Indexing time series

PANDAS FOUNDATIONS

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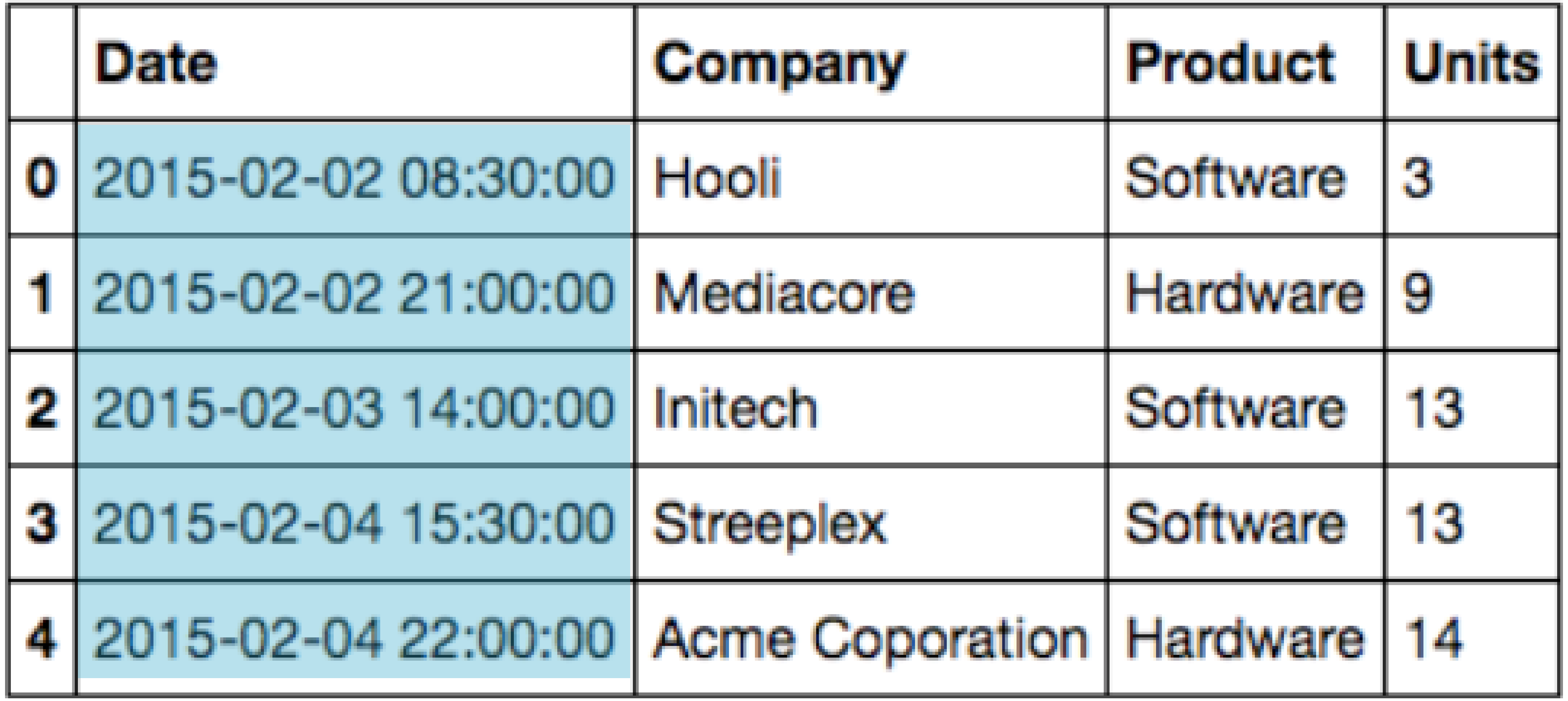
Using pandas to read datetime objects

- read_csv() function
  - Can read strings into datetime objects
  - Need to specify 'parse_dates=True'
- ISO 8601 format
  - yyyy-mm-dd hh:mm:ss

Product sales CSV



	Date	Company	Product	Units
0	2015-02-02 08:30:00	Hooli	Software	3
1	2015-02-02 21:00:00	Mediacore	Hardware	9
2	2015-02-03 14:00:00	Initech	Software	13
3	2015-02-04 15:30:00	Streeplex	Software	13
4	2015-02-04 22:00:00	Acme Coporation	Hardware	14

Parse dates

```
import pandas as pd
sales = pd.read_csv('sales-feb-2015.csv',
                        parse_dates=True, index_col= 'Date')
```

parse all compatible columns as datetime objects

Parse dates

```
sales.head()
```

```
                             Company   Product  Units
Date
2015-02-02 08:30:00            Hooli  Software      3
2015-02-02 21:00:00        Mediacore  Hardware      9
2015-02-03 14:00:00          Initech  Software     13
2015-02-04 15:30:00        Streeplex  Software     13
2015-02-04 22:00:00  Acme Coporation  Hardware     14
```

Parse dates

```
sales.info()
```

```
DatetimeIndex: 19 entries, 2015-02-02 08:30:00 to 2015-02-26 09:00:00
Data columns (total 3 columns):
Company    19 non-null object
Product    19 non-null object
Units      19 non-null int64
dtypes: int64(1), object(2)
memory usage: 608.0+ bytes
```

Selecting single datetime

```
sales.loc['2015-02-19 11:00:00', 'Company']
```

```
‘Mediacore’
```

Selecting whole day

```
sales.loc['2015-2-5']
```

```
                                Company   Product  Units
Date
2015-02-05 02:00:00  Acme Coporation  Software     19
2015-02-05 22:00:00            Hooli   Service     10
```

Partial datetime string selection

- Alternative formats:
  - sales.loc[‘February 5, 2015’]
  - sales.loc[‘2015-Feb-5’]
- Whole month: sales.loc[‘2015-2’]
- Whole year: sales.loc[‘2015’]

Selecting whole month

```
sales.loc['2015-2']
```

```
                              Company   Product  Units
Date
2015-02-02 08:30:00             Hooli  Software      3
2015-02-02 21:00:00         Mediacore  Hardware      9
2015-02-03 14:00:00           Initech  Software     13
2015-02-04 15:30:00         Streeplex  Software     13
2015-02-04 22:00:00  Acme Coporation  Hardware     14
2015-02-05 02:00:00  Acme Coporation  Software     19
2015-02-05 22:00:00             Hooli   Service     10
2015-02-07 23:00:00  Acme Coporation  Hardware      1
2015-02-09 09:00:00         Streeplex   Service     19
2015-02-09 13:00:00         Mediacore  Software      7
2015-02-11 20:00:00           Initech  Software      7
2015-02-11 23:00:00             Hooli  Software      4
2015-02-16 12:00:00             Hooli  Software     10
2015-02-19 11:00:00         Mediacore  Hardware     16
...
```

Slicing using dates/times

```
sales.loc['2015-2-16':'2015-2-20']
```

```
                       Company   Product  Units
Date
2015-02-16 12:00:00      Hooli  Software     10
2015-02-19 11:00:00  Mediacore  Hardware     16
2015-02-19 16:00:00  Mediacore   Service     10
```

Convert strings to datetime

```
evening_2_11 = pd.to_datetime(['2015-2-11 20:00',
    '2015-2-11 21:00', '2015-2-11 22:00', '2015-2-11 23:00'])
evening_2_11
```

```
DatetimeIndex(['2015-02-11 20:00:00', '2015-02-11 21:00:00',
               '2015-02-11 22:00:00', '2015-02-11 23:00:00'],
              dtype='datetime64[ns]', freq=None)
```

Reindexing DataFrame

```
sales.reindex(evening_2_11)
```

Reindexing involves providing a new index and matching data as required. Here, the reindex method returns a new DataFrame with the four rows corresponding to the times in evening_2_11.

```
                     Company   Product  Units
2015-02-11 20:00:00  Initech  Software    7.0
2015-02-11 21:00:00      NaN       NaN    NaN
2015-02-11 22:00:00      NaN       NaN    NaN
2015-02-11 23:00:00    Hooli  Software    4.0
```

Filling missing values

```
sales.reindex(evening_2_11, method='ffill')
```

```
                     Company   Product  Units
2015-02-11 20:00:00  Initech  Software      7
2015-02-11 21:00:00  Initech  Software      7
2015-02-11 22:00:00  Initech  Software      7
2015-02-11 23:00:00    Hooli  Software      4
```

```
sales.reindex(evening_2_11, method='bfill')
```

```
                     Company   Product  Units
2015-02-11 20:00:00  Initech  Software      7
2015-02-11 21:00:00    Hooli  Software      4
2015-02-11 22:00:00    Hooli  Software      4
2015-02-11 23:00:00    Hooli  Software      4
```

Let's practice!

PANDAS FOUNDATIONS

Resampling time series data

PANDAS FOUNDATIONS

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Sales data

```python
import pandas as pd
sales = pd.read_csv('sales-feb-2015.csv',
                        parse_dates=True, index_col= 'Date'
sales.head()
```

```
                              Company   Product  Units
Date
2015-02-02 08:30:00             Hooli  Software      3
2015-02-02 21:00:00         Mediacore  Hardware      9
2015-02-03 14:00:00           Initech  Software     13
2015-02-04 15:30:00         Streeplex  Software     13
2015-02-04 22:00:00  Acme Coporation  Hardware     14
```

Resampling

- Statistical methods over different time intervals
  - mean(), sum(), count(), etc.
- Downsampling
  - reduce datetime rows to slower frequency
- Upsampling
  - increase datetime rows to faster frequency

Aggregating means

```
daily_mean = sales.resample('D').mean()
daily_mean
```

```
            Units
Date
2015-02-02    6.0
2015-02-03   13.0
2015-02-04   13.5
2015-02-05   14.5
2015-02-06    NaN
2015-02-07    1.0
2015-02-08    NaN
2015-02-09   13.0
2015-02-10    NaN
2015-02-11    5.5
2015-02-12    NaN
2015-02-13    NaN
2015-02-14    NaN
```

Verifying

```
print(daily_mean.loc['2015-2-2'])
```

```
Units    6.0
Name: 2015-02-02 00:00:00, dtype: float64
```

```
print(sales.loc['2015-2-2', 'Units'])
```

```
Date
2015-02-02 08:30:00    3
2015-02-02 21:00:00    9
Name: Units, dtype: int64
```

```
sales.loc['2015-2-2', 'Units'].mean()
```

```
6.0
```

Method chaining

```
sales.resample('D').sum()
```

```
            Units
Date
2015-02-02    6.0
2015-02-03   13.0
2015-02-04   13.5
2015-02-05   14.5
2015-02-06    NaN
2015-02-07    1.0
2015-02-08    NaN
2015-02-09   13.0
2015-02-10    NaN
2015-02-11    5.5
2015-02-12    NaN
2015-02-13    NaN
```

Method chaining

```
sales.resample('D').sum().max()
```

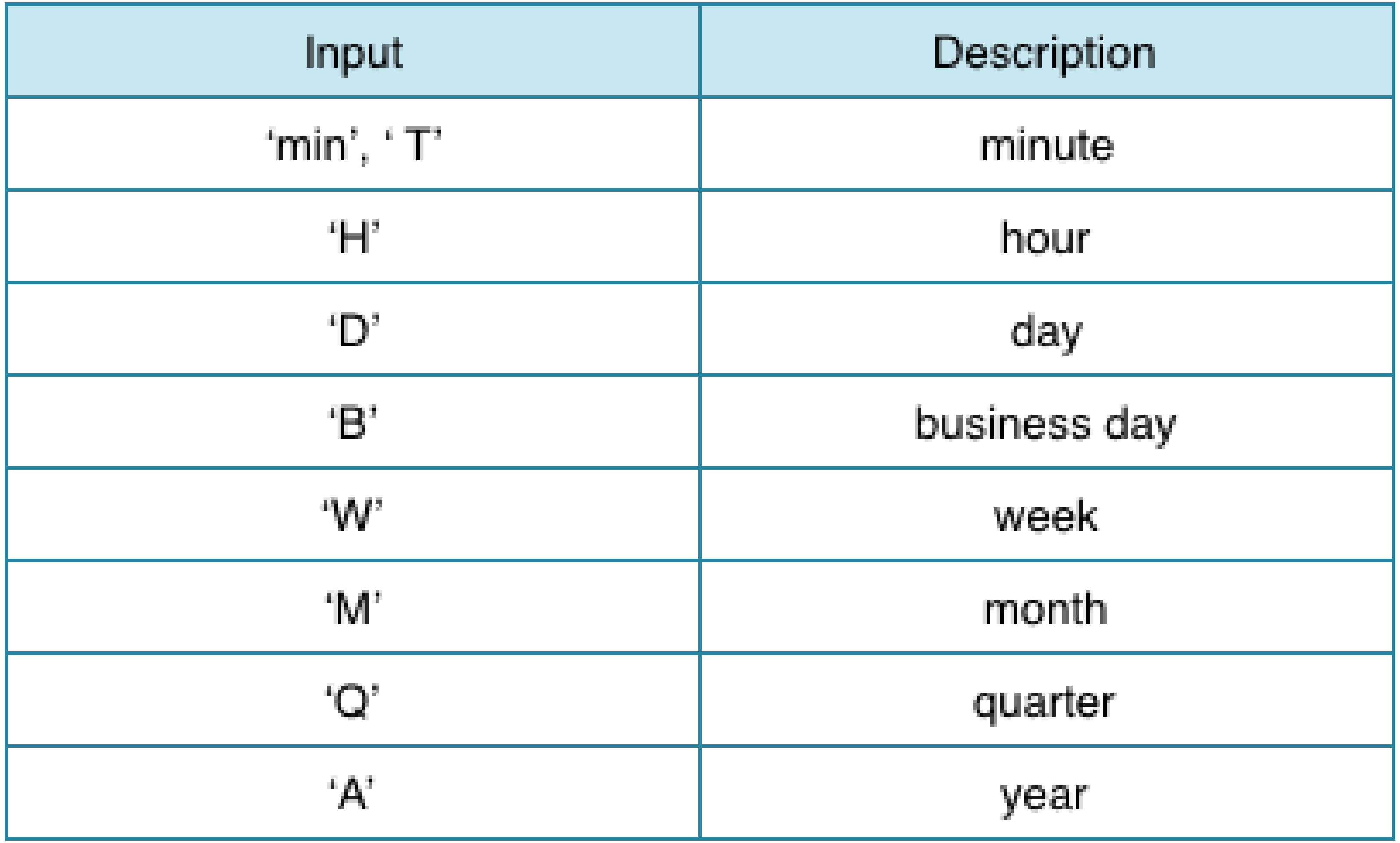
```
Units    29.0
dtype: float64
```

Resampling strings

```
sales.resample('W').count()
```

```
            Company  Product  Units
Date
2015-02-08        8        8      8
2015-02-15        4        4      4
2015-02-22        5        5      5
2015-03-01        2        2      2
```

Resampling frequencies



Input	Description
‘min’, ‘ T’	minute
‘H’	hour
‘D’	day
‘B’	business day
‘W’	week
‘M’	month
‘Q’	quarter
‘A’	year

Multiplying frequencies

```
sales.loc[:,'Units'].resample('2W').sum()
```

```
Date
2015-02-08    82
2015-02-22    79
2015-03-08    14
Freq: 2W-SUN, Name: Units, dtype: int64
```

Upsampling

```
two_days = sales.loc['2015-2-4': '2015-2-5', 'Units']
two_days
```

```
Date
2015-02-04 15:30:00    13
2015-02-04 22:00:00    14
2015-02-05 02:00:00    19
2015-02-05 22:00:00    10
Name: Units, dtype: int64
```

Upsampling and filling

```
two_days.resample('4H').ffill()
```

```
Date
Date
2015-02-04 12:00:00     NaN
2015-02-04 16:00:00    13.0
2015-02-04 20:00:00    13.0
2015-02-05 00:00:00    14.0
2015-02-05 04:00:00    19.0
2015-02-05 08:00:00    19.0
2015-02-05 12:00:00    19.0
2015-02-05 16:00:00    19.0
2015-02-05 20:00:00    19.0
Freq: 4H, Name: Units, dtype: float64
```

Let's practice!

PANDAS FOUNDATIONS

Manipulating time series data

PANDAS FOUNDATIONS

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Sales data

```python
import pandas as pd
sales = pd.read_csv('sales-feb-2015.csv',
                        parse_dates=['Date'])
sales.head()
```

```
                 Date          Company   Product  Units
0 2015-02-02 08:30:00            Hooli  Software      3
1 2015-02-02 21:00:00        Mediacore  Hardware      9
2 2015-02-03 14:00:00          Initech  Software     13
3 2015-02-04 15:30:00        Streeplex  Software     13
4 2015-02-04 22:00:00  Acme Coporation  Hardware     14
```

String methods

```
sales['Company'].str.upper()
```

```
0                HOOLI
1            MEDIACORE
2              INITECH
3            STREEPLEX
4      ACME COPORATION
5      ACME COPORATION
6                HOOLI
7      ACME COPORATION
8            STREEPLEX
9            MEDIACORE
10             INITECH
11               HOOLI
12               HOOLI
13           MEDIACORE
14           MEDIACORE
15           MEDIACORE
...
```

Substring matching

```
sales['Product'].str.contains('ware')
```

```
0      True
1      True
2      True
3      True
4      True
5      True
6     False
7      True
8     False
9      True
10     True
11     True
12     True
13     True
14    False
...
```

Boolean arithmetic

```
True + False
```

```
1
```

```
True + True
```

```
2
```

```
False + False
```

```
0
```

Boolean reduction

```
sales['Product'].str.contains('ware').sum()
```

```
14
```

Datetime methods

```
sales['Date'].dt.hour
```

```
0        8
1       21
2       14
3       15
4       22
5        2
6       22
7       23
8        9
9       13
10      20
11      23
12      12
13      11
14      16
...
```

Set timezone

```
central = sales['Date'].dt.tz_localize('US/Central')
central
```

```
0    2015-02-02 08:30:00-06:00
1    2015-02-02 21:00:00-06:00
2    2015-02-03 14:00:00-06:00
3    2015-02-04 15:30:00-06:00
4    2015-02-04 22:00:00-06:00
5    2015-02-05 02:00:00-06:00
6    2015-02-05 22:00:00-06:00
7    2015-02-07 23:00:00-06:00
8    2015-02-09 09:00:00-06:00
9    2015-02-09 13:00:00-06:00
10   2015-02-11 20:00:00-06:00
11   2015-02-11 23:00:00-06:00
12   2015-02-16 12:00:00-06:00
...
Name: Date, dtype: datetime64[ns, US/Central]
```

Convert timezone

```
central.dt.tz_convert('US/Eastern')
```

```
0    2015-02-02 09:30:00-05:00
1    2015-02-02 22:00:00-05:00
2    2015-02-03 15:00:00-05:00
3    2015-02-04 16:30:00-05:00
4    2015-02-04 23:00:00-05:00
5    2015-02-05 03:00:00-05:00
6    2015-02-05 23:00:00-05:00
7    2015-02-08 00:00:00-05:00
8    2015-02-09 10:00:00-05:00
9    2015-02-09 14:00:00-05:00
10   2015-02-11 21:00:00-05:00
11   2015-02-12 00:00:00-05:00
12   2015-02-16 13:00:00-05:00
13   2015-02-19 12:00:00-05:00
14   2015-02-19 17:00:00-05:00
...
Name: Date, dtype: datetime64[ns, US/Eastern]
```

Method chaining

```
sales['Date'].dt.tz_localize('US/Central').
     dt.tz_convert('US/Eastern')
```

```
0     2015-02-02 09:30:00-05:00
1     2015-02-02 22:00:00-05:00
2     2015-02-03 15:00:00-05:00
3     2015-02-04 16:30:00-05:00
4     2015-02-04 23:00:00-05:00
5     2015-02-05 03:00:00-05:00
6     2015-02-05 23:00:00-05:00
7     2015-02-08 00:00:00-05:00
8     2015-02-09 10:00:00-05:00
9     2015-02-09 14:00:00-05:00
10    2015-02-11 21:00:00-05:00
11    2015-02-12 00:00:00-05:00
12    2015-02-16 13:00:00-05:00
13    2015-02-19 12:00:00-05:00
14    2015-02-19 17:00:00-05:00
...
Name: Date, dtype: datetime64[ns, US/Eastern]
```

World Population

```
population = pd.read_csv('world_population.csv',
     parse_dates=True, index_col= 'Date')
population
```

```
              Population
Date
1960-12-31  2.087485e+10
1970-12-31  2.536513e+10
1980-12-31  3.057186e+10
1990-12-31  3.644928e+10
2000-12-31  4.228550e+10
2010-12-31  4.802217e+10
```

Upsample population

```
population.resample('A').first()
```

```
              Population
Date
1960-12-31  2.087485e+10
1961-12-31           NaN
1962-12-31           NaN
1963-12-31           NaN
1964-12-31           NaN
1965-12-31           NaN
1966-12-31           NaN
1967-12-31           NaN
1968-12-31           NaN
1969-12-31           NaN
1970-12-31  2.536513e+10
1971-12-31           NaN
1972-12-31           NaN
```

Interpolate missing data

```
population.resample('A').first().interpolate('linear')
```

```
              Population
Date
1960-12-31  2.087485e+10
1961-12-31  2.132388e+10
1962-12-31  2.177290e+10
1963-12-31  2.222193e+10
1964-12-31  2.267096e+10
1965-12-31  2.311999e+10
1966-12-31  2.356902e+10
1967-12-31  2.401805e+10
1968-12-31  2.446707e+10
1969-12-31  2.491610e+10
1970-12-31  2.536513e+10
1971-12-31  2.588580e+10
1972-12-31  2.640648e+10
```

Let's practice!

PANDAS FOUNDATIONS

Time series visualization

PANDAS FOUNDATIONS

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Topics

- Line types
- Plot types
- Subplots

S&P 500 Data

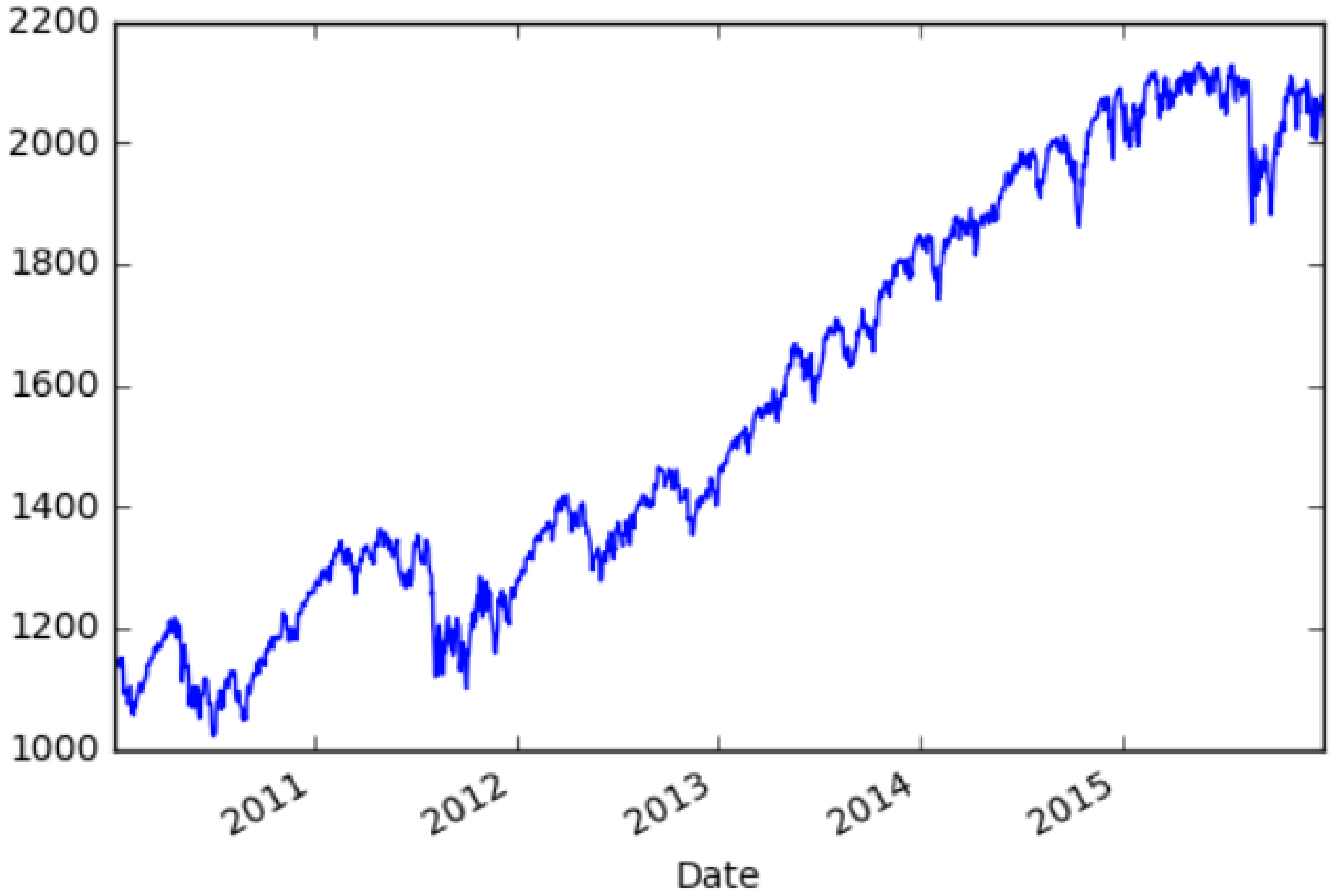
```
import pandas as pd
import matplotlib.pyplot as plt
sp500 = pd.read_csv('sp500.csv', parse_dates=True,
                        index_col= 'Date')
sp500.head()
```

```
                   Open         High          Low        Close      Volume    Adj Close
Date
2010-01-04  1116.560059  1133.869995  1116.560059  1132.989990  3991400000  1132.989990
2010-01-05  1132.660034  1136.630005  1129.660034  1136.520020  2491020000  1136.520020
2010-01-06  1135.709961  1139.189941  1133.949951  1137.140015  4972660000  1137.140015
2010-01-07  1136.270020  1142.459961  1131.319946  1141.689941  5270680000  1141.689941
2010-01-08  1140.520020  1145.390015  1136.219971  1144.979980  4389590000  1144.979980
```

Pandas plot

```
sp500['Close'].plot()
plt.show()
```

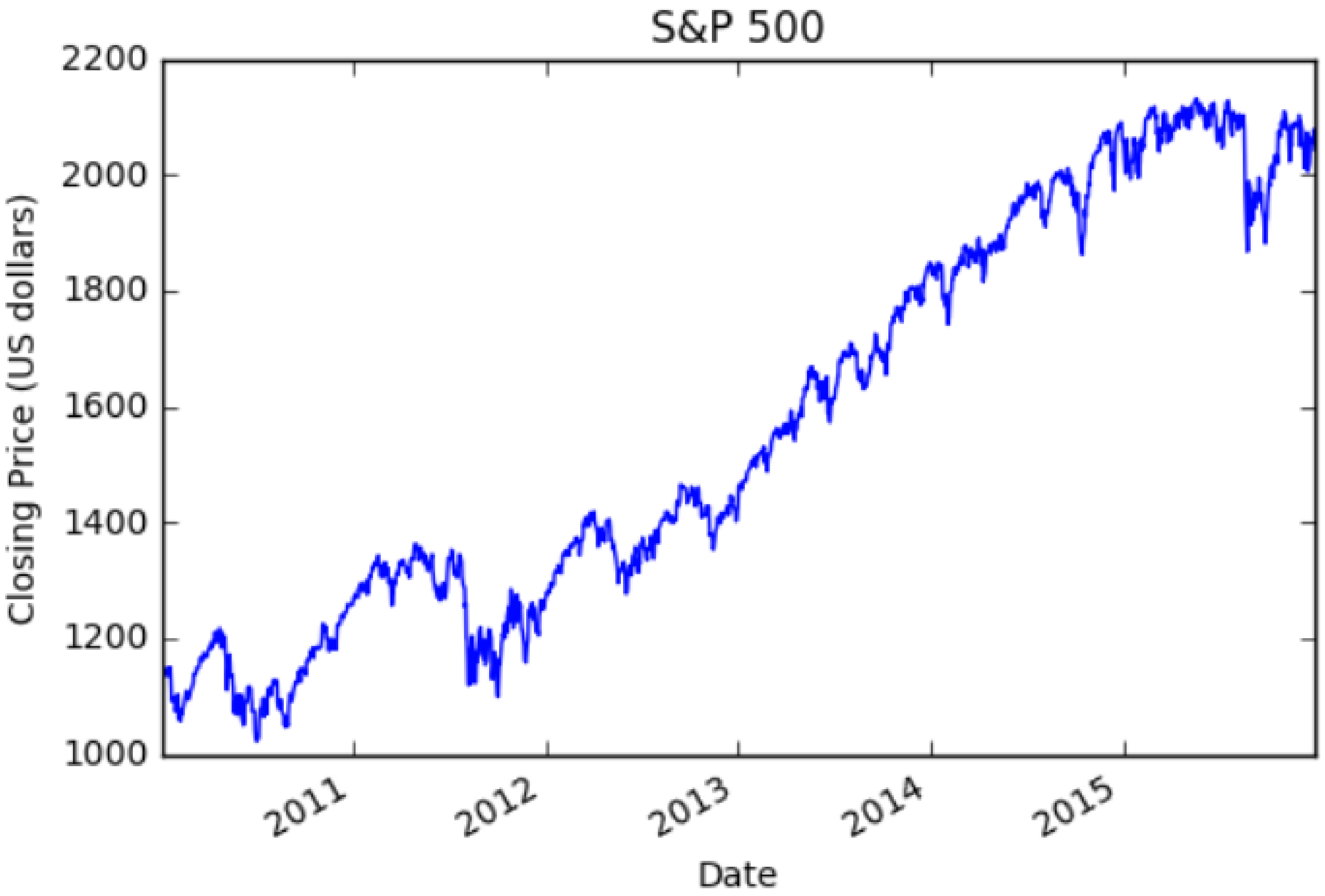
Default plot



Labels and title

```
sp500['Close'].plot(title='S&P 500')
plt.ylabel('Closing Price (US Dollars)')
plt.show()
```

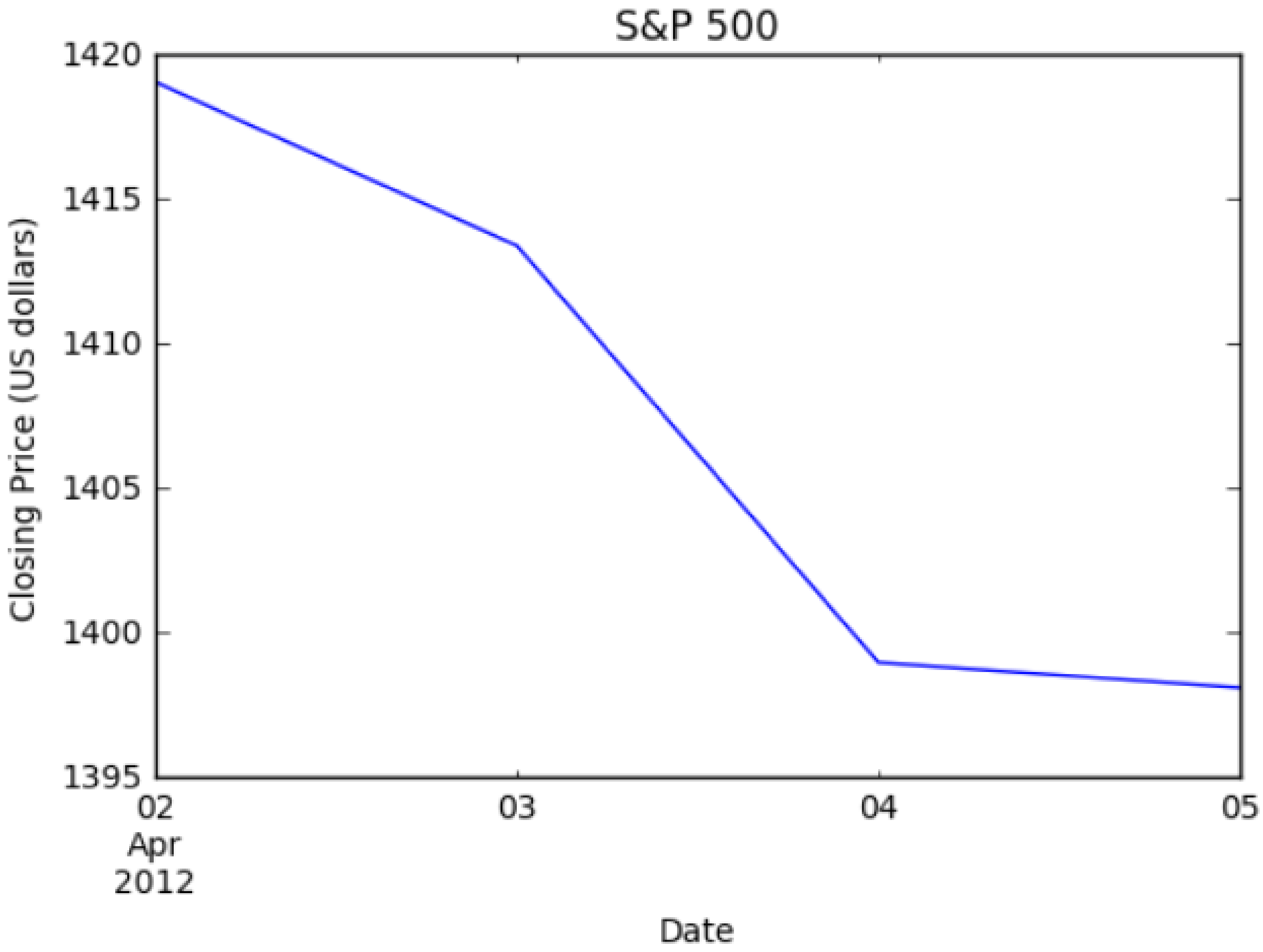
Labels and title



One week

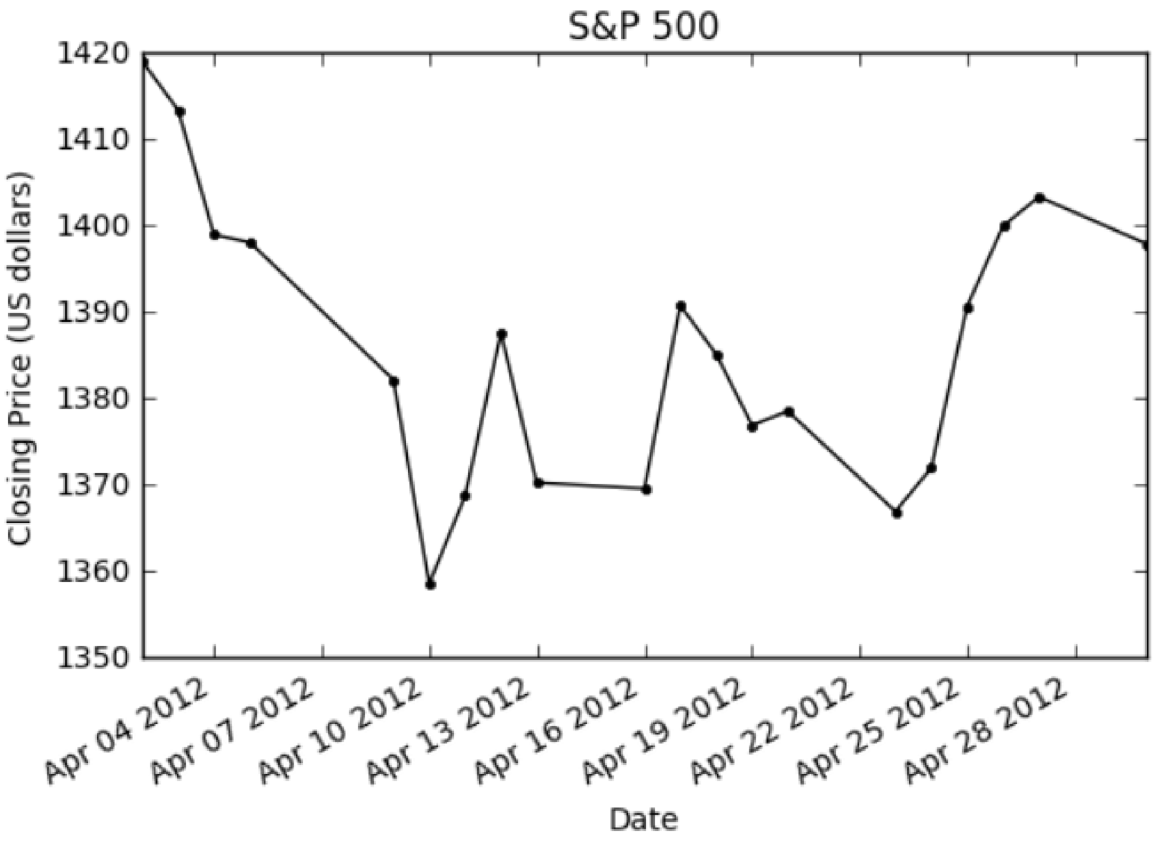
```
sp500.loc['2012-4-1':'2012-4-7', 'Close'].plot(title='S&P 500')
plt.ylabel('Closing Price (US Dollars)')
plt.show()
```

One week


S&P 500
1420
1415
1410
1405
1400
1395
Closing Price (US dollars)
02
Apr
2012
03
04
05
Date

Plot styles

```
sp500.loc['2012-4', 'Close'].plot(style='k.-',
                                  title='S&P500')
plt.ylabel('Closing Price (US Dollars)')
plt.show()
```



More plot styles

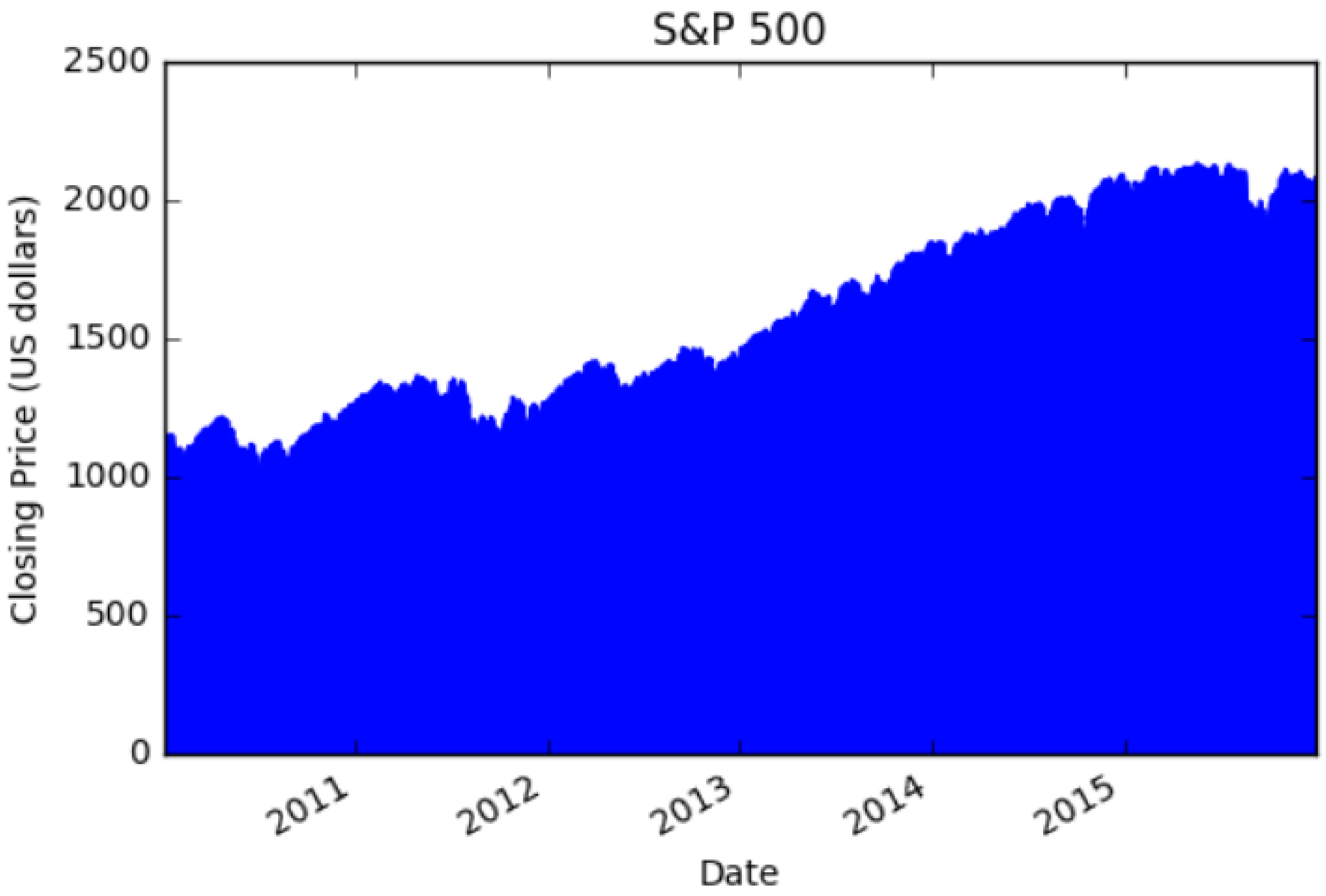
- Style format string
  - color (k: black)
  - marker (. : dot)
  - line type (-: solid)

More plot styles

Color	Marker	Line
b: blue	o: circle	: dotted
g: green	*: star	–: dashed
r: red	s: square	
c: cyan	+: plus	

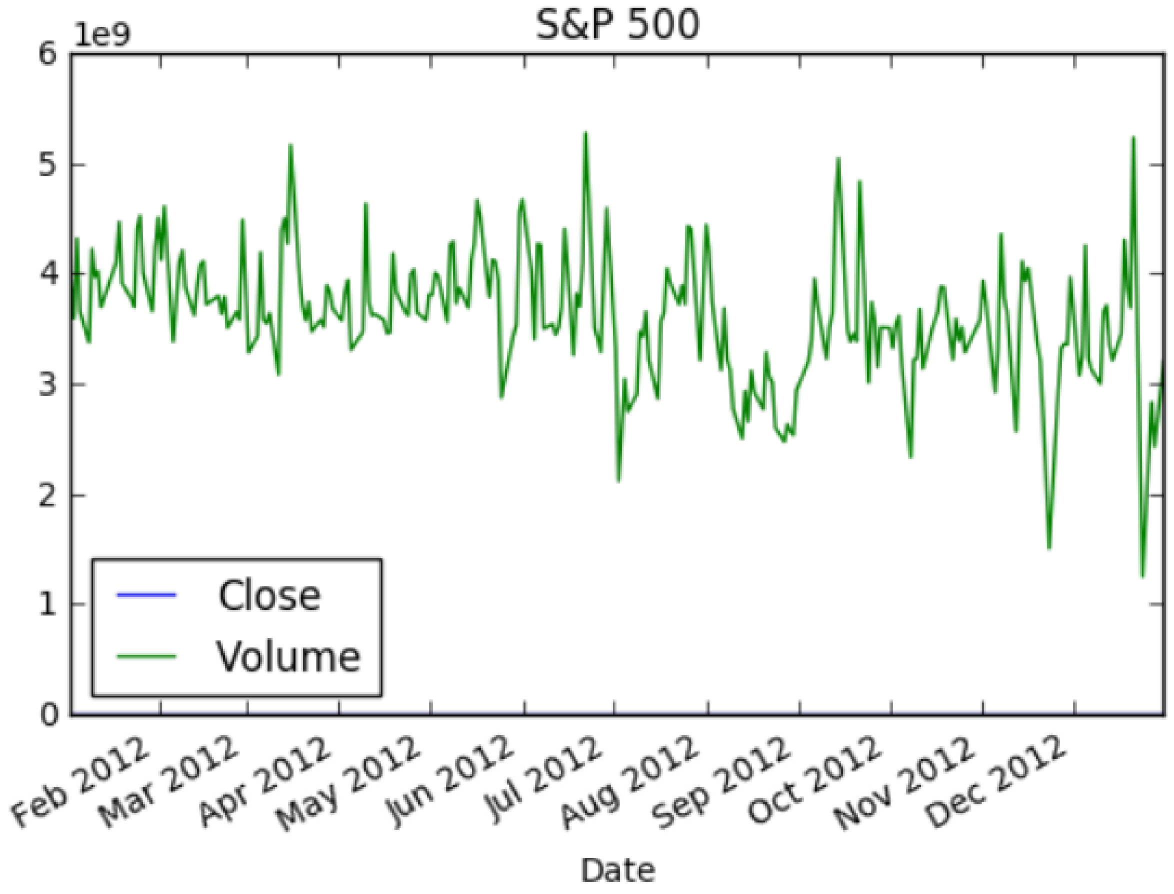
Area plot

```
sp500['Close'].plot(kind='area', title='S&P 500')
plt.ylabel('Closing Price (US Dollars)')
plt.show()
```



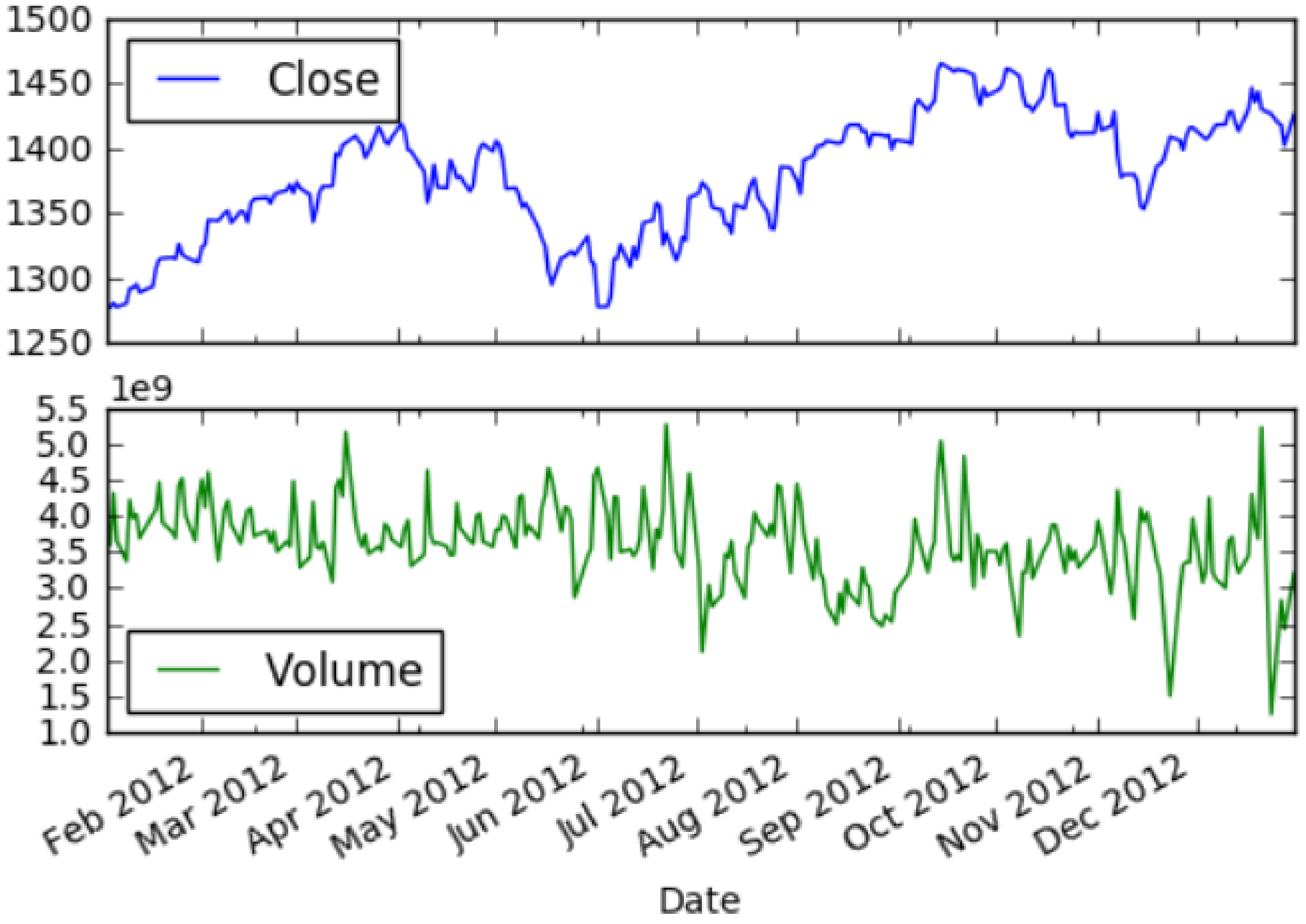
Multiple columns

```
sp500.loc['2012', ['Close','Volume']].plot(title='S&P
     500')
plt.show()
```



Subplots

```
sp500.loc['2012', ['Close','Volume']].plot(subplots=True)
plt.show()
```



Let's practice!

PANDAS FOUNDATIONS