In [1]:

```
import pandas as pd
import numpy as np
from sklearn.decomposition import PCA
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn import preprocessing
import tools as t
```

In [2]:

```
%pylab inline
import scipy.stats
from collections import defaultdict  # default dictionary
plt.style.use('ggplot')
matplotlib.rcParams['figure.figsize'] = (10.0, 8.0)

import numpy as np
```

```
Populating the interactive namespace from numpy and matplotlib
```

In [3]:

```
flights = pd.read_csv("flights.csv")
flights.head()
```

Out[3]:

	YEAR	MONTH	DAY	DAY_OF_WEEK	AIRLINE	FLIGHT_NUMBER	TAIL_NUMBER	ORIGIN
0	2015	1	1	4	AS	98	N407AS	
1	2015	1	1	4	AA	2336	N3KUAA	
2	2015	1	1	4	US	840	N171US	
3	2015	1	1	4	AA	258	N3HYAA	
4	2015	1	1	4	AS	135	N527AS	

5 rows × 34 columns

In [4]:

```
airlines = pd.read_csv("airlines.csv")
```

In [5]:

```
airlines
```

Out[5]:

	IATA_CODE	AIRLINE
0	UA	United Air Lines Inc.
1	AA	American Airlines Inc.
2	US	US Airways Inc.
3	F9	Frontier Airlines Inc.
4	B6	JetBlue Airways
5	OO	Skywest Airlines Inc.
6	AS	Alaska Airlines Inc.
7	NK	Spirit Air Lines
8	WN	Southwest Airlines Co.
9	DL	Delta Air Lines Inc.
10	EV	Atlantic Southeast Airlines
11	HA	Hawaiian Airlines Inc.
12	MQ	American Eagle Airlines Inc.
13	VX	Virgin America

In [6]:

```
airports = pd.read_csv("airports.csv")
```

In [7]:

```
airports
```

Out[7]:

	IATA_CODE	AIRPORT	CITY	STATE	COUNTRY	LATITUDE	LC
0	ABE	Lehigh Valley International Airport	Allentown	PA	USA	40.65236	
1	ABI	Abilene Regional Airport	Abilene	TX	USA	32.41132	
2	ABQ	Albuquerque International Sunport	Albuquerque	NM	USA	35.04022	-
3	ABR	Aberdeen Regional Airport	Aberdeen	SD	USA	45.44906	
4	ABY	Southwest Georgia Regional Airport	Albany	GA	USA	31.53552	
...	...	...	...	...	...	...	
317	WRG	Wrangell Airport	Wrangell	AK	USA	56.48433	-
318	WYS	Westerly State Airport	West Yellowstone	MT	USA	44.68840	
319	XNA	Northwest Arkansas Regional Airport	Fayetteville/Springdale/Rogers	AR	USA	36.28187	
320	YAK	Yakutat Airport	Yakutat	AK	USA	59.50336	-
321	YUM	Yuma International Airport	Yuma	AZ	USA	32.65658	-

322 rows × 7 columns

In [8]:

```
# flights['DepDate'] = pd.to_datetime(flights.YEAR*10000+flights.MONTH*100+flights.DAY,
format='%Y%m%d')
```

In [9]:

```
flights.head()
```

Out[9]:

	YEAR	MONTH	DAY	DAY_OF_WEEK	AIRLINE	FLIGHT_NUMBER	TAIL_NUMBER	ORIGIN
0	2015	1	1	4	AS	98	N407AS	
1	2015	1	1	4	AA	2336	N3KUAA	
2	2015	1	1	4	US	840	N171US	
3	2015	1	1	4	AA	258	N3HYAA	
4	2015	1	1	4	AS	135	N527AS	

5 rows × 34 columns

Cleaning DATA

In [10]:

```
for dataset in flights:
    flights.loc[flights['ARRIVAL_DELAY'] <= -3, 'Status'] = 0
    flights.loc[flights['ARRIVAL_DELAY'] >= -3, 'Status'] = 1
    flights.loc[flights['ARRIVAL_DELAY'] >= 39, 'Status'] = 2
    flights.loc[flights['DIVERTED'] == 1, 'Status'] = 3
    flights.loc[flights['CANCELLED'] == 1, 'Status'] = 4


#Cancellation cause
flights.loc[flights["CANCELLATION_REASON"] =="A", 'CANCELLATION_REASON'] = "0"
flights.loc[flights["CANCELLATION_REASON"] =="B", 'CANCELLATION_REASON'] = "1"
flights.loc[flights["CANCELLATION_REASON"] =="C", 'CANCELLATION_REASON'] = "2"
flights.loc[flights["CANCELLATION_REASON"] =="D", 'CANCELLATION_REASON'] = "3"

# dropping the unwanted data
# flights = flights.drop("Unnamed: 0",1) #Empty
flights = flights.drop("YEAR",1) #Converted to date
flights = flights.drop("DAY",1) #Converted to date
flights = flights.drop("MONTH",1) #Converted to date
flights = flights.drop("DAY_OF_WEEK",1) #Converted to date
flights = flights.drop("DEPARTURE_TIME",1) #Of the departure data we only keep the expe
cted
flights = flights.drop("DEPARTURE_DELAY",1)
flights = flights.drop("ARRIVAL_TIME",1)
flights = flights.drop("SCHEDULED_TIME",1)
flights = flights.drop("ELAPSED_TIME",1)
flights = flights.drop("AIR_TIME",1)
flights = flights.drop("DIVERTED",1)
flights = flights.drop("CANCELLED",1)
flights = flights.drop("DISTANCE",1)
flights = flights.drop("FLIGHT_NUMBER",1)
flights = flights.drop("TAIL_NUMBER",1)
```

Converting All columns to numaric value

In [11]:

```
for i in airlines.index:
    flights.AIRLINE.loc[flights[flights.AIRLINE == airlines.loc[i].IATA_CODE].index] =
i

for i in airports.index:
    flights.ORIGIN_AIRPORT.loc[flights[flights.ORIGIN_AIRPORT == airports.loc[i].IATA_C
ODE].index] = i
    flights.DESTINATION_AIRPORT.loc[flights[flights.DESTINATION_AIRPORT == airports.loc
[i].IATA_CODE].index] = i
```

```
C:\Users\Waqar_Shakeel\anaconda3\lib\site-packages\pandas\core\indexing.p
y:670: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-doc
s/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  self._setitem_with_indexer(indexer, value)
```

In [12]:

```
flights
```

Out[12]:

	AIRLINE	ORIGIN_AIRPORT	DESTINATION_AIRPORT	SCHEDULED_DEPARTURE	TA
0	6	17	277	5	
1	1	176	235	10	
2	2	278	66	20	
3	1	176	203	20	
4	6	277	17	25	
...	...	...	...	...	
1048570	6	121	277	500	
1048571	4	248	166	500	
1048572	4	285	39	500	
1048573	4	285	166	500	
1048574	9	109	216	500	

1048575 rows × 20 columns

In [13]:

```
flights = flights.replace(np.nan,9)
```

In [14]:

```
Y = flights.Y.values
```

In [15]:

```
fl1 = flights.drop('Y', axis=1)
```

In [16]:

```
x = fl1.values
```

Applying PCA for Dimension Reduction

In [17]:

```
pca = PCA()
principalComponents = pca.fit_transform(x)
```

Spliting into Test and Train

In [18]:

```
X_train, X_test, y_train, y_test = train_test_split(principalComponents, Y, test_size=
0.2, random_state=0)
```

Selecting Best Hyperparameters

In [19]:

```
maxi = -1
index = -1
for j in range(20):
    if(j == 0):
        continue
    clf = RandomForestClassifier(max_depth=j, random_state=0)
    clf.fit(X_train, y_train)
    p = clf.predict(X_test)
    count = 0
    for i in range(len(p)):
        if(p[i] == y_test[i]):
            count = count + 1
    accu = count/len(p)
    if(maxi < accu):
        maxi = accu
        index = j
    print(j,count/len(p))
```

```
1 0.9121188279331474
2 0.9490642061845839
3 0.9898528955964047
4 0.9938201845361562
5 0.9985074982714637
6 0.9992847435805736
7 0.9996137615335098
8 0.9997520444412655
9 0.9998474119638557
10 0.9998664854683738
11 0.9998998641012803
12 0.9999284743580573
13 0.9999189376057983
14 0.9999141692296688
15 0.9999284743580573
16 0.9999284743580573
17 0.9999046324774098
18 0.9999141692296688
19 0.9999189376057983
```

In [20]:

```
clf = RandomForestClassifier(max_depth=15, random_state=0)
clf.fit(X_train, y_train)
```

Out[20]:

```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=12, max_features='aut
o',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=100,
                       n_jobs=None, oob_score=False, random_state=0, verbo
se=0,
                       warm_start=False)
```

In [21]:

```
p = clf.predict(X_test)
count = 0
for i in range(len(p)):
    if(p[i] ==y_test[i]):
        count = count + 1
print(count/len(p))
```

```
0.9999284743580573
```

In [22]:

```
t.print_confusion_matrix(p,y_test)
```

Out[22]:

Predicted	**0**	**1**	**2**	**3**	**All**
Actual					
0	79427	0	0	12	79439
1	0	494	0	0	494
2	0	0	7286	0	7286
3	3	0	0	122493	122496
All	79430	494	7286	122505	209715

In [ ]:

```

```

Will flight arrive on time or not?

In [40]:

```
fl2 = flights.drop('ON_TIME', axis=1)
```

In [41]:

```
fl2
```

Out[41]:

	AIRLINE	ORIGIN_AIRPORT	DESTINATION_AIRPORT	SCHEDULED_DEPARTURE	TA
0	6	17	277	5	
1	1	176	235	10	
2	2	278	66	20	
3	1	176	203	20	
4	6	277	17	25	
...	...	...	...	...	
1048570	6	121	277	500	
1048571	4	248	166	500	
1048572	4	285	39	500	
1048573	4	285	166	500	
1048574	9	109	216	500	

1048575 rows × 19 columns

In [42]:

```
x = fl2.values
```

In [43]:

```
Y = flights.ON_TIME.values
```

In [44]:

```
pca = PCA()
principalComponents = pca.fit_transform(x)
```

In [45]:

```
X_train, X_test, y_train, y_test = train_test_split(principalComponents, Y, test_size=
0.2, random_state=0)
```

In [46]:

```
maxi = -1
index = -1
for j in range(20):
    if(j == 0):
        continue
    clf = RandomForestClassifier(max_depth=j, random_state=0)
    clf.fit(X_train, y_train)
    p = clf.predict(X_test)
    count = 0
    for i in range(len(p)):
        if(p[i] == y_test[i]):
            count = count + 1
    accu = count/len(p)
    if(maxi < accu):
        maxi = accu
        index = j
    print(j,count/len(p))
```

```
1 0.947848270271559
2 0.9850654459623776
3 0.9905919938964786
4 0.9964523281596452
5 0.9979257563836635
6 0.9986028657940539
7 0.9991416922966884
8 0.9994707102496245
9 0.9996280666618983
10 0.9997234341844885
11 0.9997615811935245
12 0.9998235700832082
13 0.9998474119638557
14 0.9998426435877262
15 0.9998617170922443
16 0.9998855589728918
17 0.9998807905967623
18 0.9999094008535393
19 0.9998903273490213
```

In [47]:

```
clf2 = RandomForestClassifier(max_depth=18, random_state=0)
clf2.fit(X_train, y_train)
```

Out[47]:

```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=18, max_features='aut
o',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=100,
                       n_jobs=None, oob_score=False, random_state=0, verbo
se=0,
                       warm_start=False)
```

In [48]:

```
p = clf2.predict(X_test)
count = 0
for i in range(len(p)):
    if(p[i] ==y_test[i]):
        count = count + 1
print(count/len(p))
```

```
0.9999094008535393
```

In [49]:

```
t.print_confusion_matrix(p,y_test)
```

Out[49]:

Predicted	**0**	**1**	**All**
Actual			
0	87203	16	87219
1	3	122493	122496
All	87206	122509	209715

In [ ]:

```

```

Will the flight arrival late before departure or not?

In [50]:

```
fl3 = flights.drop('ARRIVAL_DELAY_STATUS', axis=1)
```

In [51]:

```
x = fl2.values
```

In [52]:

```
Y = flights.ARRIVAL_DELAY_STATUS.values
```

In [53]:

```
pca = PCA()
principalComponents = pca.fit_transform(x)
```

In [54]:

```
X_train, X_test, y_train, y_test = train_test_split(principalComponents, Y, test_size=
0.2, random_state=0)
```

In [55]:

```
maxi = -1
index = -1
for j in range(20):
    if(j == 0):
        continue
    clf = RandomForestClassifier(max_depth=j, random_state=0)
    clf.fit(X_train, y_train)
    p = clf.predict(X_test)
    count = 0
    for i in range(len(p)):
        if(p[i] == y_test[i]):
            count = count + 1
    accu = count/len(p)
    if(maxi < accu):
        maxi = accu
        index = j
    print(j,count/len(p))
```

```
1 0.9273299477862814
2 0.9747895954032854
3 0.990549078511313
4 0.996833798250006
5 0.9979829768972176
6 0.9987363803256801
7 0.9992513649476671
8 0.9994468683689769
9 0.9996137615335098
10 0.9997329709367475
11 0.9997949598264311
12 0.9998378752115967
13 0.9998474119638557
14 0.9998521803399852
15 0.9998664854683738
16 0.9998903273490213
17 0.9998712538445033
18 0.9998807905967623
19 0.9998855589728918
```

In [56]:

```
clf2 = RandomForestClassifier(max_depth=19, random_state=0)
clf2.fit(X_train, y_train)
```

Out[56]:

```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=16, max_features='aut
o',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=100,
                       n_jobs=None, oob_score=False, random_state=0, verbo
se=0,
                       warm_start=False)
```

In [57]:

```
p = clf2.predict(X_test)
count = 0
for i in range(len(p)):
    if(p[i] ==y_test[i]):
        count = count + 1
print(count/len(p))
```

```
0.9998903273490213
```

In [58]:

```
t.print_confusion_matrix(p,y_test)
```

Out[58]:

Predicted	0	1	All
Actual			
0	130276	0	130276
1	23	79416	79439
All	130299	79416	209715

In [ ]:

```

```

Predict Value of Taxi Out on the basis of Taxi In (Linear Regression)

In [ ]:

```
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
import matplotlib.pyplot as plt  # To visualize
```

In [322]:

```
Xw = fd.iloc[:, 13].values#.reshape(-1, 1)  # values converts it into a numpy array
Yw = fd.iloc[:, 18].values#.reshape(-1, 1)
d = fd.dropna()

Xw = d.iloc[:, 13].values#.reshape(-1, 1)  # values converts it into a numpy array
Yw = d.iloc[:, 18].values#.reshape(-1, 1)

# Xw = [3 if np.isnan(i) else i for i in Xw]
# Yw = [3 if np.isnan(i) else i for i in Yw]
Xw = np.array(Xw).reshape(-1,1)
Yw = np.array(Yw).reshape(-1,1)
```

In [323]:

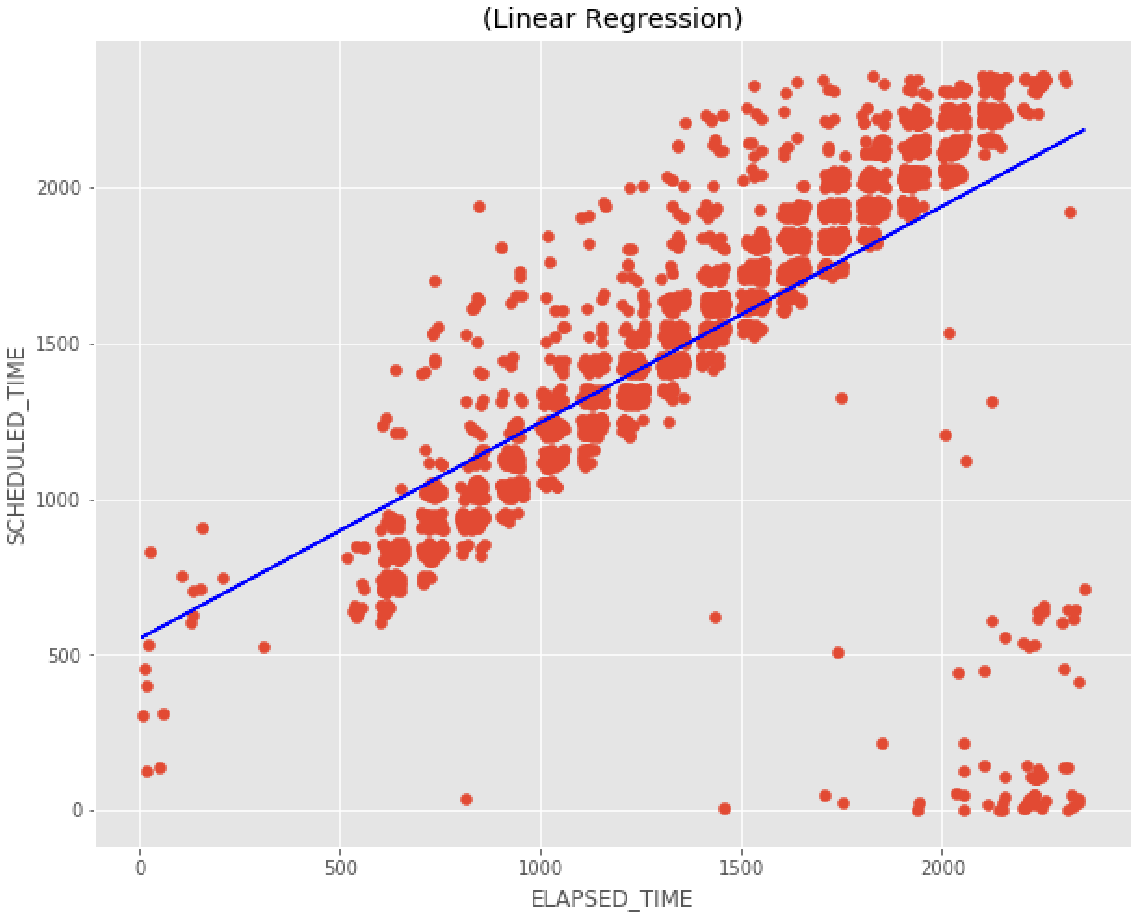
```
X_trai, X_tes, y_trai, y_tes = train_test_split(Xw, Yw, test_size=0.2, random_state=0)
```

In [324]:

```
linear_regressor = LinearRegression()
linear_regressor.fit(X_trai, y_trai)
Y_pred = linear_regressor.predict(X_trai)
```

In [325]:

```
plt.scatter(X_trai, y_trai)
plt.plot(X_trai, Y_pred, color='b')
plt.title('(Linear Regression)')
plt.xlabel('ELAPSED_TIME')
plt.ylabel('SCHEDULED_TIME')
plt.show()
plt.show()
```



In [ ]:

Relation of Scheduled as Elapsed Time

In [326]:

```
d = fd.dropna()

Xz = d.iloc[:, 14].values#.reshape(-1, 1)  # values converts it into a numpy array
Yz = d.iloc[:, 15].values#.reshape(-1, 1)

# Xw = [3 if np.isnan(i) else i for i in Xw]
# Yw = [3 if np.isnan(i) else i for i in Yw]
Xz = np.array(Xz).reshape(-1,1)
Yz = np.array(Yz).reshape(-1,1)
```

In [327]:

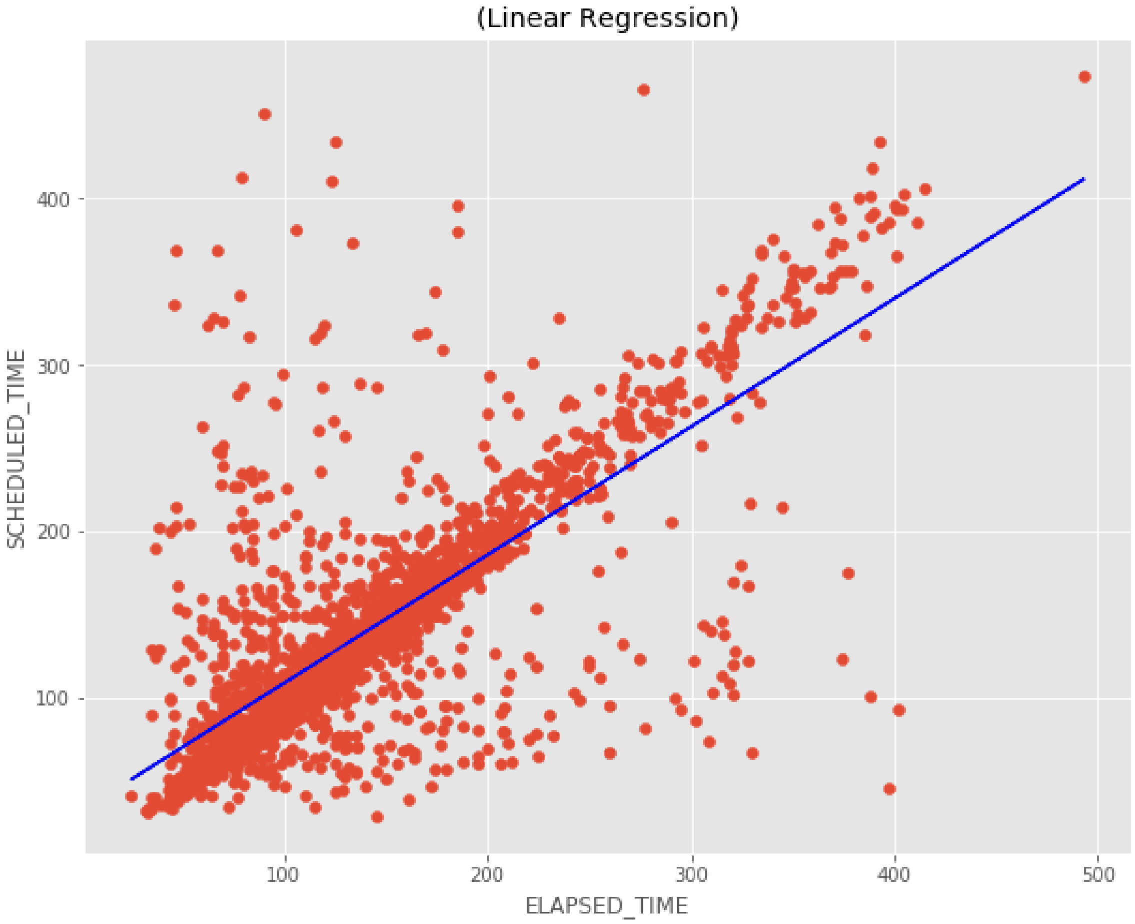
```
X_trai, X_tes, y_trai, y_tes = train_test_split(Xz, Yz, test_size=0.2, random_state=0)
```

In [328]:

```
linear_regressor = LinearRegression()
linear_regressor.fit(X_trai, y_trai)
Y_pred = linear_regressor.predict(X_trai)
```

In [329]:

```
plt.scatter(X_trai, y_trai)
plt.plot(X_trai, Y_pred, color='b')
plt.title('(Linear Regression)')
plt.xlabel('ELAPSED_TIME')
plt.ylabel('SCHEDULED_TIME')
plt.show()
```



In [330]:

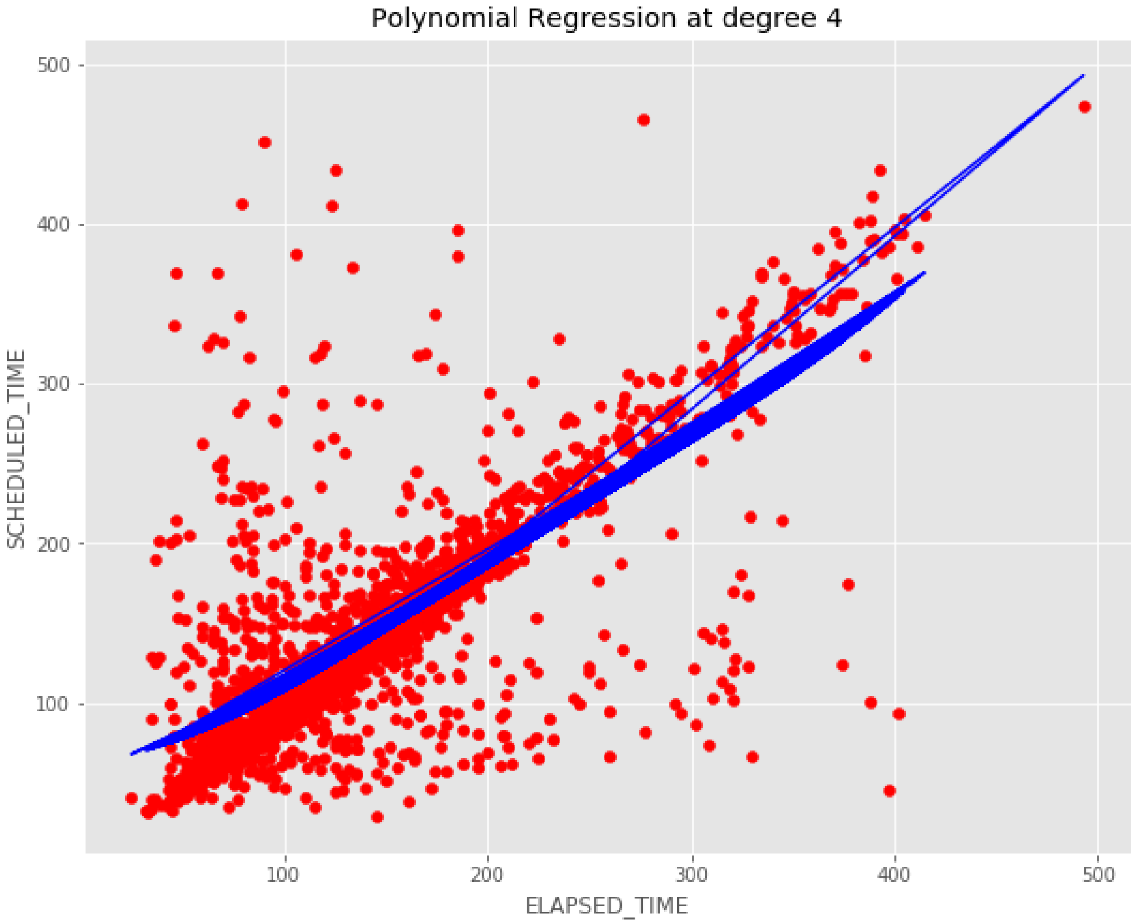
```
poly_reg=PolynomialFeatures(degree=4)
X_poly=poly_reg.fit_transform(X_trai)
poly_reg.fit(X_poly,y_trai)
lin_reg2=LinearRegression()
lin_reg2.fit(X_poly,y_trai)
```

Out[330]:

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=F
alse)
```

In [331]:

```
plt.scatter(X_trai,y_trai,color='red')
plt.plot(X_trai,lin_reg2.predict(poly_reg.fit_transform(X_trai)),color='blue')
plt.title('Polynomial Regression at degree 4')
plt.xlabel('ELAPSED_TIME')
plt.ylabel('SCHEDULED_TIME')
plt.show()
```



In [ ]:

```
```

Check with Different Degrees

In [332]:

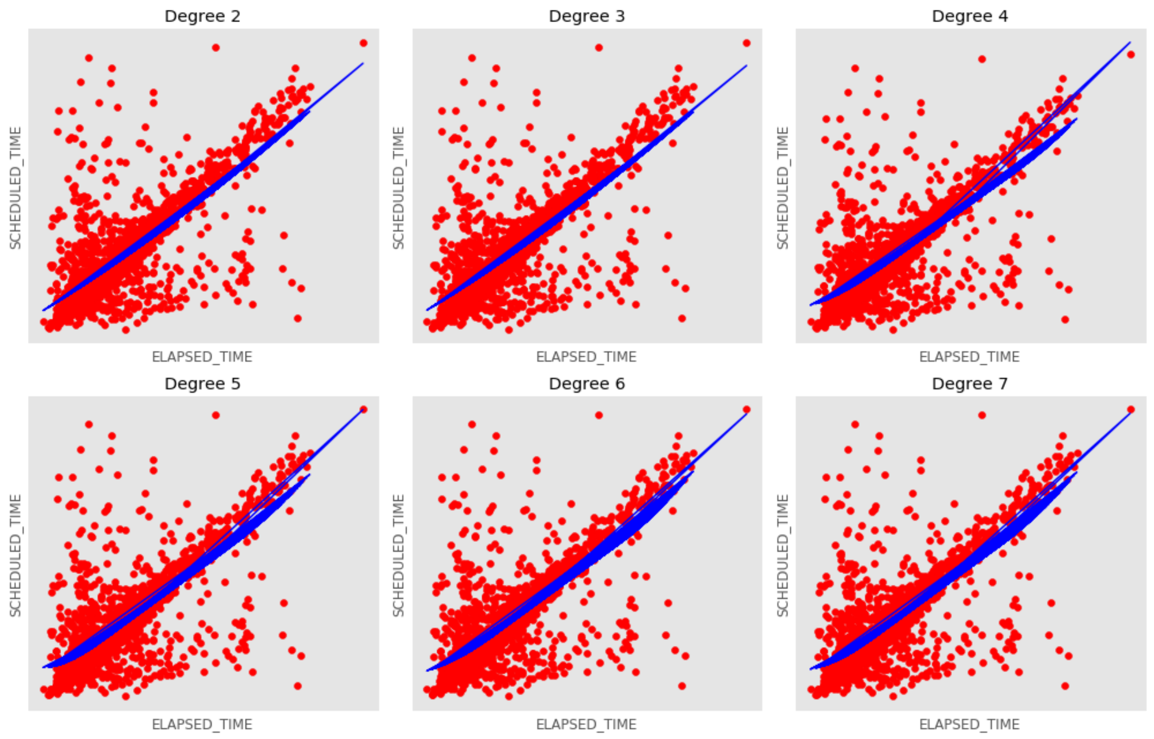
```python
degrees = [2, 3, 4, 5, 6, 7]

plt.figure(figsize=(14, 9))
for i in range(len(degrees)):
    ax = plt.subplot(2, 3, i + 1)
    plt.setp(ax, xticks=(), yticks=())

    poly_reg=PolynomialFeatures(degree=degrees[i])
    X_poly=poly_reg.fit_transform(X_trai)
    poly_reg.fit(X_poly,y_trai)
    lin_reg2=LinearRegression()
    lin_reg2.fit(X_poly,y_trai)

    plt.scatter(X_trai,y_trai,color='red')
    plt.plot(X_trai,lin_reg2.predict(poly_reg.fit_transform(X_trai)),color='blue')
    plt.title("Degree " + str(degrees[i]))
    plt.xlabel('ELAPSED_TIME')
    plt.ylabel('SCHEDULED_TIME')

plt.tight_layout()
plt.show()
```



Degree 2

Degree 3

Degree 4

Degree 5

Degree 6

Degree 7

In [ ]: