Time Series

A brief overview of Time series

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Time Series

Date and Time Data types and tools

- Converting between Sting and Datetime

Time series basics

- Indexing, selection, subsetting
- Time series with duplicate indices

Data Ranges, Frequencies, and Shifting

- Generating Date Ranges
- Frequencies and Date offsets
- Shifting (Leading and Lagging) Data
- Shifting dates with offsets

Time Zone Handling

- Time zone Loacalization and Conversion
- Operations with Time Zone-Aware Timestamp Objects
- Operations between different time zones

Periods and Period Arithmetic

- period frequency conversion
- Quaterly period frequencies
- Converting timestamps to periods (and back)
- Creating a PeriodIndex from Arrays

Resampling and Frequency Conversion

- Donwsampling
- Open-high-low-close(OHLC) resampling
- Unsampling and Interpolation
- Resampling with periods
- Grouped time resampling

Moving window functions

- Exponentially weighted functions
- Binary moving window functions
- User-defined window functions

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

from datetime import datetime
```

```
## Data and Time Data Types and Tools

now = datetime.now()

now
```

```
now.year, now.month, now.day
```

```
delta = datetime(2011, 1, 7) - datetime(2008, 6, 3, 4, 1, 4)

delta
```

```
delta.days
```

```
delta.seconds
```

```
# add or subtract a timedelta to yield a new shifted object
```

```python
from datetime import timedelta

start = datetime(2024, 2, 28)

start + timedelta(12)
```

```python
start - 2 * timedelta(12)
```

```python
help(datetime)
```

```python
### Converting between String and DateFrame

stamp = datetime(2024, 1, 30)

str(stamp)
```

```python
stamp.strftime("%Y-%m-%d")
```

```python
value = '2024-2-28'
datetime.strptime(value, '%Y-%m-%d')
```

```python
datestrs = ["2/23/2024", "2/28/2024"]

[datetime.strptime(x, "%m/%d/%Y") for x in datestrs]
```

```python
# using pandas
datestrs = ["2024-2-23 12:00:00", "2024-2-28 00:00:00"]
```

```python
pd.to_datetime(datestrs)
```

```python
idx = pd.to_datetime(datestrs+ [None])
```

```python
idx
```

```python
idx[2]
```

```
pd.isna(idx)
```

Time series basics

```
dates = [datetime(2024,2,23), datetime(2024,2,24),
        datetime(2024,2,25), datetime(2024,2,26),
        datetime(2024,2,27), datetime(2024,2,28)]
```

```
ts = pd.Series(np.random.standard_normal(6),
              index = dates)
```

```
ts
```

```
ts.index
```

```
ts + ts[::2]
```

```
ts.index.dtype
```

```
stamp = ts.index[0]
```

```
stamp
```

Indexing, Selection, Subsetting

```
stamp = ts.index[2]
```

```
ts[stamp]
```

```
stamp
```

```
ts["2024-02-25"]
```

```
longer_ts = pd.Series(np.random.standard_normal(1000),
                     index = pd.date_range("2000-01-01",
                                           periods=1000))
```

```
longer_ts
```

```
longer_ts["2001"]
```

```
longer_ts["2001-05"]
```

```
# slicing with datatime objects works aswell

ts[datetime(2011,1,7):]
```

```
ts.truncate(after="2001-01-09")
```

```
# for DataFrame
dates_df = pd.date_range("2024-01-01",
                          periods=100,
                         freq= "W-WED")
```

```
long_df = pd.DataFrame(np.random.standard_normal((6, 4)),
                       index = dates,
                       columns = ['Colorado', 'Texas',
                                  'New York', "Ohio"])
```

```
long_df.loc["2011-05-01"]
```

Time series with duplicate indices

```
dates = pd.DatetimeIndex(["2017-12-03", "2018-11-06", "2019-11-06",
                          "2021-01-28", "2022-09-06"])

dup_ts = pd.Series(np.arange(5), index=dates)
```

```
dup_ts
```

```
# checking if the index is unique
dup_ts.index.is_unique
```

```
# unique indexes can be grouped
grouped = dup_ts.groupby(level=0)
```

```
grouped.mean()
```

```
grouped.count()
```

Data Ranges, Frequencies, and Shifting

```
ts
```

```
resampler = ts.resample("D")
```

```
resampler
```

Generating date ranges

- shortcut details

```
index = pd.date_range("2012-04-01", "2012-06-01")
index
```

```
pd.date_range(start="2024-04-01", periods=20)
```

```
pd.date_range(end="2024-03-24", periods=20)
```

```
pd.date_range("2000-01-01", '2000-12-01', freq="BM")
```

Frequencies and date offsets

```
from pandas.tseries.offsets import Hour, Minute
```

```
hour = Hour()
```

```
hour
```

```
four_hours = Hour(4)
```

```
four_hours
```

```
# combined addition
Hour(2) + Minute(30)
```

```
pd.date_range("2023-05-01", periods = 10, freq='1h30min')
```

```
# week of month dates
monthly_dates = pd.date_range("2012-01-01", "2012-09-01",
                              freq="WOM-3FRI")
list(monthly_dates)
```

Shifting (Leading and Lagging Data)

- moving backward and forward through time

```
ts = pd.Series(np.random.standard_normal(4),
               index=pd.date_range("2022-01-01", periods=4,
                                   freq="M"))
ts
```

```
ts.shift(2)
```

```
ts.shift(-2)
```

```
ts/ts.shift(1)-1
```

```
ts.shift(2, freq="M")
```

```
# groupby
ts = pd.Series(np.random.standard_normal(20),
              index=pd.date_range("2024-10-02",
                                  periods=20, freq="4D"))
```

```
ts
```

```
ts.groupby(MonthEnd().rollfoward).mean()
```

```
ts.resample("M").mean()
```

```
2024-10-31    0.076767
2024-11-30   -0.177065
2024-12-31    0.635081
Freq: M, dtype: float64
```

Time Zone handling

```
import pytz

pytz.common_timezones[-5:]
```

```
['US/Eastern', 'US/Hawaii', 'US/Mountain', 'US/Pacific', 'UTC']
```

```
# to get timezones, use pytz.timezone

tz = pytz.timezone("America/New_York")

tz
```

```
<DstTzInfo 'America/New_York' LMT-1 day, 19:04:00 STD>
```

```
### Time zone localization and conversion
dates = pd.date_range("2021-11-17 09:30", periods=6)
```

```
ts = pd.Series(np.random.standard_normal(len(dates)),
              index = dates)
```

```
ts
```

```
2021-11-17 09:30:00    0.808643
2021-11-18 09:30:00    1.435830
2021-11-19 09:30:00    0.764818
2021-11-20 09:30:00    0.345263
2021-11-21 09:30:00   -0.671032
2021-11-22 09:30:00    0.694027
Freq: D, dtype: float64
```

```
print(ts.index.tz)
```

```
None
```

```
# Dates from timezone set
pd.date_range("2023-3-01", periods=10, tz="UTC")
```

```
DatetimeIndex(['2023-03-01 00:00:00+00:00', '2023-03-02 00:00:00+00:00',
               '2023-03-03 00:00:00+00:00', '2023-03-04 00:00:00+00:00',
               '2023-03-05 00:00:00+00:00', '2023-03-06 00:00:00+00:00',
               '2023-03-07 00:00:00+00:00', '2023-03-08 00:00:00+00:00',
               '2023-03-09 00:00:00+00:00', '2023-03-10 00:00:00+00:00'],
              dtype='datetime64[ns, UTC]', freq='D')
```

Periods and Period Arithmetic

```
pd.Series(np.random.standard_normal(6),
       )
```

```
0    0.434382
1    1.383303
2    0.975721
3   -1.377090
4    0.659404
5    1.098894
dtype: float64
```

```
values= ["2001Q3", "20022Q2", '20033Q1']
```

```
periods = pd.period_range("2000-01-01", "2000-06-30",
                          freq="M")
```

```
index = pd.PeriodIndex(values, freq="Q-Dec")
```

```
p = pd.Period("2011", freq= "A-Jun")
```

```
p
```

```
Period('2011', 'A-JUN')
```

```
p.asfreq("M", how='start')
```

```
Period('2010-07', 'M')
```

```
p.asfreq("M", how="end")
```

```
Period('2011-06', 'M')
```

```
# period index
periods = pd.period_range("2006", "2009",
                          freq="A-Dec")
```

```
ts= pd.Series(np.random.standard_normal
             (len(periods)), index= periods)
```

```
ts
```

```
2006    1.079865
2007   -1.891582
2008   -0.634198
2009    0.155782
Freq: A-DEC, dtype: float64
```

```
ts.asfreq("M", how='start')
```

```
2006-01    1.079865
2007-01   -1.891582
2008-01   -0.634198
2009-01    0.155782
Freq: M, dtype: float64
```

Converting timestamps to periods (and back)

```
dates = pd.date_range("2000-01-01",
                      periods=3, freq="M")
```

```
ts= pd.Series(np.random.standard_normal(3),
             index=dates)
```

```
ts
```

```
2000-01-31   -1.472182
2000-02-29    0.042816
2000-03-31    1.232869
Freq: M, dtype: float64
```

```
pts = ts.to_period()
```

```
pts
```

```
2000-01   -1.472182
2000-02    0.042816
2000-03    1.232869
Freq: M, dtype: float64
```

```python
dates = pd.date_range("2022-01-29", periods=6)
```

```python
ts2 = pd.Series(np.random.standard_normal(6),
               index= dates)
```

```python
ts2
```

```
2022-01-29   -0.865524
2022-01-30    1.518387
2022-01-31    0.327414
2022-02-01    0.380410
2022-02-02   -0.984295
2022-02-03   -2.798704
Freq: D, dtype: float64
```

```python
ts2.to_period
```

```
<bound method Series.to_period of 2022-01-29   -0.865524
2022-01-30    1.518387
2022-01-31    0.327414
2022-02-01    0.380410
2022-02-02   -0.984295
2022-02-03   -2.798704
Freq: D, dtype: float64>
```

```python
pts = ts2.to_period()
```

```python
pts
```

```
2022-01-29   -0.865524
2022-01-30    1.518387
2022-01-31    0.327414
```

```
2022-02-01    0.380410
2022-02-02   -0.984295
2022-02-03   -2.798704
Freq: D, dtype: float64
```

```python
pts.to_timestamp(how='end')
```

```
2022-01-29 23:59:59.999999999   -0.865524
2022-01-30 23:59:59.999999999    1.518387
2022-01-31 23:59:59.999999999    0.327414
2022-02-01 23:59:59.999999999    0.380410
2022-02-02 23:59:59.999999999   -0.984295
2022-02-03 23:59:59.999999999   -2.798704
Freq: D, dtype: float64
```

Reshaping and sample frequency conversion

```python
dates = pd.date_range("2022-12-10", periods=100)
```

```python
ts= pd.Series(np.random.standard_normal(len(dates)),
             index=dates)
```

```python
ts
```

```
2022-12-10    0.655061
2022-12-11   -2.144779
2022-12-12    0.489381
2022-12-13   -0.117629
2022-12-14    0.782097
                ...
2023-03-15   -1.263925
2023-03-16   -0.317576
2023-03-17    0.398997
2023-03-18   -0.237727
2023-03-19   -1.407480
Freq: D, Length: 100, dtype: float64
```

```python
ts.resample("M").mean()
```

```
2022-12-31   -0.177024
2023-01-31    0.218224
2023-02-28   -0.040488
2023-03-31   -0.288735
Freq: M, dtype: float64
```

```python
ts.resample("M", kind="period").mean()
```

```
2022-12   -0.177024
2023-01    0.218224
2023-02   -0.040488
2023-03   -0.288735
Freq: M, dtype: float64
```

downsampling

```python
dates = pd.date_range("2022-01-01",
                      periods=12, freq="T")
```

```python
ts = pd.Series(np.arange(len(dates)), index=dates)
```

```python
ts
```

```
2022-01-01 00:00:00     0
2022-01-01 00:01:00     1
2022-01-01 00:02:00     2
2022-01-01 00:03:00     3
2022-01-01 00:04:00     4
2022-01-01 00:05:00     5
2022-01-01 00:06:00     6
2022-01-01 00:07:00     7
2022-01-01 00:08:00     8
2022-01-01 00:09:00     9
2022-01-01 00:10:00    10
2022-01-01 00:11:00    11
Freq: T, dtype: int32
```

```
ts.resample("5min").sum()
```

```
2022-01-01 00:00:00    10
2022-01-01 00:05:00    35
2022-01-01 00:10:00    21
Freq: 5T, dtype: int32
```

```
ts.resample("5min", closed="right",
            label="right").sum()
```

```
2022-01-01 00:00:00     0
2022-01-01 00:05:00    15
2022-01-01 00:10:00    40
2022-01-01 00:15:00    11
Freq: 5T, dtype: int32
```

open-high-low-close(OHLC) resampling

```
ts = pd.Series(np.random.permutation
               (np.arange(len(dates))), index=dates)
```

```
ts.resample("5min").ohlc()
```

	open	high	low	close
2022-01-01 00:00:00	1	11	1	5
2022-01-01 00:05:00	3	7	0	0
2022-01-01 00:10:00	8	10	8	10

upsampling and interpolation

```
frame = pd.DataFrame(np.random.standard_normal((2,5)),
                     index=pd.date_range("2022-01-01",
                                         periods=2, freq="W-WED"),
                      columns = ["fdk", 'sadik', 'golewala','pipli','mudki'])
```

```python
frame
```

	fdk	sadik	golewala	pipli	mudki
2022-01-05	-0.500335	-0.286433	0.805294	0.557015	-1.293101
2022-01-12	0.470091	-0.574010	-0.817633	0.197509	0.189306

```python
for n in range(10):
    print(n)
```

```python
#list comprehension

[n**2 + 2 for n in range(5)]
```

```
[2, 3, 6, 11, 18]
```

```python
# for loop
for n in [n**2 + 2 for n in range(5)]:
    print(n)
```

```
2
3
6
11
18
```

```python
df_daily = frame.resample('D').asfreq()
```

```python
df_daily
```

	fdk	sadik	golewala	pipli	mudki
2022-01-05	-0.500335	-0.286433	0.805294	0.557015	-1.293101
2022-01-06	NaN	NaN	NaN	NaN	NaN
2022-01-07	NaN	NaN	NaN	NaN	NaN
2022-01-08	NaN	NaN	NaN	NaN	NaN
2022-01-09	NaN	NaN	NaN	NaN	NaN

	fdk	sadik	golewala	pipli	mudki
2022-01-10	NaN	NaN	NaN	NaN	NaN
2022-01-11	NaN	NaN	NaN	NaN	NaN
2022-01-12	0.470091	-0.574010	-0.817633	0.197509	0.189306

```
# filling certain number of periods
frame.resample("D").ffill(limit=2)
```

	fdk	sadik	golewala	pipli	mudki
2022-01-05	-0.500335	-0.286433	0.805294	0.557015	-1.293101
2022-01-06	-0.500335	-0.286433	0.805294	0.557015	-1.293101
2022-01-07	-0.500335	-0.286433	0.805294	0.557015	-1.293101
2022-01-08	NaN	NaN	NaN	NaN	NaN
2022-01-09	NaN	NaN	NaN	NaN	NaN
2022-01-10	NaN	NaN	NaN	NaN	NaN
2022-01-11	NaN	NaN	NaN	NaN	NaN
2022-01-12	0.470091	-0.574010	-0.817633	0.197509	0.189306

```
frame.resample("W-THU").ffill()
```

	fdk	sadik	golewala	pipli	mudki
2022-01-06	-0.500335	-0.286433	0.805294	0.557015	-1.293101
2022-01-13	0.470091	-0.574010	-0.817633	0.197509	0.189306

Resampling with periods

```
frame2 = pd.DataFrame(np.random.standard_normal((24,4)),
                      index = pd.period_range("1-2000","12-2001",
                                              freq="M"),
                      columns=['fzp', 'fdk', 'btd', 'mudki'])
```

```
frame2.head()
```

	fzp	fdk	btd	mudki
2000-01	-0.438864	0.122812	-1.157890	0.403075
2000-02	-0.688525	-0.721772	0.011549	-0.979600
2000-03	0.607322	-1.119676	0.089442	0.060338
2000-04	0.690526	-0.095600	0.212831	0.410823
2000-05	-1.016129	-0.430221	-1.235741	0.250289

```
annual_frame = frame2.resample("A-DEC").mean()
```

```
annual_frame
```

	fzp	fdk	btd	mudki
2000	-0.094852	-0.436623	-0.600286	-0.715234
2001	0.025365	-0.347140	0.035530	-0.521633

```
# Q-DEC:Quarterly, year ending in Dec
annual_frame.resample("Q-DEC").ffill()
```

	fzp	fdk	btd	mudki
2000Q1	-0.094852	-0.436623	-0.600286	-0.715234
2000Q2	-0.094852	-0.436623	-0.600286	-0.715234
2000Q3	-0.094852	-0.436623	-0.600286	-0.715234
2000Q4	-0.094852	-0.436623	-0.600286	-0.715234
2001Q1	0.025365	-0.347140	0.035530	-0.521633
2001Q2	0.025365	-0.347140	0.035530	-0.521633
2001Q3	0.025365	-0.347140	0.035530	-0.521633
2001Q4	0.025365	-0.347140	0.035530	-0.521633

```
annual_frame.resample("Q-Dec", convention="end").asfreq()
```

	fzp	fdk	btd	mudki
2000Q4	-0.094852	-0.436623	-0.600286	-0.715234
2001Q1	NaN	NaN	NaN	NaN
2001Q2	NaN	NaN	NaN	NaN
2001Q3	NaN	NaN	NaN	NaN

	fzp	fdk	btd	mudki
2001Q4	0.025365	-0.347140	0.035530	-0.521633

```
annual_frame.resample("Q-MAR").ffill()
```

	fzp	fdk	btd	mudki
2000Q4	-0.094852	-0.436623	-0.600286	-0.715234
2001Q1	-0.094852	-0.436623	-0.600286	-0.715234
2001Q2	-0.094852	-0.436623	-0.600286	-0.715234
2001Q3	-0.094852	-0.436623	-0.600286	-0.715234
2001Q4	0.025365	-0.347140	0.035530	-0.521633
2002Q1	0.025365	-0.347140	0.035530	-0.521633
2002Q2	0.025365	-0.347140	0.035530	-0.521633
2002Q3	0.025365	-0.347140	0.035530	-0.521633

Grouped time sampling

```
N = 15
times = pd.date_range("2024-02-29 00:00", freq="1min",
                      periods=N)
df = pd.DataFrame({'time':times,
                   "value":np.arange(N)})
```

```
df
```

	time	value
0	2024-02-29 00:00:00	0
1	2024-02-29 00:01:00	1
2	2024-02-29 00:02:00	2
3	2024-02-29 00:03:00	3
4	2024-02-29 00:04:00	4
5	2024-02-29 00:05:00	5
6	2024-02-29 00:06:00	6
7	2024-02-29 00:07:00	7
8	2024-02-29 00:08:00	8
9	2024-02-29 00:09:00	9
10	2024-02-29 00:10:00	10

	time	value
11	2024-02-29 00:11:00	11
12	2024-02-29 00:12:00	12
13	2024-02-29 00:13:00	13
14	2024-02-29 00:14:00	14

```
# resmpling for 5 min count
times2 = pd.date_range("2024-02-29 00:00", freq="5min",
                       periods=N)
df2 = pd.DataFrame({'time':times2,
                    "value":np.arange(N)})
df2
```

	time	value
0	2024-02-29 00:00:00	0
1	2024-02-29 00:05:00	1
2	2024-02-29 00:10:00	2
3	2024-02-29 00:15:00	3
4	2024-02-29 00:20:00	4
5	2024-02-29 00:25:00	5
6	2024-02-29 00:30:00	6
7	2024-02-29 00:35:00	7
8	2024-02-29 00:40:00	8
9	2024-02-29 00:45:00	9
10	2024-02-29 00:50:00	10
11	2024-02-29 00:55:00	11
12	2024-02-29 01:00:00	12
13	2024-02-29 01:05:00	13
14	2024-02-29 01:10:00	14

```
# simply resampling
df.set_index('time').resample("5min").count()
```

	value
time	
2024-02-29 00:00:00	5
2024-02-29 00:05:00	5
2024-02-29 00:10:00	5

```python
# DataFrame with multiple time series,

df3 = pd.DataFrame({"time":times.repeat(3),
                    "key":np.tile(["a","b","c"],N),
                    'value':np.arange(N*3.)})


df3.head()
```

	time	key	value
0	2024-02-29 00:00:00	a	0.0
1	2024-02-29 00:00:00	b	1.0
2	2024-02-29 00:00:00	c	2.0
3	2024-02-29 00:01:00	a	3.0
4	2024-02-29 00:01:00	b	4.0

```python
# pandas grouper object
time_key = pd.Grouper(freq="5min")
```

```python
resampled = (df3.set_index("time")
            .groupby(["key", time_key])
            .sum())
```

```python
resampled
```

		value
key	time	
	2024-02-29 00:00:00	30.0
a	2024-02-29 00:05:00	105.0
	2024-02-29 00:10:00	180.0
	2024-02-29 00:00:00	35.0
b	2024-02-29 00:05:00	110.0
	2024-02-29 00:10:00	185.0
	2024-02-29 00:00:00	40.0
c	2024-02-29 00:05:00	115.0
	2024-02-29 00:10:00	190.0

```
resampled.reset_index()
```

	key	time	value
0	a	2024-02-29 00:00:00	30.0
1	a	2024-02-29 00:05:00	105.0
2	a	2024-02-29 00:10:00	180.0
3	b	2024-02-29 00:00:00	35.0
4	b	2024-02-29 00:05:00	110.0
5	b	2024-02-29 00:10:00	185.0
6	c	2024-02-29 00:00:00	40.0
7	c	2024-02-29 00:05:00	115.0
8	c	2024-02-29 00:10:00	190.0

Moving window functions

- used for noisy or gappy data
- exclude automatically missing data

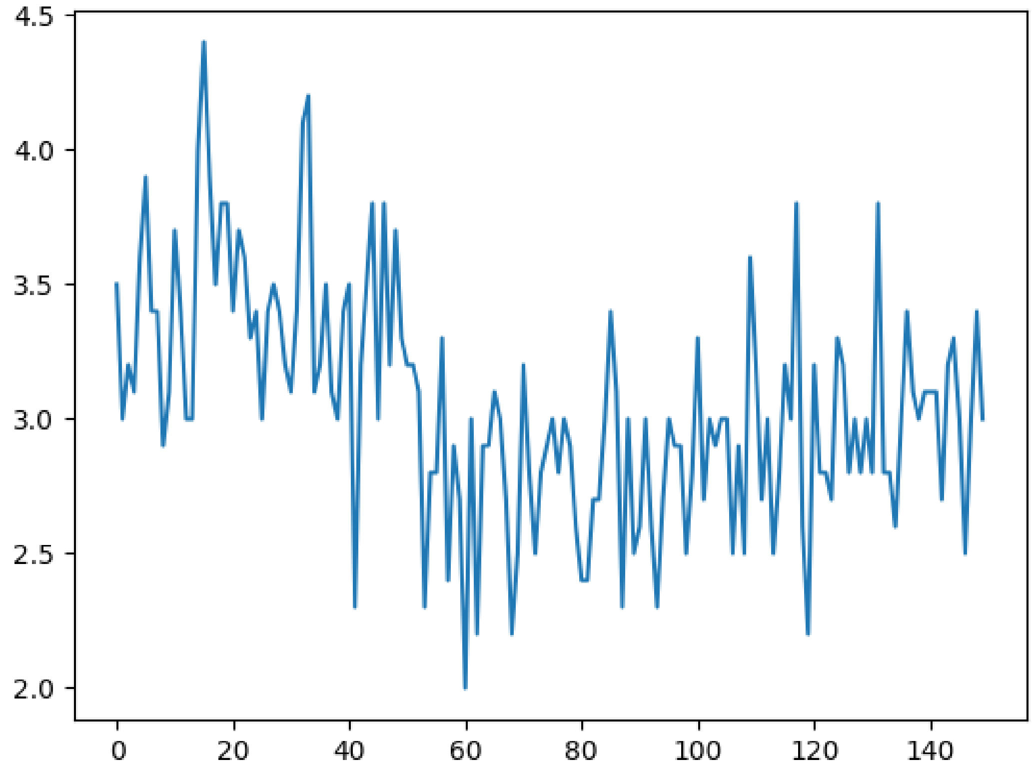
```
data = pd.read_csv("E:\pythonfordatanalysis\semainedu26fevrier\iris.csv")
```

```
data.columns
```

```
Index(['Id', 'Sepal Length (cm)', 'Sepal Width (cm)', 'Petal Length (cm)',
       'Petal Width (cm)', 'Species'],
      dtype='object')
```

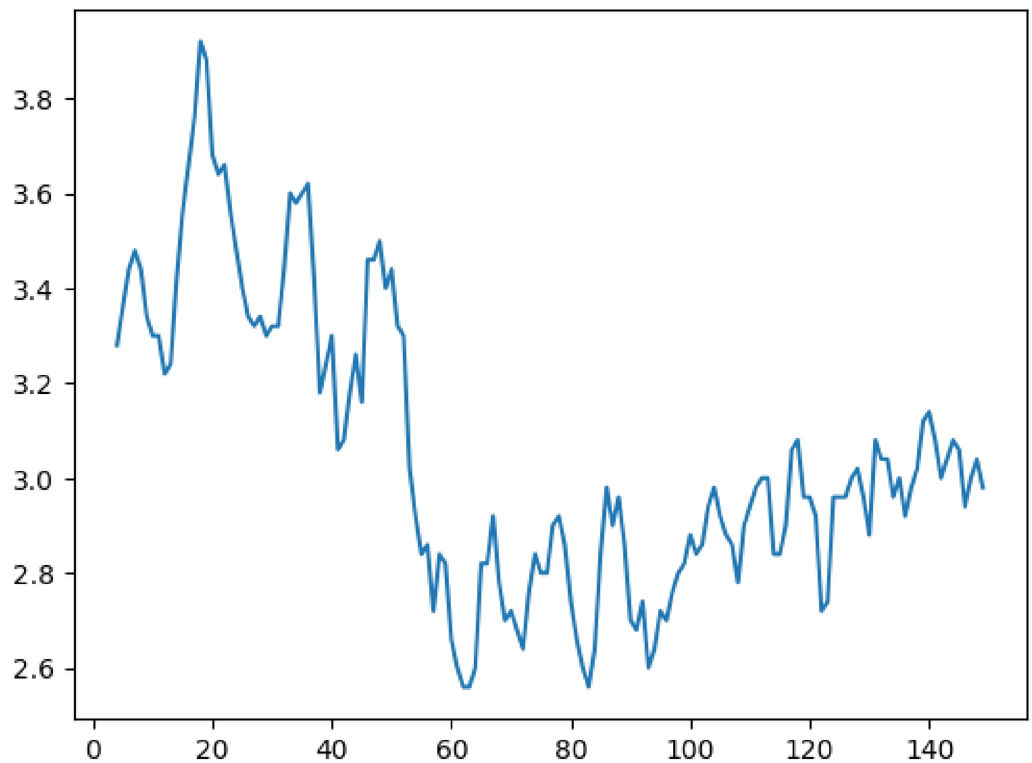
```
data['Sepal Width (cm)'].plot()
```

```
<Axes: >
```




```
data["Sepal Width (cm)"].rolling(5).mean().plot()
```

```
<Axes: >
```



3.8
3.6
3.4
3.2
3.0
2.8
2.6
0
20
40
60
80
100
120
140