04-01	14805.611
2008-07-01	14835.187
2008-10-01	14559.543
2009-01-01	14394.547
2009-04-01	14352.850
2009-07-01	14420.312
2009-10-01	14628.021
2010-01-01	14721.350
2010-04-01	14926.098
2010-07-01	15079.917
2010-10-01	15240.843
2011-01-01	15285.828
2011-04-01	15496.189

Extract only data in 1 April

- First, we have to create a data range.
- Then, we need to compare the date using isin() method which will return a list of Boolean values.
- Use the Booleans list to extract the specific rows.

In [59]:

```
dates =  pd.date_range(start="1998-04-01", end="2017-04-01", freq=pd.DateOffset(years = 1))
dates
```

Out[59]:

```
DatetimeIndex(['1998-04-01', '1999-04-01', '2000-04-01', '2001-04-01',
               '2002-04-01', '2003-04-01', '2004-04-01', '2005-04-01',
               '2006-04-01', '2007-04-01', '2008-04-01', '2009-04-01',
               '2010-04-01', '2011-04-01', '2012-04-01', '2013-04-01',
               '2014-04-01', '2015-04-01', '2016-04-01', '2017-04-01'],
              dtype='datetime64[ns]', freq='<DateOffset: years=1>')
```

In [60]:

```
mask = gdp.index.isin(dates)
mask
```

Out[60]:

```
array([False, False, False, False, False, False, False, False, False,
       False, False, False, False, False, False, False, False, False,
       False, False, False, False, False, False, False, False, False,
       False, False, False, False, False, False,  True, False, False,
       False,  True, False, False, False,  True, False, False, False,
        True, False, False, False,  True, False, False, False,  True,
       False, False, False,  True, False, False, False,  True, False,
       False, False,  True, False, False, False,  True, False, False,
       False,  True, False, False, False,  True, False, False, False,
        True, False, False, False,  True, False, False, False,  True,
       False, False, False,  True, False, False, False,  True, False,
       False, False,  True, False, False, False,  True, False, False,
       False,  True, False, False, False, False, False, False])
```

In [61]:

```
gdp[mask]
```

Out[61]:

	GDP
DATE	
1998-04-01	8969.699
1999-04-01	9524.152
2000-04-01	10247.679
2001-04-01	10597.822
2002-04-01	10893.207
2003-04-01	11312.875
2004-04-01	12108.987
2005-04-01	12910.022
2006-04-01	13749.806
2007-04-01	14382.363
2008-04-01	14805.611
2009-04-01	14352.850
2010-04-01	14926.098
2011-04-01	15496.189
2012-04-01	16152.257
2013-04-01	16637.926
2014-04-01	17432.909
2015-04-01	18219.405
2016-04-01	18637.253
2017-04-01	19356.649

10. Timestamp Object Attributes

We will be using the GDP Datasets from FRED.

- Previously, we have learned about Timestamp attributes.
- Let's see how those attributes can help us understand the date more.

In [62]:

```
from pandas_datareader import data
gdp = data.DataReader('GDP', 'fred', start="1990-01-01", end="2018-12-01")
gdp.head()
```

Out[62]:

	GDP
DATE	
1990-01-01	5872.701
1990-04-01	5960.028
1990-07-01	6015.116
1990-10-01	6004.733
1991-01-01	6035.178

In [63]:

```
someday = gdp.index[100]
someday
```

Out[63]:

```
Timestamp('2015-01-01 00:00:00')
```

In [64]:

```
someday.day_name()
```

Out[64]:

```
'Thursday'
```

In [65]:

```
someday.is_quarter_start
```

Out[65]:

```
True
```

In [66]:

```
someday.is_year_start
```

Out[66]:

```
True
```

We can create a new column to indicate the day of the date

In [67]:

```
gdp.insert(loc=0, column="Day of Date" , value=gdp.index.day_name())
```

In [68]:

```
gdp.head()
```

Out[68]:

DATE	Day of Date	GDP
1990-01-01	Monday	5872.701
1990-04-01	Sunday	5960.028
1990-07-01	Sunday	6015.116
1990-10-01	Monday	6004.733
1991-01-01	Tuesday	6035.178

We can create a new column to check whether the date is on the start of the year.

In [69]:

```
gdp.insert(loc=1, column="Is Year Start", value=gdp.index.is_year_start)
```

In [70]:

```
gdp.head()
```

Out[70]:

DATE	Day of Date	Is Year Start	GDP
1990-01-01	Monday	True	5872.701
1990-04-01	Sunday	False	5960.028
1990-07-01	Sunday	False	6015.116
1990-10-01	Monday	False	6004.733
1991-01-01	Tuesday	True	6035.178

11 .truncate() method

Works like slicing with loc[ ] and iloc[ ].

In [71]:

```
gdp.head()
```

Out[71]:

	Day of Date	Is Year Start	GDP
DATE			
1990-01-01	Monday	True	5872.701
1990-04-01	Sunday	False	5960.028
1990-07-01	Sunday	False	6015.116
1990-10-01	Monday	False	6004.733
1991-01-01	Tuesday	True	6035.178

The difference between the slicing technique using loc[ ] or iloc[ ] is that, it finds the nearest value with the *after* date. On the other hand, if we place the value in loc[ ] incorrectly, it will prompt error.

In [72]:

```
gdp.truncate(before="1998-01-01", after="1998-08-01")
```

Out[72]:

	Day of Date	Is Year Start	GDP
DATE			
1998-01-01	Thursday	True	8866.480
1998-04-01	Wednesday	False	8969.699
1998-07-01	Wednesday	False	9121.097

12. pd.DateOffSet() object

- Manipulate date object to perform addition or subtraction on dates.
- These operations can be used for hours, days, weeks, months and year.

For example, if we want to add a day from 12 July 1998. This method will not work.

In [73]:

```
pd.Timestamp("12 July 1998") + 1
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-73-8a65837f4538> in <module>
----> 1 pd.Timestamp("12 July 1998") + 1

pandas\_libs\tslibs\c_timestamp.pyx in pandas._libs.tslibs.c_timestamp._Time
stamp.__add__()

ValueError: Cannot add integral value to Timestamp without freq.
```

To do an addition operation, we need to use **pd.DateOffset() method**. We can specify the arguments according to what we want.

In [74]:

```
pd.Timestamp("12 July 2019")  + pd.DateOffset(months = 1, years = 1)
```

Out[74]:

```
Timestamp('2020-08-12 00:00:00')
```

We can also apply this technique in Pandas DataFrame.

Hint : dt.datetime.now() will return today's date. It is useful when we want to set the endpoint to the current date.

In [75]:

```
from pandas_datareader import data
import datetime as dt
gdp = data.DataReader('GDP', 'fred', start="1990-01-01", end=dt.datetime.now())
gdp.head()
```

Out[75]:

	GDP
DATE	
1990-01-01	5872.701
1990-04-01	5960.028
1990-07-01	6015.116
1990-10-01	6004.733
1991-01-01	6035.178

The first row of the dataFrame is 1st Jan 1990. If we do an addition of 1 month on all indexes, each of them will receive an increment of 1 month.

In [76]:

```
gdp.index + pd.DateOffset(months = 1)
```

Out[76]:

```
DatetimeIndex(['1990-02-01', '1990-05-01', '1990-08-01', '1990-11-01',
               '1991-02-01', '1991-05-01', '1991-08-01', '1991-11-01',
               '1992-02-01', '1992-05-01',
               ...
               '2017-05-01', '2017-08-01', '2017-11-01', '2018-02-01',
               '2018-05-01', '2018-08-01', '2018-11-01', '2019-02-01',
               '2019-05-01', '2019-08-01'],
              dtype='datetime64[ns]', name='DATE', length=119, freq='QS-NO
V')
```

Complex operation on Datetime

- We have learnt how to do addition and subtraction on a specific day.
- What if we want to round off the date to the begining or end of a Month? Every month has different number of days.
- Pandas has tseries library to handle this kind of cases.

Next Months End

In [77]:

```
pd.Timestamp("12 July 1998") + pd.tseries.offsets.MonthEnd()
```

Out[77]:

```
Timestamp('1998-07-31 00:00:00')
```

Next Month Begin

In [78]:

```
pd.Timestamp("12 July 1998") + pd.tseries.offsets.MonthBegin()
```

Out[78]:

```
Timestamp('1998-08-01 00:00:00')
```

Last Month End

In [79]:

```
pd.Timestamp("12 July 1998") - pd.tseries.offsets.MonthEnd()
```

Out[79]:

```
Timestamp('1998-06-30 00:00:00')
```

Last Month Begin

In [80]:

```
pd.Timestamp("12 July 1998") - pd.tseries.offsets.MonthBegin()
```

Out[80]:

```
Timestamp('1998-07-01 00:00:00')
```

To make the code shorter, we can directly import **pd.tseries.offsets**

In [81]:

```
from pandas.tseries.offsets import *
```

In [82]:

```
pd.Timestamp("12 July 1998") - MonthBegin()
```

Out[82]:

```
Timestamp('1998-07-01 00:00:00')
```

Round off the value to the nearest Year Quarter . Since July is in 3rd Quarter, the end of the Q3 is 30th September.

In [83]:

```
pd.Timestamp("12 July 1998") + QuarterEnd()
```

Out[83]:

```
Timestamp('1998-09-30 00:00:00')
```

In [84]:

```
pd.Timestamp("12 July 1998") - QuarterEnd()
```

Out[84]:

```
Timestamp('1998-06-30 00:00:00')
```

In [85]:

```
pd.Timestamp("12 July 1998") + QuarterBegin()
```

Out[85]:

```
Timestamp('1998-09-01 00:00:00')
```

13. Timedelta Object

Duration or distance of time.

In [86]:

```
timeA = pd.Timestamp("12 July 1998")
timeB = pd.Timestamp("22 July 1998")
```

In [87]:

```
timeB - timeA
```

Out[87]:

```
Timedelta('10 days 00:00:00')
```

We can also create Timedelta objects using **parameter or string**

In [88]:

```
pd.Timedelta(days = 10)
```

Out[88]:

```
Timedelta('10 days 00:00:00')
```

We can do operations with Timedelta Objects just like pd.DateOffset. However, in pd.Timedelta, years parameter does not exist.

In [89]:

```
timeA + pd.Timedelta(days = 10)
```

Out[89]:

```
Timestamp('1998-07-22 00:00:00')
```

In [90]:

```
pd.Timedelta("12 days 6 hours 50 minutes 37 seconds")
```

Out[90]:

```
Timedelta('12 days 06:50:37')
```

14. Timedelta in DataFrame

In [91]:

```
shipping = pd.read_csv("data/ecommerce.csv", index_col="ID" , parse_dates=["order_date","de
shipping.head()
```

Out[91]:

	order_date	delivery_date
ID		
1	1998-05-24	1999-02-05
2	1992-04-22	1998-03-06
4	1991-02-10	1992-08-26
5	1992-07-21	1997-11-20
7	1993-09-02	1998-06-10

Now, let's calculate the difference in order date and delivery date.

In [92]:

```
shipping["Delivery Time"] = shipping["delivery_date"] - shipping["order_date"]
shipping.head()
```

Out[92]:

ID	order_date	delivery_date	Delivery Time
1	1998-05-24	1999-02-05	257 days
2	1992-04-22	1998-03-06	2144 days
4	1991-02-10	1992-08-26	563 days
5	1992-07-21	1997-11-20	1948 days
7	1993-09-02	1998-06-10	1742 days

As we can see, the type of our new column is **Timedelta**

In [93]:

```
shipping.dtypes
```

Out[93]:

```
order_date        datetime64[ns]
delivery_date     datetime64[ns]
Delivery Time    timedelta64[ns]
dtype: object
```