In [1]:

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

Airlines

In [2]:

```
df=pd.read_excel('/Users/acer/Sandesh Pal/Data Science Assgn/SVM/Airlines+Data.xlsx')
df
```

Out[2]:

	Month	Passengers
0	1995-01-01	112
1	1995-02-01	118
2	1995-03-01	132
3	1995-04-01	129
4	1995-05-01	121
...	...	...
91	2002-08-01	405
92	2002-09-01	355
93	2002-10-01	306
94	2002-11-01	271
95	2002-12-01	306

96 rows × 2 columns

In [3]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 96 entries, 0 to 95
Data columns (total 2 columns):
 #   Column      Non-Null Count  Dtype         
---  ------      --------------  -----         
 0   Month       96 non-null     datetime64[ns]
 1   Passengers  96 non-null     int64         
dtypes: datetime64[ns](1), int64(1)
memory usage: 1.6 KB
```

In [4]:

```
df.notnull().value_counts()
```

Out[4]:

```
Month  Passengers
True   True          96
dtype: int64
```

In [5]:

```
df.shape
```

Out[5]:

```
(96, 2)
```

In [6]:

```
df.describe()
```

Out[6]:

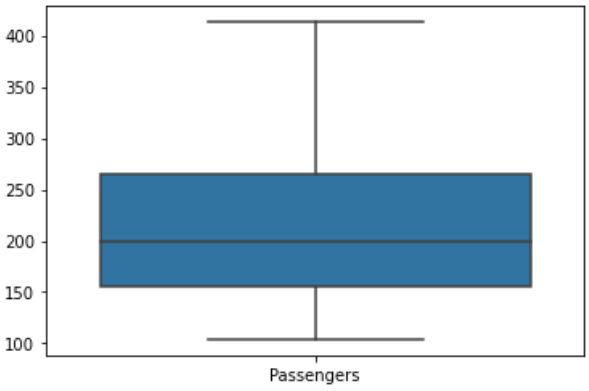
	Passengers
count	96.000000
mean	213.708333
std	71.918216
min	104.000000
25%	156.000000
50%	200.000000
75%	264.750000
max	413.000000

In [7]:

```
sns.boxplot(data=df)
```

Out[7]:

```
<AxesSubplot:>
```



In [8]:

```
df1= df.set_index('Month')
df1
```

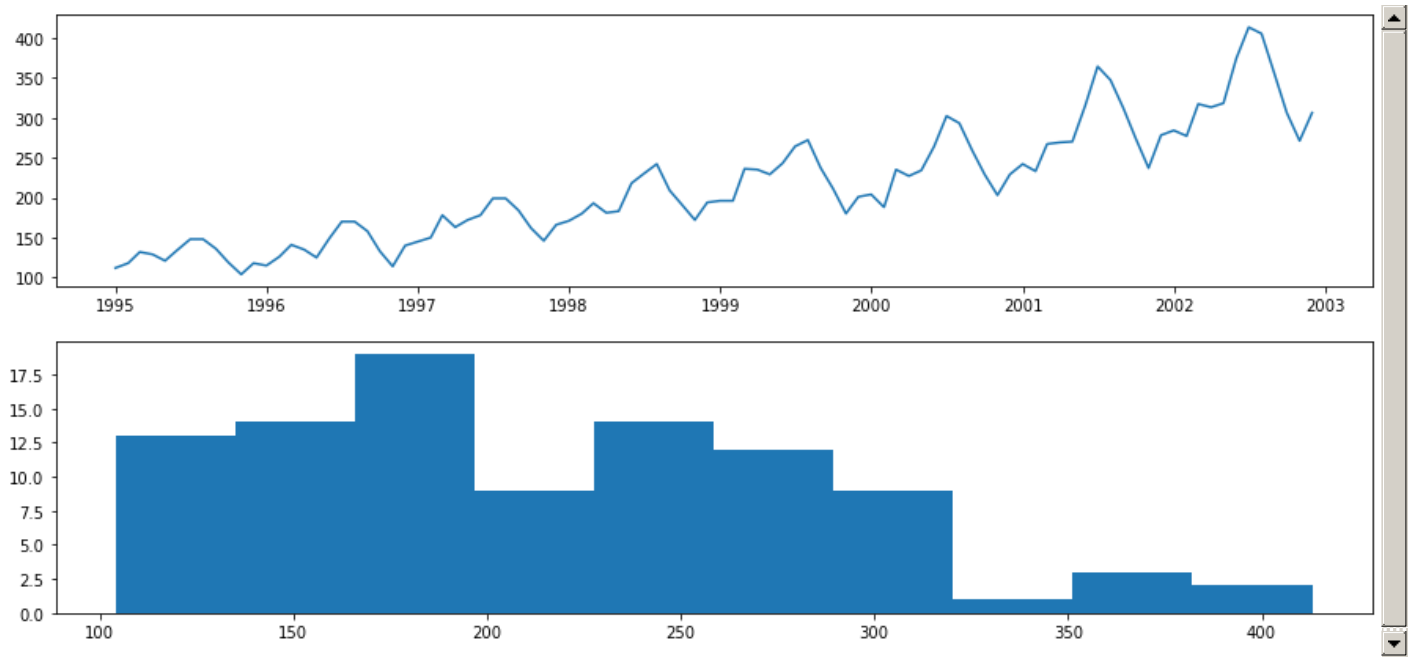
Out[8]:

	Passengers
Month	
1995-01-01	112
1995-02-01	118
1995-03-01	132
1995-04-01	129
1995-05-01	121
...	...
2002-08-01	405
2002-09-01	355
2002-10-01	306
2002-11-01	271
2002-12-01	306

96 rows × 1 columns

In [14]:

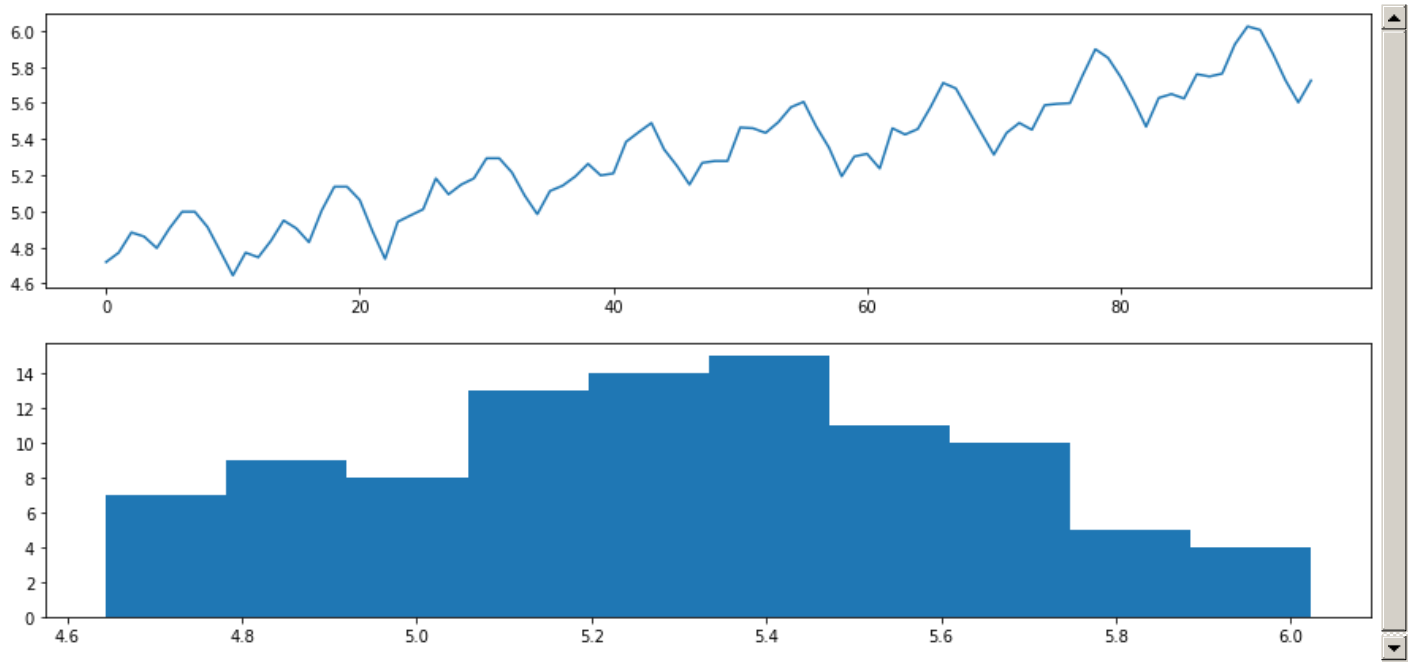
```
plt.figure(figsize=(15,7))
# line plot
plt.subplot(211)
plt.plot(df1)
# histogram
plt.subplot(212)
plt.hist(df1)
plt.show()
```



Log transformation Value

In [15]:

```
from numpy import log
from pandas import DataFrame
dataframe=DataFrame(df1.values)
dataframe.columns=['Passengers']
dataframe['Passengers']=log(dataframe['Passengers'])
dataframe
plt.figure(figsize=(15,7))
# line plot
plt.subplot(211)
plt.plot(dataframe['Passengers'])
# histogram
plt.subplot(212)
plt.hist(dataframe['Passengers'])
plt.show()
```

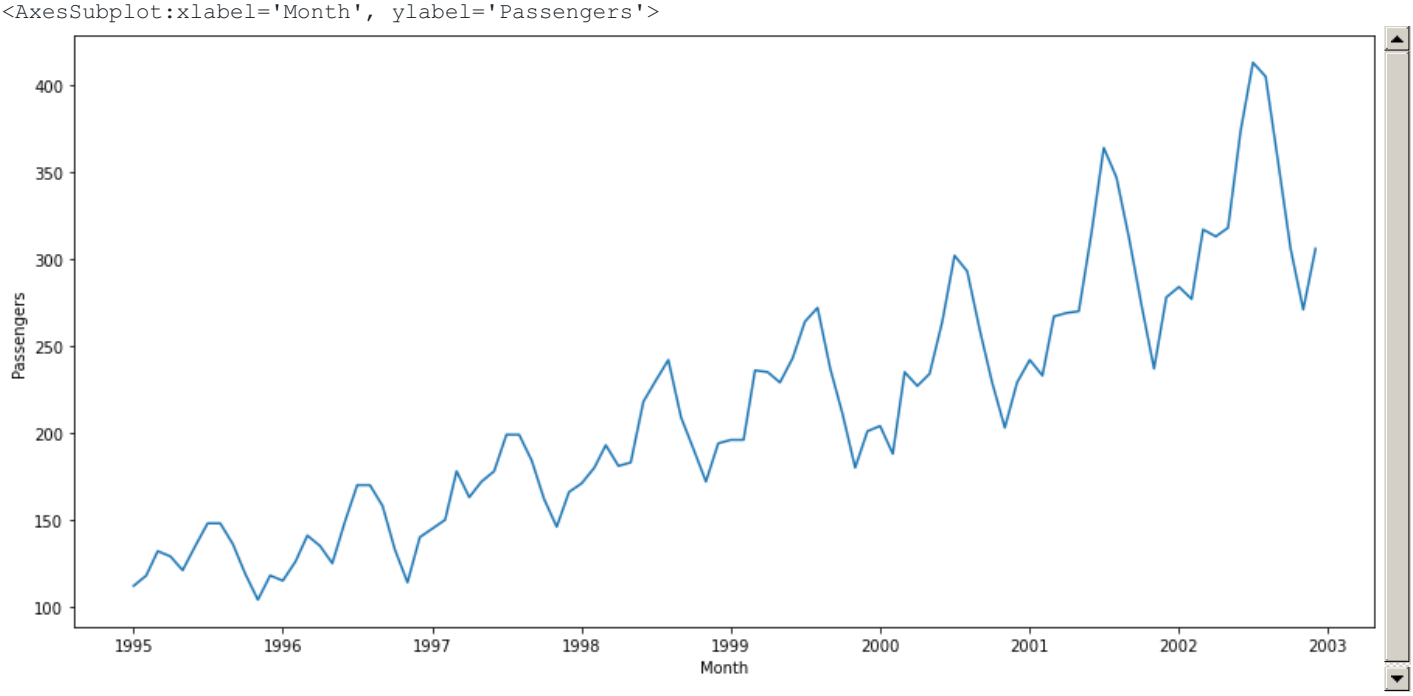


In [16]:

```
plt.figure(figsize=(15,7))
sns.lineplot(x="Month",y="Passengers",data=df1)
```

Out[16]:

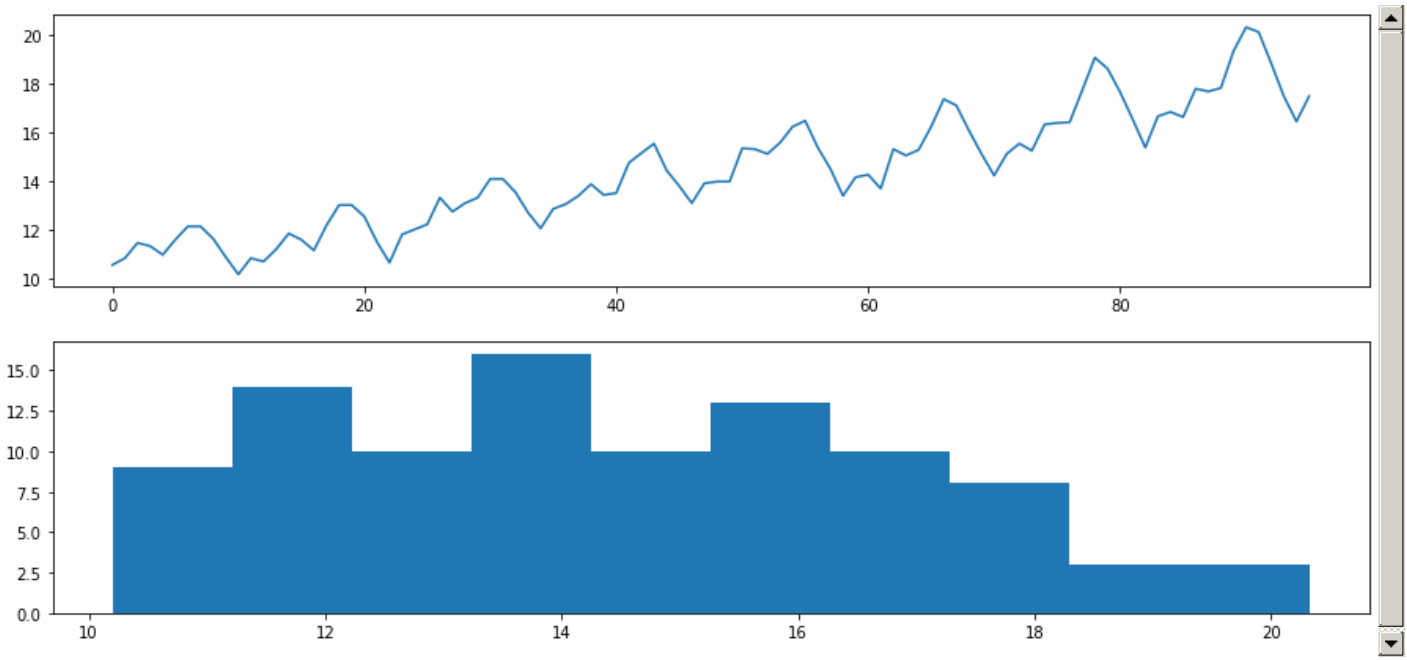
```
<AxesSubplot:xlabel='Month', ylabel='Passengers'>
```



Square root transformation

In [17]:

```
from numpy import sqrt
from pandas import DataFrame
dataframe = DataFrame(df1.values)
dataframe.columns = ['Passengers']
dataframe['Passengers'] = sqrt(dataframe['Passengers'])
plt.figure(figsize=(15,7))
# line plot
plt.subplot(211)
plt.plot(dataframe['Passengers'])
# histogram
plt.subplot(212)
plt.hist(dataframe['Passengers'])
plt.show()
```



In [18]:

```
dataframe
```

Out[18]:

	Passengers
0	10.583005
1	10.862780
2	11.489125
3	11.357817
4	11.000000
...	...
91	20.124612
92	18.841444
93	17.492856
94	16.462078
95	17.492856

96 rows × 1 columns

In [19]:

```
df1["t"] = np.arange(1,97)
df1["t_sq"] = df1["t"]*df1["t"]
df1["log_Passengers"] = np.log(df1["Passengers"])
df1
```

Out[19]:

	Passengers	t	t_sq	log_Passengers
Month				
1995-01-01	112	1	1	4.718499
1995-02-01	118	2	4	4.770685
1995-03-01	132	3	9	4.882802
1995-04-01	129	4	16	4.859812
1995-05-01	121	5	25	4.795791
...	...	...	...	...
2002-08-01	405	92	8464	6.003887
2002-09-01	355	93	8649	5.872118
2002-10-01	306	94	8836	5.723585
2002-11-01	271	95	9025	5.602119
2002-12-01	306	96	9216	5.723585

96 rows × 4 columns

In [20]:

```
Train = df1.head(50)
Test = df1.tail(10)
```

In [21]:

```
#Linear Model
import statsmodels.formula.api as smf
linear_model = smf.ols('Passengers~t',data=Train).fit()
pred_linear = pd.Series(linear_model.predict(pd.DataFrame(Test['t'])))
rmse_linear = np.sqrt(np.mean((np.array(Test['Passengers'])-np.array(pred_linear))**2))
rmse_linear
```

Out[21]:

```
69.76920940351852
```

In [22]:

```
#Exponential
Exp = smf.ols('log_Passengers~t',data=Train).fit()
pred_Exp = pd.Series(Exp.predict(pd.DataFrame(Test['t'])))
rmse_Exp = np.sqrt(np.mean((np.array(Test['Passengers'])-np.array(np.exp(pred_Exp)))**2))
rmse_Exp
```

Out[22]:

```
48.744014057738376
```

In [23]:

```
#Quadratic
Quad = smf.ols('Passengers~t+t_sq',data=Train).fit()
pred_Quad = pd.Series(Quad.predict(Test[["t","t_sq"]]))
rmse_Quad = np.sqrt(np.mean((np.array(Test['Passengers'])-np.array(pred_Quad))**2))
rmse_Quad
```

Out[23]:

```
48.089224091608294
```

In [24]:

```
#Compare the results
data = {"MODEL":pd.Series(["rmse_linear","rmse_Exp","rmse_Quad"]),"RMSE_Values":pd.Series([rmse_linear,rm
table_rmse=pd.DataFrame(data)
table_rmse.sort_values(['RMSE_Values'])
```

Out[24]:

	MODEL	RMSE_Values
2	rmse_Quad	48.089224
1	rmse_Exp	48.744014
0	rmse_linear	69.769209

In [25]:

```
df2 = df1.iloc[:,0:1]
df2
```

Out[25]:

	Passengers
Month	
1995-01-01	112
1995-02-01	118
1995-03-01	132
1995-04-01	129
1995-05-01	121
...	...
2002-08-01	405
2002-09-01	355
2002-10-01	306
2002-11-01	271
2002-12-01	306

96 rows × 1 columns

In [26]:

```
# separate out a validation dataset
split_point = len(df2) - 10
dataset, validation = df2[0:split_point], df2[split_point:]
print('Dataset %d, Validation %d' % (len(dataset), len(validation)))
dataset.to_csv('dataset.csv', header=False)
validation.to_csv('validation.csv', header=False)
```

```
Dataset 86, Validation 10
```

Persistence/ Base model

In [27]:

```
# evaluate a persistence model
from pandas import read_csv
from sklearn.metrics import mean_squared_error
from math import sqrt
# load data
train = read_csv('dataset.csv', header=None, index_col=0, parse_dates=True, squeeze=True)
# prepare data
X = train.values
X = X.astype('float32')
```

```
train_size = int(len(X) * 0.50)
train, test = X[0:train_size], X[train_size:]
```

In [28]:

```
# walk-forward validation
history = [x for x in train]
predictions = list()
for i in range(len(test)):
 yhat = history[-1]
 predictions.append(yhat)
# observation
 obs = test[i]
 history.append(obs)
 print('>Predicted=%.3f, Expected=%.3f' % (yhat, obs))
# report performance
rmse = sqrt(mean_squared_error(test, predictions))
print('RMSE: %.3f' % rmse)
```

```
>Predicted=230.000, Expected=242.000
>Predicted=242.000, Expected=209.000
>Predicted=209.000, Expected=191.000
>Predicted=191.000, Expected=172.000
>Predicted=172.000, Expected=194.000
>Predicted=194.000, Expected=196.000
>Predicted=196.000, Expected=196.000
>Predicted=196.000, Expected=236.000
>Predicted=236.000, Expected=235.000
>Predicted=235.000, Expected=229.000
>Predicted=229.000, Expected=243.000
>Predicted=243.000, Expected=264.000
>Predicted=264.000, Expected=272.000
>Predicted=272.000, Expected=237.000
>Predicted=237.000, Expected=211.000
>Predicted=211.000, Expected=180.000
>Predicted=180.000, Expected=201.000
>Predicted=201.000, Expected=204.000
>Predicted=204.000, Expected=188.000
>Predicted=188.000, Expected=235.000
>Predicted=235.000, Expected=227.000
>Predicted=227.000, Expected=234.000
>Predicted=234.000, Expected=264.000
>Predicted=264.000, Expected=302.000
>Predicted=302.000, Expected=293.000
>Predicted=293.000, Expected=259.000
>Predicted=259.000, Expected=229.000
>Predicted=229.000, Expected=203.000
>Predicted=203.000, Expected=229.000
>Predicted=229.000, Expected=242.000
>Predicted=242.000, Expected=233.000
>Predicted=233.000, Expected=267.000
>Predicted=267.000, Expected=269.000
>Predicted=269.000, Expected=270.000
>Predicted=270.000, Expected=315.000
>Predicted=315.000, Expected=364.000
>Predicted=364.000, Expected=347.000
>Predicted=347.000, Expected=312.000
>Predicted=312.000, Expected=274.000
>Predicted=274.000, Expected=237.000
>Predicted=237.000, Expected=278.000
>Predicted=278.000, Expected=284.000
>Predicted=284.000, Expected=277.000
RMSE: 25.698
```

ARIMA Hyperparameters

In [66]:

```
# grid search ARIMA parameters for a time series

import warnings
from pandas import read_csv
from statsmodels.tsa.arima_model import ARIMA
from sklearn.metrics import mean_squared_error
from math import sqrt


# evaluate an ARIMA model for a given order (p,d,q) and return RMSE
def evaluate_arima_model(X, arima_order):
```

```
# prepare training dataset
    X = X.astype('float32')
    train_size = int(len(X) * 0.50)
    train, test = X[0:train_size], X[train_size:]
    history = [x for x in train]
# make predictions
    predictions = list()
    for t in range(len(test)):
        model = ARIMA(history, order=arima_order)
# model_fit = model.fit(disp=0)
        model_fit = model.fit(disp=0)
        yhat = model_fit.forecast()[0]
        predictions.append(yhat)
        history.append(test[t])
# calculate out of sample error
    rmse = sqrt(mean_squared_error(test, predictions))
    return rmse
```

Grid search for p,d,q values

In [67]:

```
# evaluate combinations of p, d and q values for an ARIMA model
def evaluate_models(dataset, p_values, d_values, q_values):
    dataset = dataset.astype('float32')
    best_score, best_cfg = float('inf'), None
    for p in p_values:
        for d in d_values:
            for q in q_values:
                order = (p,d,q)
                try:
                    rmse = evaluate_arima_model(train, order)
                    if rmse < best_score:
                        best_score, best_cfg = rmse, order
                    print('ARIMA%s RMSE=%.3f' % (order,rmse))
                except:
                    continue
    print('Best ARIMA%s RMSE=%.3f' % (best_cfg, best_score))
```

In [68]:

```
# load dataset
train = read_csv('dataset.csv', header=None, index_col=0, parse_dates=True, squeeze=True)
#evaluate parameters
p_values = range(0, 5)
d_values = range(0, 5)
q_values = range(0, 5)
warnings.filterwarnings("ignore")
evaluate_models(train.values, p_values, d_values, q_values)
```

```
ARIMA(0, 0, 0) RMSE=78.563
ARIMA(0, 0, 1) RMSE=44.789
ARIMA(0, 1, 0) RMSE=25.903
ARIMA(0, 1, 1) RMSE=25.355
ARIMA(0, 1, 2) RMSE=27.772
ARIMA(0, 1, 3) RMSE=23.806
ARIMA(0, 1, 4) RMSE=22.640
ARIMA(0, 2, 0) RMSE=32.474
ARIMA(0, 2, 1) RMSE=26.640
ARIMA(0, 2, 2) RMSE=25.942
ARIMA(0, 2, 3) RMSE=27.914
ARIMA(0, 2, 4) RMSE=25.149
ARIMA(1, 0, 0) RMSE=26.036
ARIMA(1, 0, 1) RMSE=25.282
ARIMA(1, 0, 2) RMSE=465.101
ARIMA(1, 1, 0) RMSE=25.679
ARIMA(1, 2, 0) RMSE=31.603
ARIMA(2, 0, 0) RMSE=25.620
ARIMA(2, 1, 0) RMSE=25.467
ARIMA(2, 2, 0) RMSE=30.414
ARIMA(3, 0, 0) RMSE=25.510
ARIMA(3, 0, 1) RMSE=24.974
ARIMA(3, 1, 0) RMSE=25.648
ARIMA(3, 2, 0) RMSE=30.597
ARIMA(4, 0, 0) RMSE=25.764
ARIMA(4, 1, 0) RMSE=25.344
ARIMA(4, 2, 0) RMSE=29.205
ARIMA(4, 2, 1) RMSE=26.016
Best ARIMA(0, 1, 4) RMSE=22.640
```

Build Model based on the optimized values¶

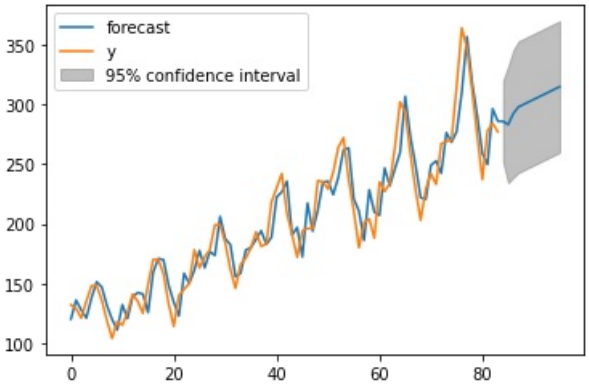
In [69]:

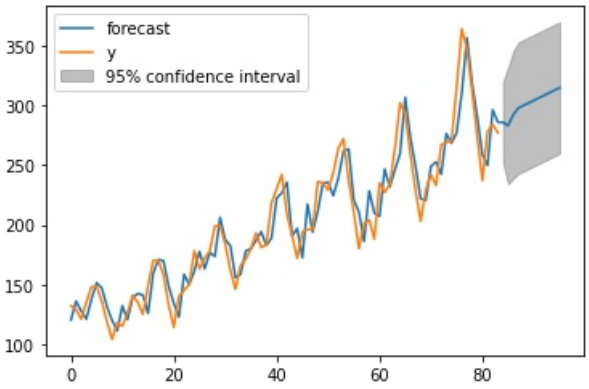
```
# save finalized model to file
from pandas import read_csv
from statsmodels.tsa.arima_model import ARIMA
import numpy

# load data
train = read_csv('dataset.csv', header=0, index_col=0, parse_dates=True)
# prepare data
X = train.values
X = X.astype('float32')

# fit model
model = ARIMA(X, order=(0,1,4))
model_fit = model.fit()
forecast=model_fit.forecast(steps=10)[0]
model_fit.plot_predict(1, 96)
```

Out[69]:





In [70]:

```
#Error on the test data
val=pd.read_csv('validation.csv',header=None)
rmse = sqrt(mean_squared_error(val[1], forecast))
rmse
```

Out[70]:

```
59.81127355081032
```

Combine train and test data and build final model

In [73]:

```
# fit model
df = pd.read_excel('/Users/acer/Sandesh Pal/Data Science Assgn/SVM/Airlines+Data.xlsx')
df1= df.set_index('Month')

# prepare data
X = df1.values
X = X.astype('float32')
```

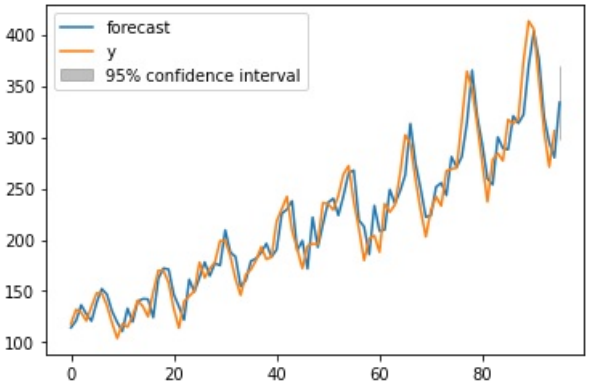
In [74]:

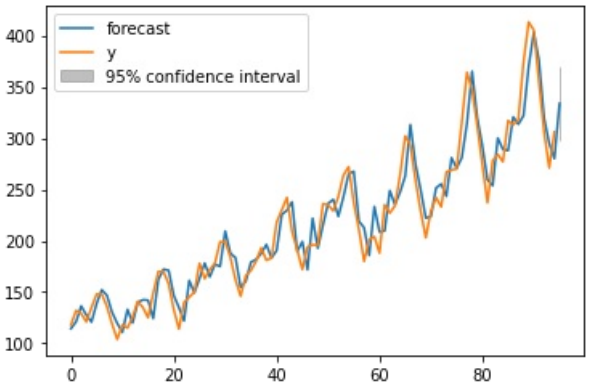
```
model = ARIMA(X, order=(0,1,4))
model_fit = model.fit()
```

In [75]:

```
forecast=model_fit.forecast(steps=10)[0]
model_fit.plot_predict(1,96)
```

Out[75]:





In [76]:

```
forecast
```

Out[76]:

```
array([333.64542033, 338.10561726, 344.4764098 , 334.99091438,
       337.34157055, 339.69222672, 342.0428829 , 344.39353907,
       346.74419524, 349.09485141])
```

In [ ]: