In [ ]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import mplfinance as mpf
from statsmodels.stats.diagnostic import acorr_ljungbox
from statsmodels.graphics.tsaplots import plot_acf
from statsmodels.tsa.stattools import adfuller
```

In [ ]:

```
df = pd.read_csv('data/IBM.csv', index_col=0, parse_dates=True)
df.head()
```

Out[ ]:

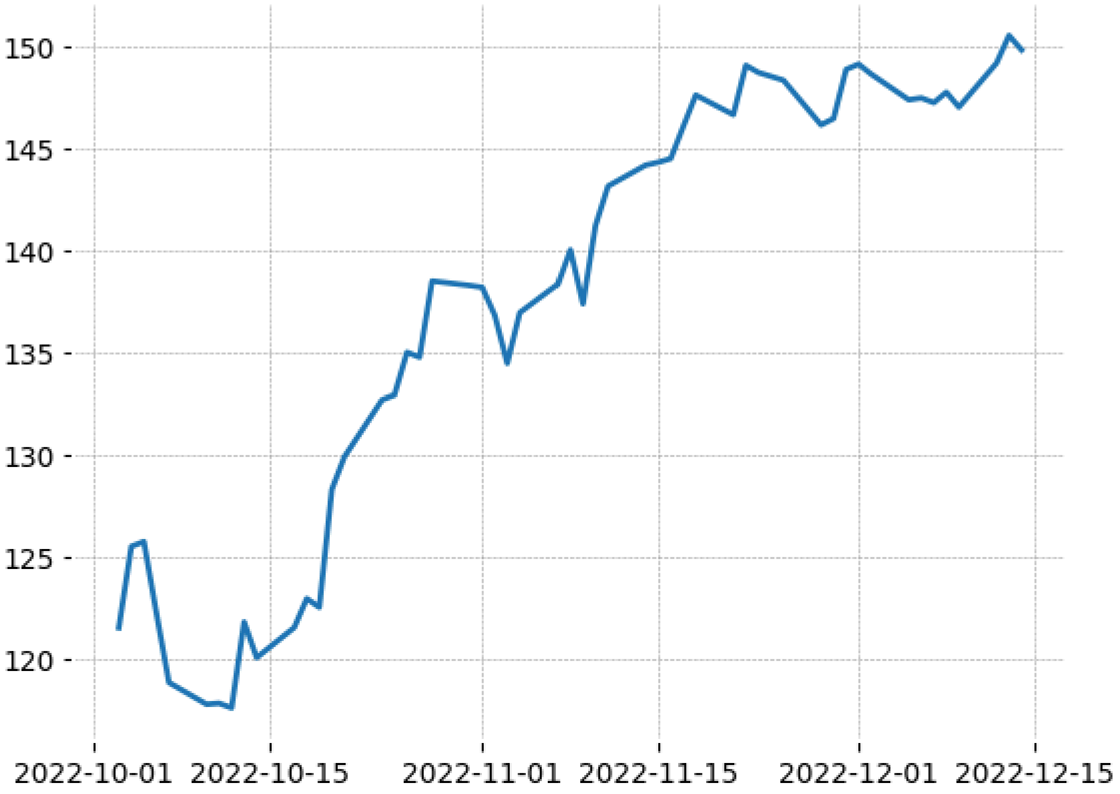
	Open	High	Low	Close	Adj Close	Volume
Date						
2022-10-03	120.160004	122.209999	119.599998	121.510002	113.363289	4261700
2022-10-04	122.800003	125.650002	122.519997	125.500000	117.085762	4566100
2022-10-05	124.709999	126.459999	124.230003	125.739998	117.309669	3212900
2022-10-06	124.879997	125.300003	121.769997	122.230003	114.034996	5074600
2022-10-07	121.500000	121.800003	118.070000	118.820000	110.853630	4499700

In [ ]:

```
plt.plot(df['Close'])
```

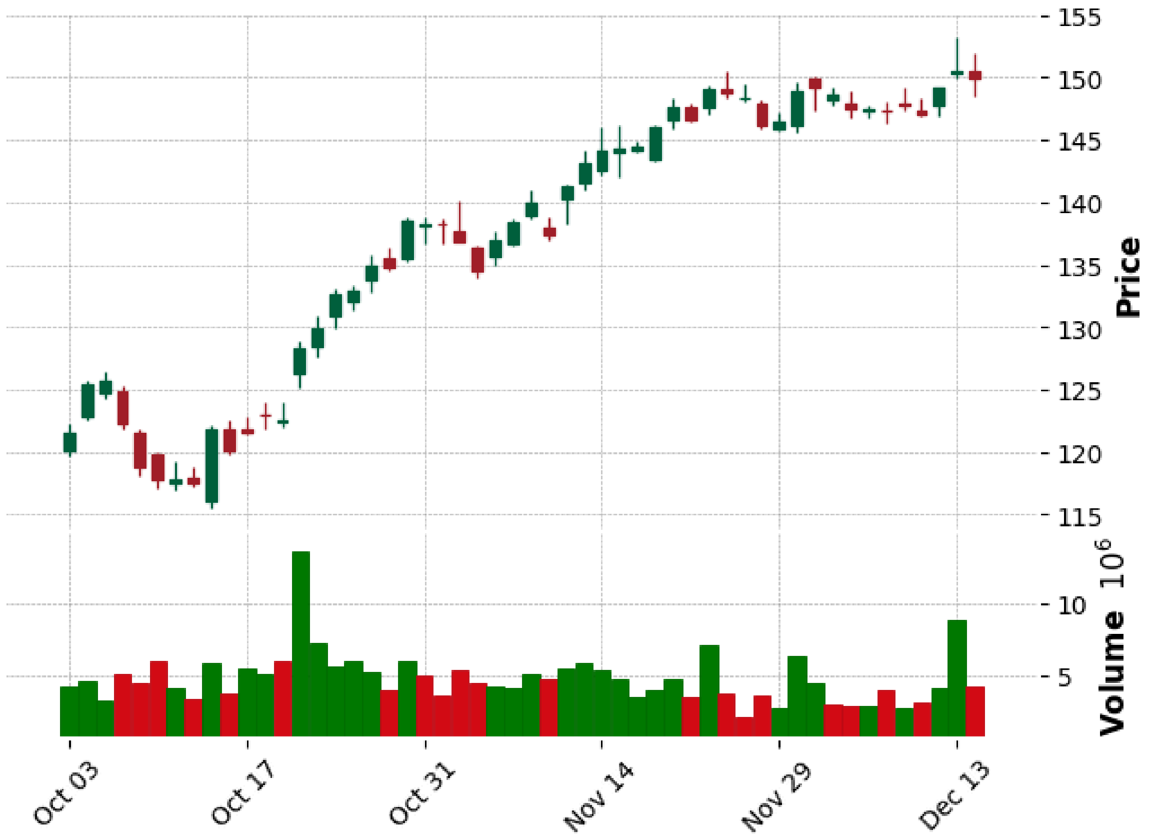
Out[ ]:

```
[<matplotlib.lines.Line2D at 0x26918c827b0>]
```



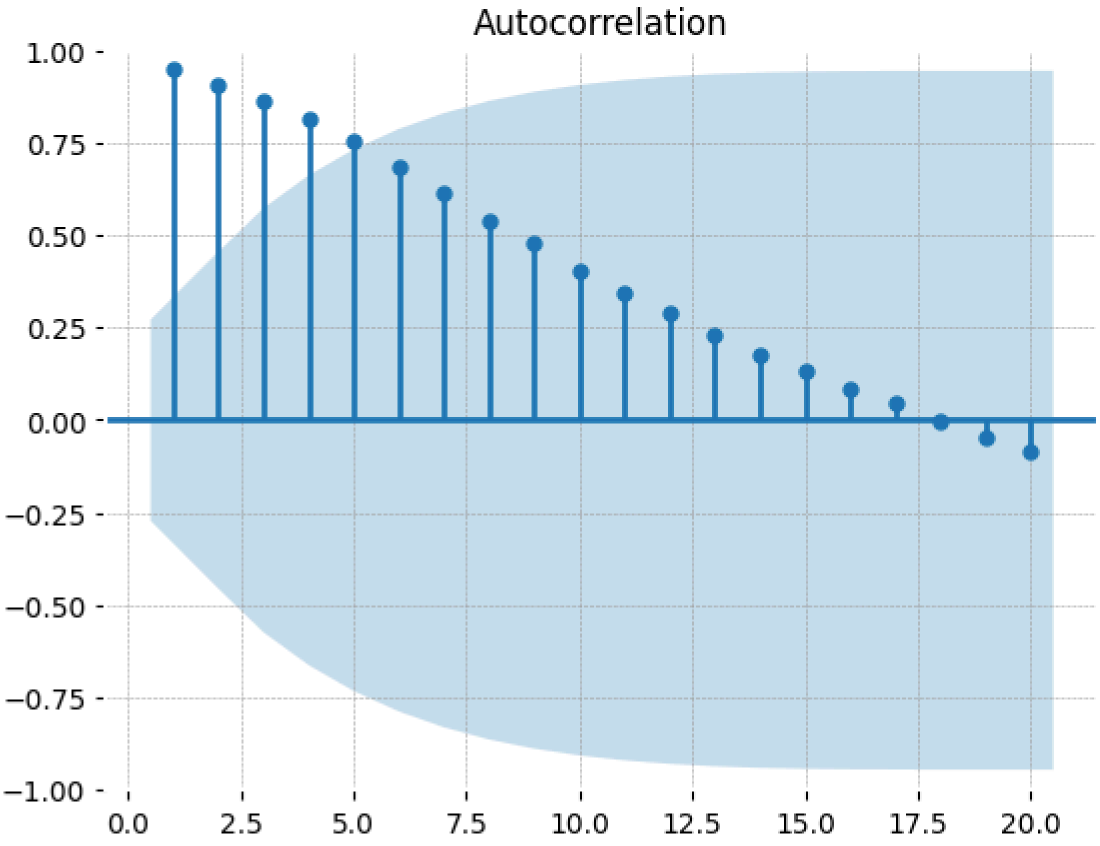
In [ ]:

```
mpf.plot(df, type='candle', volume=True, style='charles')
```



In [ ]:

```
fig = plot_acf(df['Close'], lags=20, zero=False)
```



In [ ]:

```
acorr_ljungbox(df['Close'], lags=20, return_df=True)
```

Out[ ]:

	lb_stat	lb_pvalue
1	49.647329	1.840204e-12
2	95.709808	1.647705e-21
3	138.188973	9.288206e-30
4	176.923862	3.412791e-37
5	210.847023	1.355455e-43
6	239.542178	7.030766e-49
7	263.157367	4.372787e-53
8	281.815526	3.037164e-56
9	296.638981	1.347451e-58
10	307.566167	3.905240e-60
11	315.677890	4.335147e-61
12	321.573294	1.370713e-61
13	325.408024	1.139871e-61
14	327.752735	1.884774e-61
15	329.032435	5.036557e-61
16	329.614929	1.820388e-60
17	329.772034	7.810616e-60
18	329.772079	3.501981e-59
19	329.974878	1.384866e-58
20	330.602741	4.359210e-58

p-values are all smaller than 0.05 so we reject the null hypothesis that the data is independently distributed

In [ ]:

```
adfuller(df['Close'])
```

Out[ ]:

```
(-0.9398265150729506,
 0.7745742973095588,
 0,
 51,
 {'1%': -3.5656240522121956,
  '5%': -2.920142229157715,
  '10%': -2.598014675124952},
 155.18453180208093)
```

adfuller test p-value is bigger than 0.05 so the data is not stationary

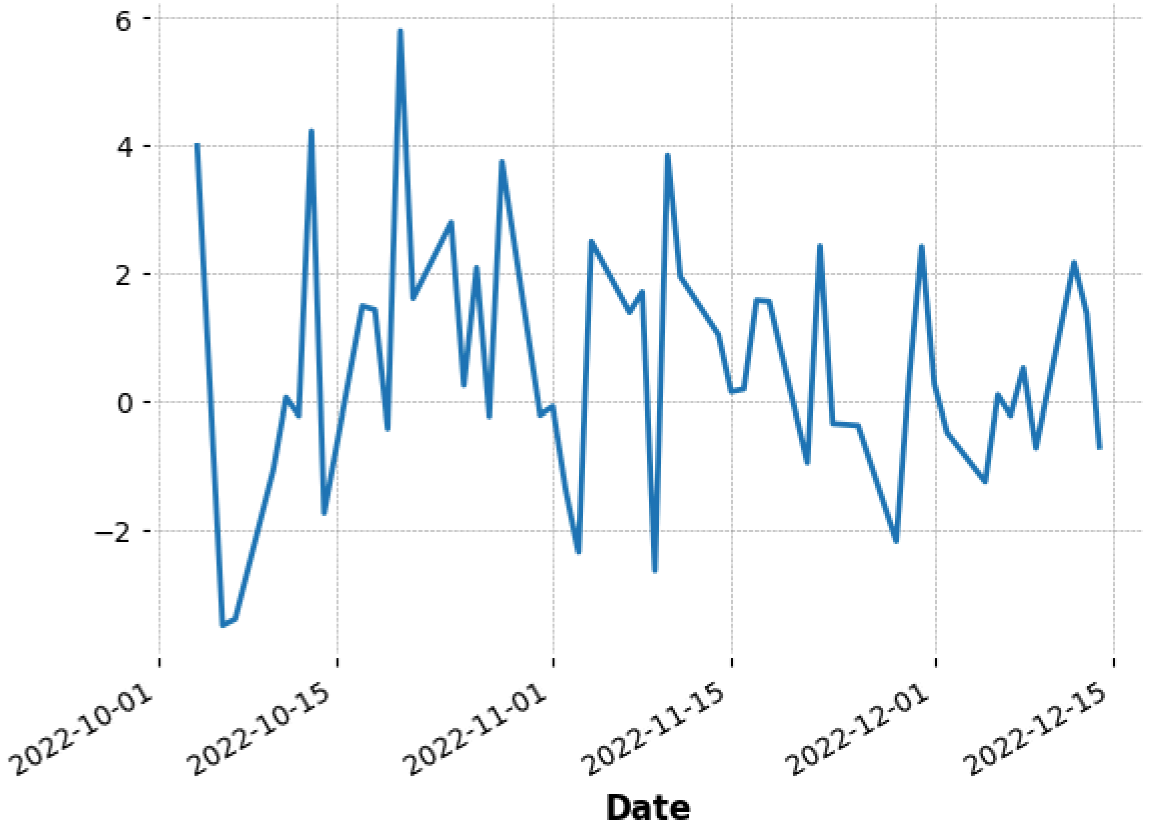
In [ ]:

```
df['Diff Close'] = df['Close'].diff()
```

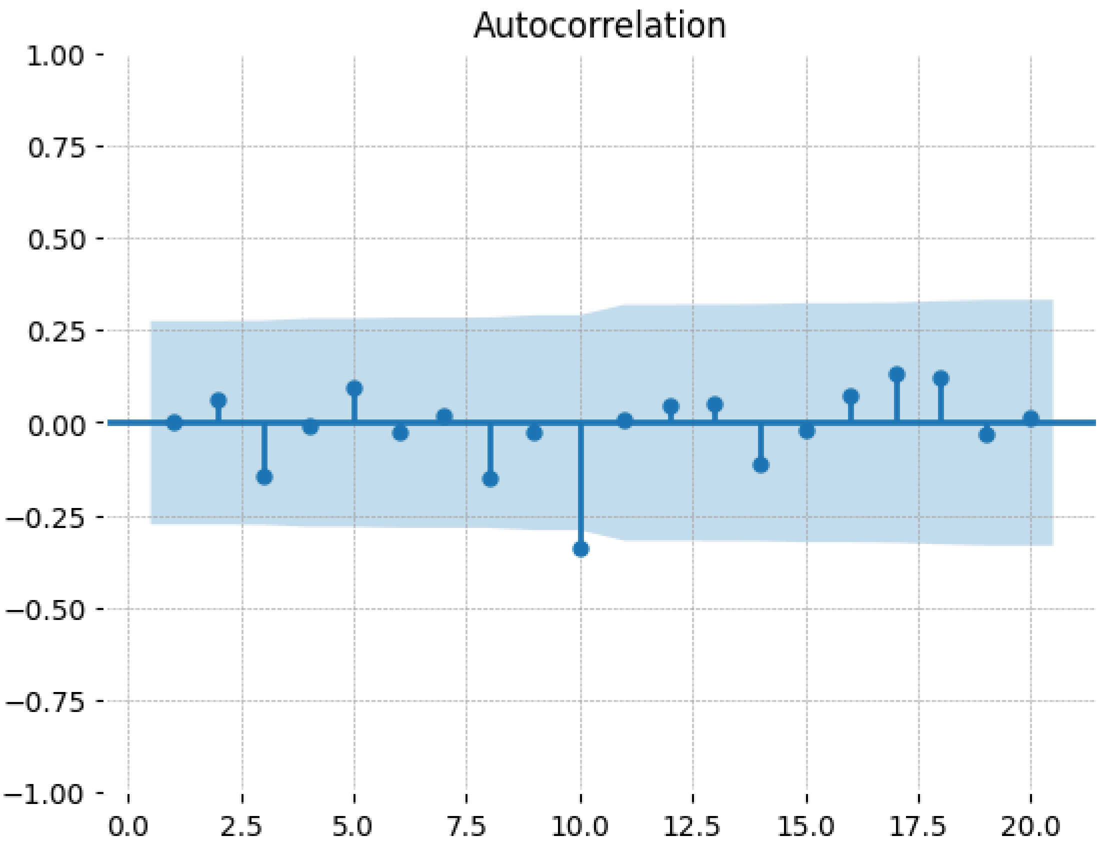
In [ ]:

```
df['Diff Close'].plot()
```

Out[ ]:
```
<Axes: xlabel='Date'>
```



In [ ]:
```
fig = plot_acf(df['Diff Close'].dropna(), lags=20, zero=False)
```



In [ ]:
```
acorr_ljungbox(df['Diff Close'].dropna(), lags=20, return_df=True)
```

Out[ ]:

	lb_stat	lb_pvalue
1	0.000186	0.989111
2	0.210220	0.900226
3	1.363646	0.714078
4	1.367764	0.849778
5	1.922366	0.859780
6	1.964599	0.922925
7	1.982913	0.960780
8	3.421346	0.905207
9	3.460383	0.943222
10	11.117494	0.348438
11	11.119942	0.433270
12	11.259661	0.506807
13	11.451655	0.573036
14	12.336669	0.579285
15	12.363347	0.651344
16	12.775100	0.689125
17	14.214791	0.651844
18	15.373498	0.636182
19	15.440260	0.694235
20	15.453292	0.749909

Ljunbox test p-value for differentiated data is bigger than 0.05 so changes in the data are random

In [ ]:

```
adfuller(df['Diff Close'].dropna())
```

Out[ ]:

```
(-3.4975414025237135,
 0.008050461013716129,
 9,
 41,
 {'1%': -3.60098336718852,
  '5%': -2.9351348158036012,
  '10%': -2.6059629803688282},
 153.7775047611643)
```

adfuller test p-value for differentiated data is smaller than 0.05 so the changes in data are stationary