Part 1: Data Acquisition & Preprocessing

Objective: Acquire and preprocess S&P 500 stock price data for portfolio analysis.

Key Tasks: 1. Scrape top 100 S&P 500 tickers by market capitalization 2. Download 5 years of End-of-Day OHLCV data 3. Clean and align data to uniform trading calendar 4. Compute daily log returns

Deliverables: - `prices`: Adjusted close price matrix (DataFrame) - `log_returns`: Daily log returns matrix (DataFrame) - Complete code workflow for data acquisition and preprocessing

```
# Import required libraries
import yfinance as yf
import pandas as pd
import numpy as np
import warnings
import matplotlib.pyplot as plt
warnings.filterwarnings('ignore')

print("Libraries imported successfully!")
```

```
Libraries imported successfully!
```

Task 1: Scrape Top 100 S&P 500 Tickers by Market Cap

```
# Get S&P 500 tickers from Wikipedia and select top 100 by market cap
def get_sp500_tickers():
    """Scrape S&P 500 tickers from Wikipedia"""
    url = 'https://en.wikipedia.org/wiki/List_of_S%26P_500_companies'
    tables = pd.read_html(url)
    sp500_table = tables[0]
```

```python
    tickers = sp500_table['Symbol'].str.replace('.', '-').tolist()
    return tickers

# Get all S&P 500 tickers
sp500_tickers = get_sp500_tickers()
print(f"Found {len(sp500_tickers)} S&P 500 tickers")

# Get market caps to select top 100
print("Getting market capitalizations...")
market_caps = {}

# Process efficiently - check first 150 tickers
for ticker in sp500_tickers[:150]:
    try:
        stock = yf.Ticker(ticker)
        info = stock.info
        market_cap = info.get('marketCap', 0)
        if market_cap > 0:
            market_caps[ticker] = market_cap
    except:
        continue

# Sort by market cap and get top 100
sorted_tickers = sorted(market_caps.items(), key=lambda x: x[1], reverse=True)
top_100_tickers = [ticker for ticker, _ in sorted_tickers[:100]]

print(f"  Selected top 100 tickers by market cap")
print(f"Sample tickers: {top_100_tickers[:5]}..." +
      f"{top_100_tickers[-5:]}")
print(f"Total: {len(top_100_tickers)} tickers")
```

```
Found 503 S&P 500 tickers
Getting market capitalizations...
  Selected top 100 tickers by market cap
Sample tickers: ['AAPL', 'GOOG', 'GOOGL', 'AMZN', 'AVGO']...['STZ', 'AWK', 'AEE', 'ADM', 'AVB
Total: 100 tickers
  Selected top 100 tickers by market cap
Sample tickers: ['AAPL', 'GOOG', 'GOOGL', 'AMZN', 'AVGO']...['STZ', 'AWK', 'AEE', 'ADM', 'AVB
Total: 100 tickers
```

Task 2: Download EOD OHLCV Data (5 Years)

```
# Download 5 years of EOD OHLCV data
from datetime import datetime, timedelta

# Define date range
end_date = datetime.now()
start_date = end_date - timedelta(days=5*365)

print(f"Downloading data from {start_date.strftime('%Y-%m-%d')} to " +
      f"{end_date.strftime('%Y-%m-%d')} for {len(top_100_tickers)} tickers...")
# Download data for all tickers
raw_data = yf.download(
    tickers=top_100_tickers,
    start=start_date.strftime('%Y-%m-%d'),
    end=end_date.strftime('%Y-%m-%d'),
    group_by='ticker',
    auto_adjust=True,
    prepost=False,
    threads=True
)

print(f"  Download completed!")
print(f"Data shape: {raw_data.shape}")
print(f"Date range: {raw_data.index[0]} to {raw_data.index[-1]}")

# Display first 5 rows of raw data
print("Displaying first 5 rows of raw data:")
print(raw_data.head(5))
```

```
Downloading data from 2020-08-07 to 2025-08-06 for 100 tickers...

[*******************100%***********************]  100 of 100 completed

  Download completed!
Data shape: (1254, 500)
Date range: 2020-08-07 00:00:00 to 2025-08-05 00:00:00
Displaying first 5 rows of raw data:
Ticker             DXCM                                                \
Price              Open        High          Low        Close    Volume
```

```
Date
2020-08-07  110.220001  114.057503  108.754997  110.175003  3715200
2020-08-10  109.827499  109.957497  101.552498  105.305000  4454800
2020-08-11  103.752502  104.802498  100.787498  102.787498  3273200
2020-08-12  103.050003  107.605003  103.050003  106.972504  2465200
2020-08-13  108.199997  109.997498  107.684998  108.820000  2421600

Ticker              BR                                                ...  \
Price             Open        High         Low       Close   Volume  ...
Date                                                                  ...
2020-08-07  124.052006  125.266405  123.555215  124.429207   768200  ...
2020-08-10  124.879978  126.085168  124.475178  125.671173   721200  ...
2020-08-11  127.722747  132.939111  127.639951  130.740326  1131400  ...
2020-08-12  130.363149  130.979544  127.777968  127.989563   837400  ...
2020-08-13  127.290356  129.029144  127.078761  127.731949   655400  ...

Ticker              BA                                                  \
Price             Open        High         Low       Close    Volume
Date
2020-08-07  171.500000  171.860001  168.699997  170.020004  19318000
2020-08-10  171.360001  179.789993  171.330002  179.410004  35857700
2020-08-11  184.509995  189.970001  179.529999  180.130005  61036600
2020-08-12  184.009995  184.149994  173.190002  175.440002  40674400
2020-08-13  173.619995  179.470001  172.429993  174.729996  22958800

Ticker              AZO
Price              Open         High          Low        Close  Volume
Date
2020-08-07  1178.369995  1184.949951  1170.219971  1182.219971  200700
2020-08-10  1185.260010  1186.880005  1169.140015  1174.719971  128600
2020-08-11  1179.199951  1182.869995  1160.780029  1171.560059  162700
2020-08-12  1176.849976  1193.790039  1174.449951  1188.369995  167000
2020-08-13  1183.359985  1190.920044  1177.310059  1187.140015  103900

[5 rows x 500 columns]
```

Task 3: Clean and Align Data to Uniform Calendar

```python
# Extract and clean adjusted close prices
print("Extracting and cleaning adjusted close prices...")

# Extract close prices for all tickers
if len(top_100_tickers) == 1:
    # Single ticker case
    prices = raw_data[['Close']].copy()
    prices.columns = top_100_tickers
else:
    # Multiple tickers case
    prices = pd.DataFrame(index=raw_data.index)
    for ticker in top_100_tickers:
        if ticker in raw_data.columns.get_level_values(0):
            prices[ticker] = raw_data[ticker]['Close']

# Clean the data
print("Cleaning data...")
# Remove columns with all NaN values
prices = prices.dropna(axis=1, how='all')
# Remove rows with all NaN values
prices = prices.dropna(how='all')
# Forward fill missing values
prices = prices.fillna(method='ffill')
# Backward fill remaining NaN values
prices = prices.fillna(method='bfill')

final_tickers = prices.columns.tolist()
print(f"  Clean price data: {prices.shape[0]} dates × " +
      f"{prices.shape[1]} tickers")
print(f"Date range: {prices.index[0]} to {prices.index[-1]}")
print(f"Final tickers count: {len(final_tickers)}")

# Display uniformly formatted output
print("Displaying first 5 rows of the cleaned price data:")
print(prices.head(5))

# Plot the first 5 tickers to visualize the data
print("Plotting first 5 tickers...")
prices.iloc[:, :5].plot(figsize=(14, 7))
plt.title('Adjusted Close Prices of Top 5 S&P 500 Tickers')
plt.xlabel('Date')
plt.ylabel('Adjusted Close Price')
```

```
plt.legend(loc='upper left')
plt.grid()
plt.show()
```

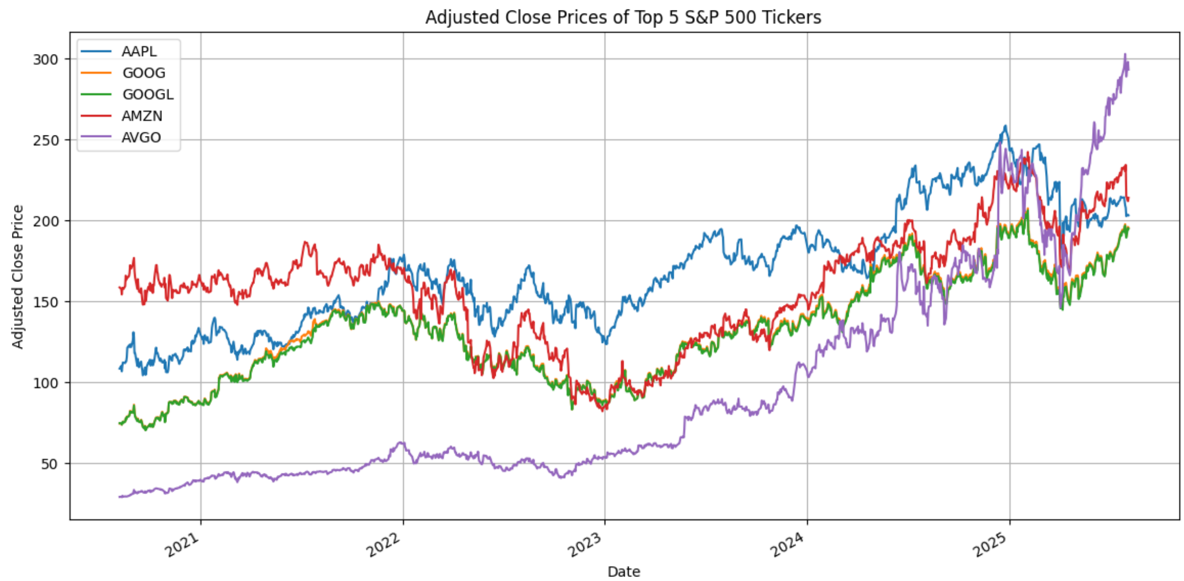
```
Extracting and cleaning adjusted close prices...
Cleaning data...
  Clean price data: 1254 dates × 100 tickers
Date range: 2020-08-07 00:00:00 to 2025-08-05 00:00:00
Final tickers count: 100
Displaying first 5 rows of the cleaned price data:
                  AAPL       GOOG      GOOGL        AMZN       AVGO  \
Date
2020-08-07  108.203766  74.282944  74.471870  158.373001  28.915100
2020-08-10  109.776505  74.362968  74.394836  157.408005  29.041964
2020-08-11  106.511765  73.578644  73.585678  154.033493  28.746538
2020-08-12  110.051590  74.885864  74.912727  158.112000  29.599096
2020-08-13  111.999245  75.473877  75.380417  158.050995  29.224720

                 BRK-B        COST       ABBV        BAC        CVX  ...  \
Date                                                                 ...
2020-08-07  209.479996  314.168182  75.978493  23.083565  69.710876  ...
2020-08-10  212.580002  313.329498  75.536949  23.481403  72.064003  ...
2020-08-11  212.660004  306.353363  75.774078  23.799673  71.975677  ...
2020-08-12  213.240005  310.343781  78.096283  23.631697  72.859085  ...
2020-08-13  211.979996  309.366821  77.417595  23.295742  72.136269  ...

                 ACGL          A          BR        BRO        DXCM  \
Date
2020-08-07  30.894695  94.532845  124.429207  44.604279  110.175003
2020-08-10  31.122908  93.914055  125.671173  44.478378  105.305000
2020-08-11  31.237015  93.101952  130.740326  44.216911  102.787498
2020-08-12  30.999290  94.387802  127.989563  44.352482  106.972504
2020-08-13  30.771076  95.489929  127.731949  44.371853  108.820000

                   STZ         AWK        AEE        ADM         AVB
Date
2020-08-07  158.571671  136.478409  71.071022  38.364456  129.755493
2020-08-10  158.506912  135.858871  71.996376  38.765251  129.704926
2020-08-11  159.819748  130.243774  70.188896  38.678131  127.967621
2020-08-12  162.251221  133.398849  70.898056  38.730404  128.954315
2020-08-13  163.286636  133.984116  70.370522  38.712975  127.090576
```

```
[5 rows x 100 columns]
Plotting first 5 tickers...
```



Task 4: Compute Daily Log Returns

Formula: r_t = ln(P_t / P_{t-1}) = ln(P_t) - ln(P_{t-1})

```python
# Compute daily log returns: r_t = ln(P_t / P_{t-1})
print("Computing daily log returns...")

log_returns = np.log(prices / prices.shift(1))
log_returns = log_returns.dropna()

# Clean any infinite or NaN values
log_returns.replace([np.inf, -np.inf], np.nan, inplace=True)
log_returns.fillna(method='ffill', inplace=True)
log_returns.fillna(0, inplace=True)

print(f" Log returns computed successfully!")
print(f"Shape: {log_returns.shape}")
print(f"Date range: {log_returns.index[0]} to {log_returns.index[-1]}")

# Basic statistics
print(f"\nSummary statistics:")
```

```python
print(f"Mean daily return: {log_returns.mean().mean():.6f}")
print(f"Std daily return: {log_returns.std().mean():.6f}")
print(f"Data quality - NaN values: {log_returns.isnull().sum().sum()}")
print(f"Data quality - Infinite values: {np.isinf(log_returns).sum().sum()}")

# Display first 5 rows of log returns
print("Displaying first 5 rows of log returns:")
print(log_returns.head(5))

# Plot log returns: cleaner and more informative visualization
import matplotlib.dates as mdates

plt.figure(figsize=(16, 7))
# Plot only a subset of tickers for clarity (e.g., top 10 by market cap)
top10 = top_100_tickers[:10]
log_returns[top10].plot(ax=plt.gca(), alpha=0.7, linewidth=1.2)

plt.title('Daily Log Returns of Top 10 S&P 500 Stocks by Market Cap',
          fontsize=18, fontweight='bold')
plt.xlabel('Date', fontsize=14)
plt.ylabel('Log Return', fontsize=14)
plt.legend(top10, loc='upper right', ncol=2, fontsize=10,
           frameon=True)
plt.grid(True, linestyle='--', alpha=0.5)
plt.tight_layout()
plt.xlim(log_returns.index[0], log_returns.index[-1])
plt.gca().xaxis.set_major_locator(mdates.YearLocator())
plt.gca().xaxis.set_major_formatter(mdates.DateFormatter('%Y'))
plt.show()
```

```
Computing daily log returns...
 Log returns computed successfully!
Shape: (1253, 100)
Date range: 2020-08-10 00:00:00 to 2025-08-05 00:00:00

Summary statistics:
Mean daily return: 0.000565
Std daily return: 0.019336
Data quality - NaN values: 0
Data quality - Infinite values: 0
Displaying first 5 rows of log returns:
                AAPL      GOOG     GOOGL      AMZN      AVGO     BRK-B  \
```

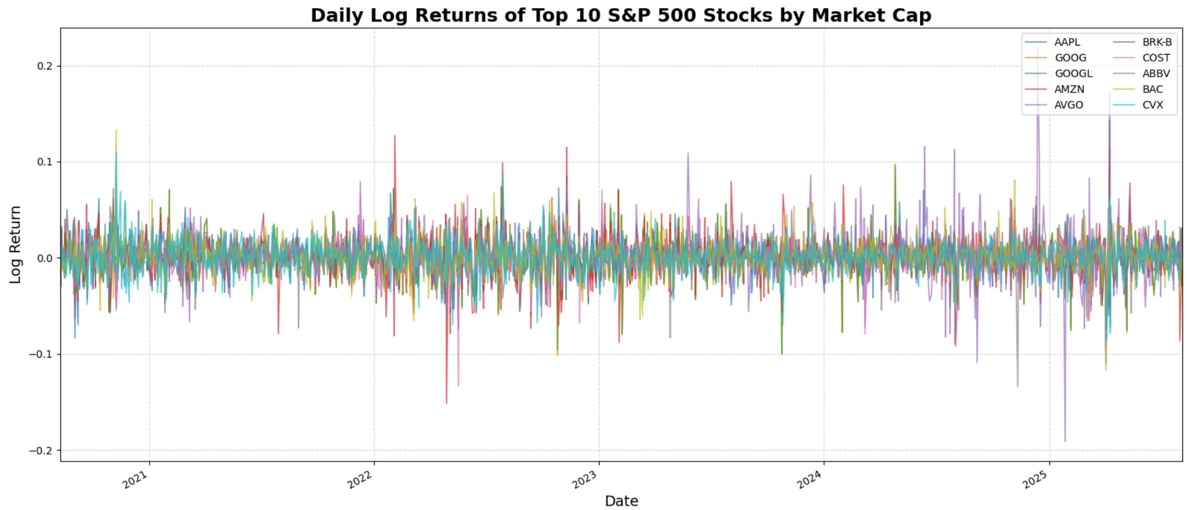
```
Date
2020-08-10  0.014430  0.001077 -0.001035 -0.006112  0.004378  0.014690
2020-08-11 -0.030191 -0.010603 -0.010936 -0.021671 -0.010224  0.000376
2020-08-12  0.032694  0.017610  0.017873  0.026134  0.029226  0.002724
2020-08-13  0.017543  0.007821  0.006224 -0.000386 -0.012729 -0.005926
2020-08-14 -0.000892 -0.007085 -0.007957 -0.004121 -0.004869 -0.004823

                COST      ABBV       BAC       CVX  ...      ACGL         A  \
Date                                                ...
2020-08-10 -0.002673 -0.005828  0.017088  0.033198  ...  0.007360 -0.006567
2020-08-11 -0.022516  0.003134  0.013463 -0.001226  ...  0.003660 -0.008685
2020-08-12  0.012941  0.030186 -0.007083  0.012199  ... -0.007639  0.013717
2020-08-13 -0.003153 -0.008728 -0.014318 -0.009970  ... -0.007389  0.011609
2020-08-14  0.001726  0.004111  0.004544  0.005884  ... -0.003405 -0.014276

                  BR       BRO      DXCM       STZ       AWK       AEE  \
Date
2020-08-10  0.009932 -0.002827 -0.045209 -0.000408 -0.004550  0.012936
2020-08-11  0.039544 -0.005896 -0.024197  0.008248 -0.042209 -0.025426
2020-08-12 -0.021264  0.003061  0.039908  0.015099  0.023936  0.010053
2020-08-13 -0.002015  0.000437  0.017123  0.006361  0.004378 -0.007469
2020-08-14  0.000288  0.000000 -0.023524 -0.003346 -0.008224 -0.001230

                 ADM       AVB
Date
2020-08-10  0.010393 -0.000390
2020-08-11 -0.002250 -0.013485
2020-08-12  0.001351  0.007681
2020-08-13 -0.000450 -0.014558
2020-08-14  0.003595  0.015473

[5 rows x 100 columns]
```



Deliverables

```
# DELIVERABLE 1: prices - Adjusted close price matrix (DataFrame)
print("DELIVERABLE 1: prices")
print("=" * 40)
print(f"Type: {type(prices)}")
print(f"Shape: {prices.shape}")
print(f"Index: {prices.index[0]} to {prices.index[-1]}")
print(f"Columns: {len(prices.columns)} tickers")
print("\nSample data (first 5 rows, first 5 columns):")
display(prices.iloc[:5, :5])

print("\n" + "=" * 40)

# DELIVERABLE 2: log_returns - Daily log returns matrix (DataFrame)
print("DELIVERABLE 2: log_returns")
print("=" * 40)
print(f"Type: {type(log_returns)}")
print(f"Shape: {log_returns.shape}")
print(f"Index: {log_returns.index[0]} to {log_returns.index[-1]}")
print(f"Columns: {len(log_returns.columns)} tickers")
print(f"Formula: r_t = ln(P_t / P_{{t-1}})")
print("\nSample data (first 5 rows, first 5 columns):")
display(log_returns.iloc[:5, :5])
```

```python
print("\n" + "=" * 40)

# DELIVERABLE 3: This notebook - Data preprocessing script
print("DELIVERABLE 3: This notebook")
print("=" * 40)
print("Type: Jupyter Notebook (.ipynb)")
print("Contains all code and comments for data acquisition " +
      "and preprocessing")
```

```
DELIVERABLE 1: prices
========================================
Type: <class 'pandas.core.frame.DataFrame'>
Shape: (1254, 100)
Index: 2020-08-07 00:00:00 to 2025-08-05 00:00:00
Columns: 100 tickers

Sample data (first 5 rows, first 5 columns):
```

Date	AAPL	GOOG	GOOGL	AMZN	AVGO
2020-08-07	108.203766	74.282944	74.471870	158.373001	28.915100
2020-08-10	109.776505	74.362968	74.394836	157.408005	29.041964
2020-08-11	106.511765	73.578644	73.585678	154.033493	28.746538
2020-08-12	110.051590	74.885864	74.912727	158.112000	29.599096
2020-08-13	111.999245	75.473877	75.380417	158.050995	29.224720

```
========================================
DELIVERABLE 2: log_returns
========================================
Type: <class 'pandas.core.frame.DataFrame'>
Shape: (1253, 100)
Index: 2020-08-10 00:00:00 to 2025-08-05 00:00:00
Columns: 100 tickers
Formula: r_t = ln(P_t / P_{t-1})

Sample data (first 5 rows, first 5 columns):
```

Date	AAPL	GOOG	GOOGL	AMZN	AVGO
2020-08-10	0.014430	0.001077	-0.001035	-0.006112	0.004378
2020-08-11	-0.030191	-0.010603	-0.010936	-0.021671	-0.010224
2020-08-12	0.032694	0.017610	0.017873	0.026134	0.029226
2020-08-13	0.017543	0.007821	0.006224	-0.000386	-0.012729
2020-08-14	-0.000892	-0.007085	-0.007957	-0.004121	-0.004869

```
========================================
DELIVERABLE 3: This notebook
========================================
Type: Jupyter Notebook (.ipynb)
Contains all code and comments for data acquisition and preprocessing
```