Ex6b: Time Series Data Analysis and Forecast

```
import numpy as np
import pandas as pd
```

```
df = pd.read_csv("/content/airline-passengers.csv", parse_dates=['Month'],
index_col='Month')
```

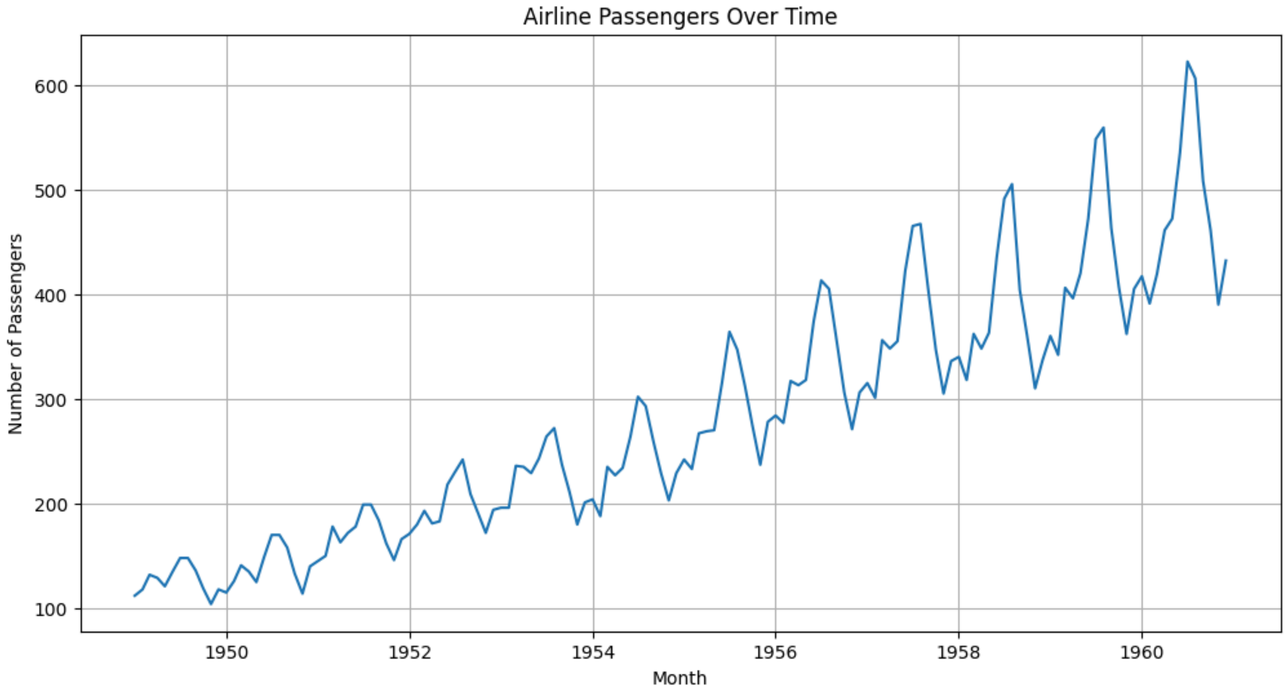
```
display(df.head())
display(df.info())
display(df.describe())
```

	Passengers
Month	
1949-01-01	112
1949-02-01	118
1949-03-01	132
1949-04-01	129
1949-05-01	121

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 144 entries, 1949-01-01 to 1960-12-01
Data columns (total 1 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   Passengers  144 non-null    int64
dtypes: int64(1)
memory usage: 2.2 KB
None
```

	Passengers
count	144.000000
mean	280.298611
std	119.966317
min	104.000000
25%	180.000000
50%	265.500000
75%	360.500000
max	622.000000

```
import matplotlib.pyplot as plt

plt.figure(figsize=(12, 6))
plt.plot(df['Passengers'])
plt.title('Airline Passengers Over Time')
plt.xlabel('Month')
plt.ylabel('Number of Passengers')
plt.grid(True)
plt.show()
```



```
from statsmodels.tsa.stattools import adfuller

result = adfuller(df['Passengers'])
print('ADF Statistic: %f' % result[0])
print('p-value: %f' % result[1])
print('Critical Values:')
for key, value in result[4].items():
    print('\t%s: %.3f' % (key, value))
```

```
ADF Statistic: 0.815369
p-value: 0.991880
Critical Values:
	1%: -3.482
	5%: -2.884
	10%: -2.579
```

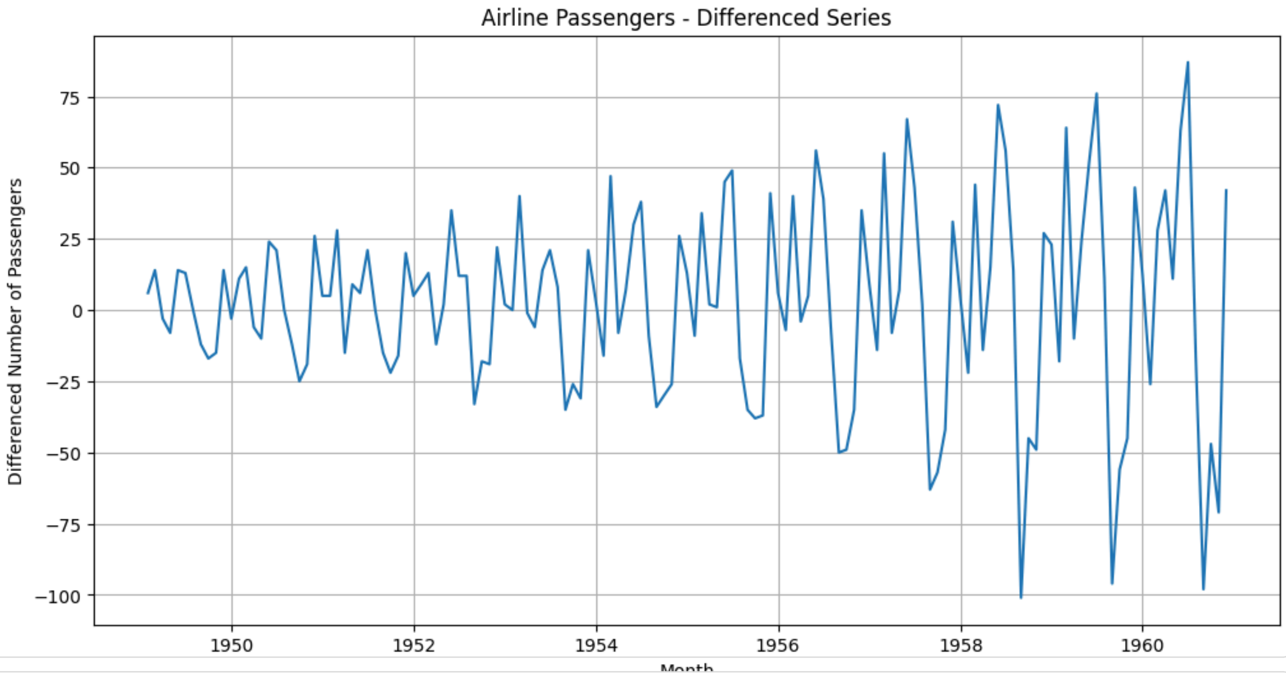
```
df_diff = df['Passengers'].diff().dropna()
display(df_diff.head())

result_diff = adfuller(df_diff)
print('ADF Statistic after differencing: %f' % result_diff[0])
print('p-value after differencing: %f' % result_diff[1])
print('Critical Values after differencing:')
for key, value in result_diff[4].items():
    print('\t%s: %.3f' % (key, value))
```

	Passengers
Month	
1949-02-01	6.0
1949-03-01	14.0
1949-04-01	-3.0
1949-05-01	-8.0
1949-06-01	14.0

dtype: float64

```
ADF Statistic after differencing: -2.829267
p-value after differencing: 0.054213
Critical Values after differencing:
    1%: -3.482
    5%: -2.884
    10%: -2.579
```

```
plt.figure(figsize=(12, 6))
plt.plot(df_diff)
plt.title('Airline Passengers - Differenced Series')
plt.xlabel('Month')
plt.ylabel('Differenced Number of Passengers')
plt.grid(True)
plt.show()
```



```
train_data = df[:-12]
test_data = df[-12:]

print("Training data shape:", train_data.shape)
print("Testing data shape:", test_data.shape)
```

```
Training data shape: (132, 1)
Testing data shape: (12, 1)
```

```
from statsmodels.tsa.arima.model import ARIMA
model = ARIMA(train_data['Passengers'], order=(5, 1, 0))
model_fit = model.fit()
print(model_fit.summary())
```

```
/usr/local/lib/python3.12/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: No frequency information was provi
  self._init_dates(dates, freq)
/usr/local/lib/python3.12/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: No frequency information was provi
  self._init_dates(dates, freq)
/usr/local/lib/python3.12/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: No frequency information was provi
  self._init_dates(dates, freq)
                               SARIMAX Results                                
==============================================================================
Dep. Variable:             Passengers   No. Observations:                  132
Model:                 ARIMA(5, 1, 0)   Log Likelihood                -621.898
Date:                Tue, 16 Sep 2025   AIC                           1255.796
Time:                        10:53:14   BIC                           1273.047
Sample:                    01-01-1949   HQIC                          1262.806
                         - 12-01-1959                                         
Covariance Type:                  opg                                         
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1          0.3005      0.101      2.986      0.003       0.103       0.498
ar.L2         -0.1903      0.096     -1.972      0.049      -0.379      -0.001
ar.L3         -0.0961      0.069     -1.391      0.164      -0.232       0.039
ar.L4         -0.2695      0.083     -3.265      0.001      -0.431      -0.108
ar.L5          0.0643      0.113      0.572      0.568      -0.156       0.285
sigma2       774.4710     98.398      7.871      0.000     581.614     967.328
===================================================================================
Ljung-Box (L1) (Q):                   0.00   Jarque-Bera (JB):                 1.64
Prob(Q):                              0.97   Prob(JB):                         0.44
Heteroskedasticity (H):               7.37   Skew:                             0.21
Prob(H) (two-sided):                  0.00   Kurtosis:                         3.35
===================================================================================

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

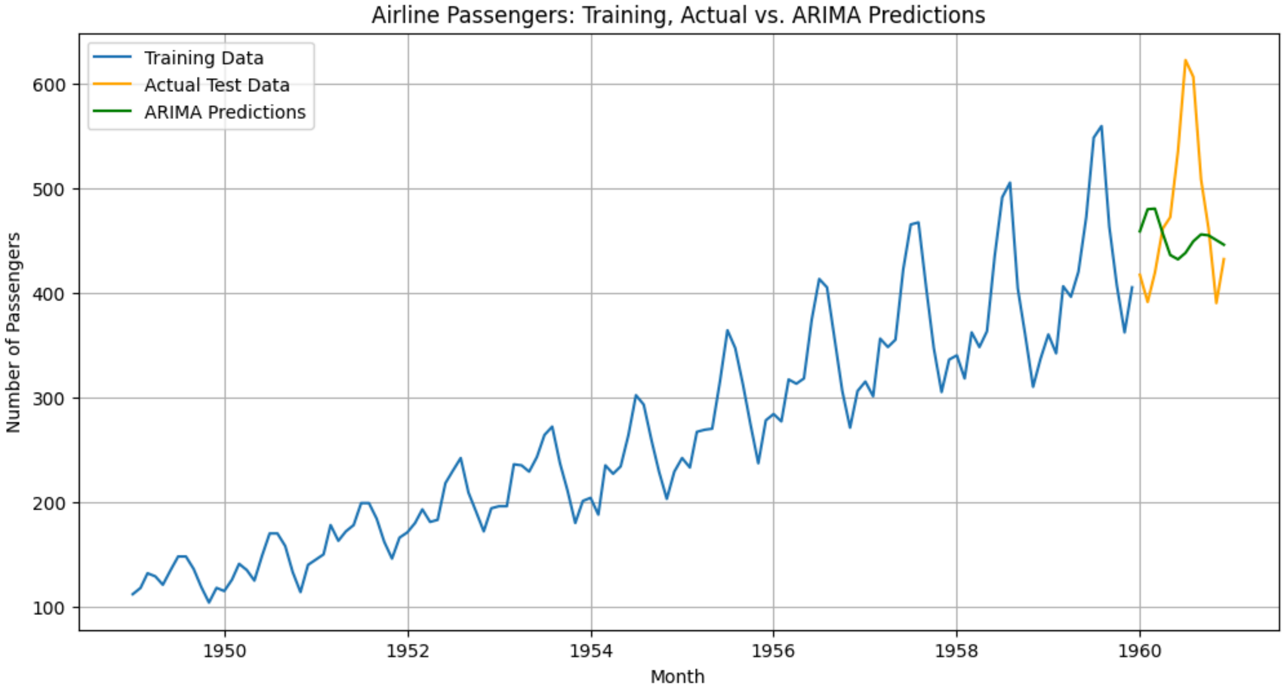
```
predictions = model_fit.predict(start=len(train_data), end=len(df)-1)
print(predictions.head())
```

```
1960-01-01    458.449443
1960-02-01    479.570531
1960-03-01    480.136849
1960-04-01    456.665330
1960-05-01    435.835310
```

```
from sklearn.metrics import mean_squared_error, mean_absolute_error
import numpy as np

mse = mean_squared_error(test_data['Passengers'], predictions)
mae = mean_absolute_error(test_data['Passengers'], predictions)
rmse = np.sqrt(mse)

print(f'MSE: {mse:.3f}')
print(f'MAE: {mae:.3f}')
print(f'RMSE: {rmse:.3f}')
```

```
MSE: 7535.999
MAE: 67.389
RMSE: 86.810
```

```
import matplotlib.pyplot as plt

plt.figure(figsize=(12, 6))
plt.plot(train_data['Passengers'], label='Training Data')
plt.plot(test_data['Passengers'], label='Actual Test Data', color='orange')
plt.plot(predictions, label='ARIMA Predictions', color='green')
plt.title('Airline Passengers: Training, Actual vs. ARIMA Predictions')
plt.xlabel('Month')
plt.ylabel('Number of Passengers')
plt.legend()
plt.grid(True)
plt.show()
```


Airline Passengers: Training, Actual vs. ARIMA Predictions
Training Data
Actual Test Data
ARIMA Predictions
Number of Passengers
Month