```
[4]: !pip install yfinance statsmodels

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import yfinance as yf

from statsmodels.tsa.stattools import adfuller
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.arima.model import ARIMA
from sklearn.metrics import mean_squared_error
import warnings
warnings.filterwarnings("ignore")
```

```
Requirement already satisfied: yfinance in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (1.1.0)
Requirement already satisfied: statsmodels in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (0.14.6)
Requirement already satisfied: pandas>=1.3.0 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (2.3.3)
Requirement already satisfied: numpy>=1.16.5 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (2.3.4)
Requirement already satisfied: requests>=2.31 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (2.32.5)
Requirement already satisfied: multitasking>=0.0.7 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (0.0.12)
Requirement already satisfied: platformdirs>=2.0.0 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (4.5.0)
Requirement already satisfied: pytz>=2022.5 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (2025.2)
Requirement already satisfied: frozendict>=2.3.4 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (2.4.7)
Requirement already satisfied: peewee>=3.16.2 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (3.19.0)
Requirement already satisfied: beautifulsoup4>=4.11.1 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (4.14.2)
Requirement already satisfied: curl_cffi<0.14,>=0.7 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (0.13.0)
Requirement already satisfied: protobuf>=3.19.0 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (6.33.4)
Requirement already satisfied: websockets>=13.0 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from yfinance) (16.0)
Requirement already satisfied: cffi>=1.12.0 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from curl_cffi<0.14,>=0.7->yfinance) (2.0.0)
Requirement already satisfied: certifi>=2024.2.2 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from curl_cffi<0.14,>=0.7->yfinance) (2025.11.12)
Requirement already satisfied: scipy!=1.9.2,>=1.8 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from statsmodels) (1.17.0)
Requirement already satisfied: patsy>=0.5.6 in c:\users\hp\appdata\local\programs\python\python313\lib\site-packages (from statsmodels) (1.0.2)
```

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```
[notice] A new release of pip is available: 25.2 -> 26.0.1
[notice] To update, run: python.exe -m pip install --upgrade pip
```

[5]:
```python
# Download stock data
data = yf.download("AAPL", start="2020-01-01", end="2024-01-01")

# Use Closing Price
stock = data['Close']

# Plot
plt.figure(figsize=(10,5))
plt.plot(stock)
plt.title("AAPL Closing Price")
plt.show()
```

```
[*********************100%***********************]  1 of 1 completed
```


AAPL Closing Price

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Code

JupyterLab Python 3 (ipykernel)

```python
result = adfuller(stock)
print("ADF Statistic:", result[0])
print("p-value:", result[1])
```

```
ADF Statistic: -1.511950425352023
p-value: 0.5275915600806567
```
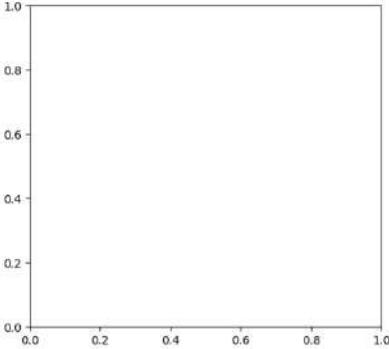
```python
stock_diff = stock.diff().dropna()

plt.figure(figsize=(12,5))

plt.subplot(121)
plot_acf(stock_diff, lags=20)

plt.subplot(122)
plot_pacf(stock_diff, lags=20)

plt.show()
```
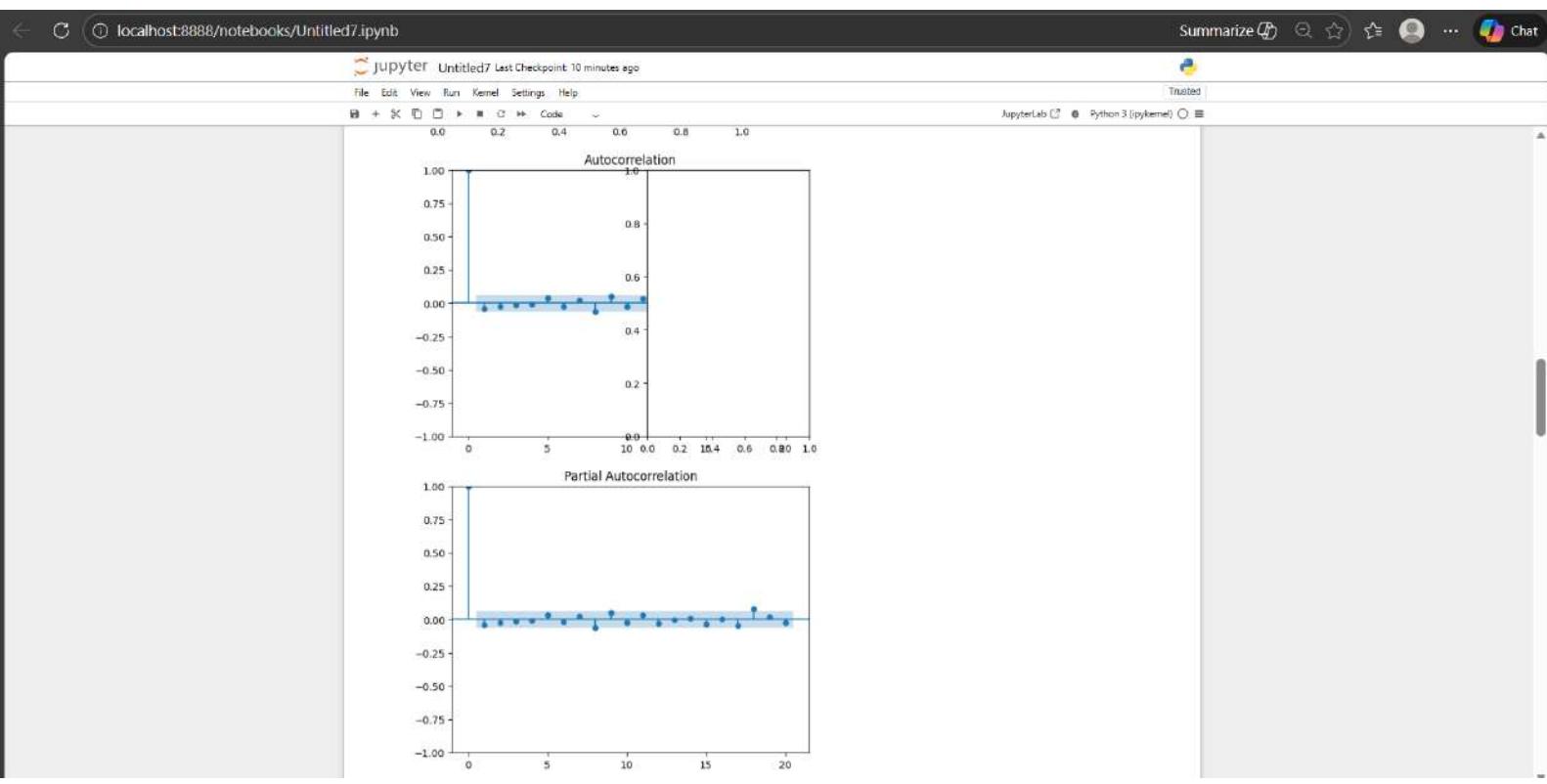
Autocorrelation

Partial Autocorrelation

```python
model_ar = ARIMA(stock, order=(2,1,0))   # AR(2)
model_ar_fit = model_ar.fit()

print(model_ar_fit.summary())
```

```
                               SARIMAX Results
==============================================================================
Dep. Variable:                   AAPL   No. Observations:                 1006
Model:                 ARIMA(2, 1, 0)   Log Likelihood               -2382.600
Date:               Sat, 07 Feb 2026   AIC                           4771.200
Time:                       10:21:51   BIC                           4785.938
Sample:                            0   HQIC                          4776.800
                              - 1006
Covariance Type:                 opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1         -0.0400      0.027     -1.497      0.134      -0.092       0.012
ar.L2         -0.0223      0.028     -0.803      0.412      -0.077       0.032
sigma2         6.7101      0.226     29.668      0.000       6.267       7.153
==============================================================================
Ljung-Box (L1) (Q):                   0.01   Jarque-Bera (JB):               114.81
Prob(Q):                              0.93   Prob(JB):                         0.00
Heteroskedasticity (H):               1.05   Skew:                            -0.09
Prob(H) (two-sided):                  0.64   Kurtosis:                         4.65
==============================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
```

```python
model_ma = ARIMA(stock, order=(0,1,1))   # MA(1)
model_ma_fit = model_ma.fit()

print(model_ma_fit.summary())
```

```
                               SARIMAX Results
==============================================================================
Dep. Variable:                   AAPL   No. Observations:                 1006
Model:                 ARIMA(0, 1, 1)   Log Likelihood               -2382.814
Date:               Sat, 07 Feb 2026   AIC                           4769.628
Time:                       10:21:56   BIC                           4779.453
Sample:                            0   HQIC                          4773.361
                              - 1006
Covariance Type:                 opg
==============================================================================
```

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```
Covariance Type:                 opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ma.L1         -0.0410      0.027     -1.532      0.126      -0.093       0.011
sigma2         0.7129      0.226     29.663      0.000       6.289       7.150
==============================================================================
Ljung-Box (L1) (Q):                0.00   Jarque-Bera (JB):           113.80
Prob(Q):                           0.96   Prob(JB):                     0.00
Heteroskedasticity (H):            1.06   Skew:                        -0.08
Prob(H) (two-sided):               0.60   Kurtosis:                     4.64
==============================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
```

[12]:
```python
model_arma = ARIMA(stock, order=(2,1,1))  # ARMA(2,1)
model_arma_fit = model_arma.fit()

print(model_arma_fit.summary())
```

```
                               SARIMAX Results
==============================================================================
Dep. Variable:                   AAPL   No. Observations:              1006
Model:                 ARIMA(2, 1, 1)   Log Likelihood             -2382.546
Date:                Sat, 07 Feb 2026   AIC                         4773.091
Time:                        10:22:01   BIC                         4792.742
Sample:                             0   HQIC                        4780.558
                               - 1006
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1          0.2560      1.111      0.231      0.818      -1.921       2.433
ar.L2         -0.0119      0.058     -0.206      0.837      -0.125       0.101
ma.L1         -0.2963      1.114     -0.266      0.790      -2.480       1.887
sigma2         6.7093      0.227     29.577      0.000       6.265       7.154
==============================================================================
Ljung-Box (L1) (Q):                0.01   Jarque-Bera (JB):           114.74
Prob(Q):                           0.94   Prob(JB):                     0.00
Heteroskedasticity (H):            1.05   Skew:                        -0.09
Prob(H) (two-sided):               0.63   Kurtosis:                     4.64
==============================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
```

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Code

JupyterLab Python 3 (ipykernel)

```
[13]: print("AR Model AIC:", model_ar_fit.aic)
      print("MA Model AIC:", model_ma_fit.aic)
      print("ARMA Model AIC:", model_arma_fit.aic)

      print("AR Model BIC:", model_ar_fit.bic)
      print("MA Model BIC:", model_ma_fit.bic)
      print("ARMA Model BIC:", model_arma_fit.bic)
```
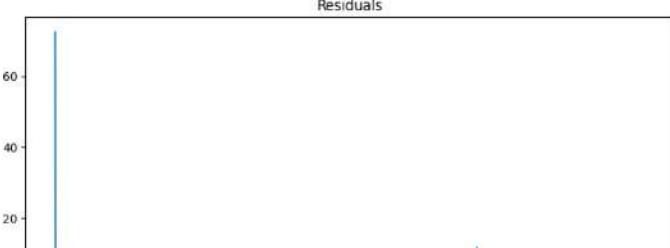
```
AR Model AIC: 4771.200128799013
MA Model AIC: 4769.62788784113
ARMA Model AIC: 4773.091318955195
AR Model BIC: 4785.938357260403
MA Model BIC: 4779.4533784251
ARMA Model BIC: 4792.742290237167
```
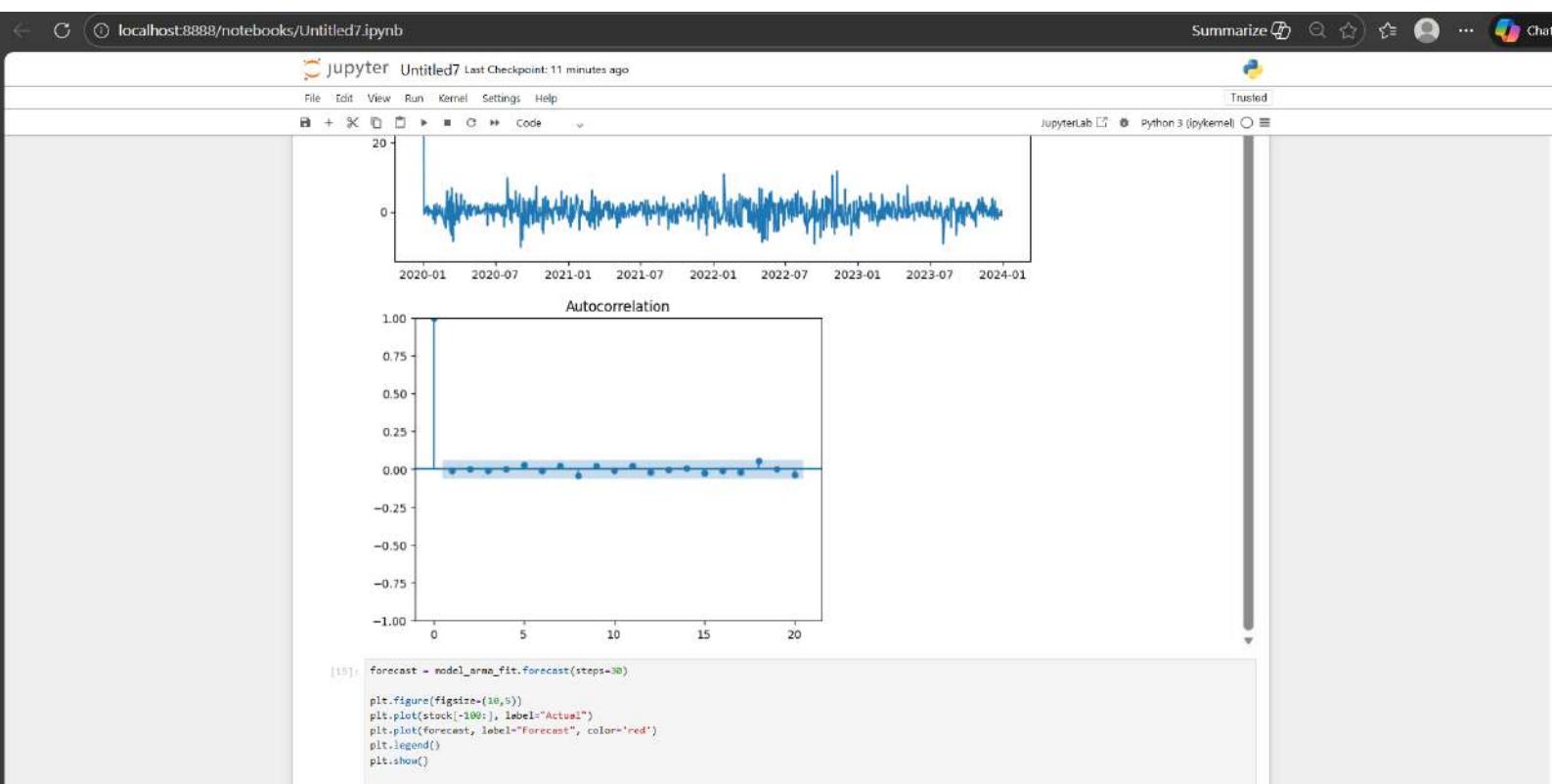
```
[14]: residuals = model_arma_fit.resid

      plt.figure(figsize=(10,5))
      plt.plot(residuals)
      plt.title("Residuals")
      plt.show()

      plot_acf(residuals, lags=20)
      plt.show()
```

Residuals

```python
[15]: forecast = model_arma_fit.forecast(steps=30)

      plt.figure(figsize=(10,5))
      plt.plot(stock[-100:], label="Actual")
      plt.plot(forecast, label="Forecast", color='red')
      plt.legend()
      plt.show()
```

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JupyterLab ☐ ⚙ Python 3 (ipykernel) ○ ≡

```
-1.00
        0       5      10      15      20
```

```python
[15]: forecast = model_arma_fit.forecast(steps=30)

      plt.figure(figsize=(10,5))
      plt.plot(stock[-100:], label="Actual")
      plt.plot(forecast, label="Forecast", color='red')
      plt.legend()
      plt.show()
```



```python
[16]: train = stock[:int(len(stock)*0.8)]
      test = stock[int(len(stock)*0.8):]

      model = ARIMA(train, order=(2,1,1))
      fit = model.fit()

      pred = fit.forecast(steps=len(test))

      rmse = np.sqrt(mean_squared_error(test, pred))
      print("RMSE:", rmse)
```

```
RMSE: 31.663196117714268
```