Flight Delay (JAN 2015)

In [ ]:

```
import pandas as pd
import numpy as np
import scipy
import scipy.stats as st
import matplotlib.pyplot as plt
# allows for plots to always be displayed in Jupyter notebook
%matplotlib inline
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LinearRegression,Ridge
from sklearn.metrics import mean_absolute_error,mean_squared_error,r2_score
```

In [ ]:

```
# Upload airlines.csv, airpots.csv, flights.csv
from google.colab import files
csvFiles = files.upload()
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving airlines.csv to airlines.csv
Saving airports.csv to airports.csv
Saving flights.csv to flights.csv
```

In [ ]:

```
# Read file
airlines_data = pd.read_csv('airlines.csv')
airports_data = pd.read_csv('airports.csv')
flights_data = pd.read_csv('flights.csv')
```

In [ ]:

```
# Visualize Data
airlines_data
```

Out[ ]:

	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 [ ]:

```
# Visualize Data
airports_data
```

Out[ ]:

	IATA_CODE	AIRPORT	CITY	STATE	COUNTRY	LATITUDE	LONGITUDE
0	ABE	Lehigh Valley International Airport	Allentown	PA	USA	40.65236	-75.44040
1	ABI	Abilene Regional Airport	Abilene	TX	USA	32.41132	-99.68190
2	ABQ	Albuquerque International Sunport	Albuquerque	NM	USA	35.04022	-106.60919
3	ABR	Aberdeen Regional Airport	Aberdeen	SD	USA	45.44906	-98.42183
4	ABY	Southwest Georgia Regional Airport	Albany	GA	USA	31.53552	-84.19447
...	...	...	...	...	...	...	...
317	WRG	Wrangell Airport	Wrangell	AK	USA	56.48433	-132.36982
318	WYS	Westerly State Airport	West Yellowstone	MT	USA	44.68840	-111.11764
319	XNA	Northwest Arkansas Regional Airport	Fayetteville/Springdale/Rogers	AR	USA	36.28187	-94.30681
320	YAK	Yakutat Airport	Yakutat	AK	USA	59.50336	-139.66023
321	YUM	Yuma International Airport	Yuma	AZ	USA	32.65658	-114.60597

322 rows × 7 columns

In [ ]:

```
# Visualize Data
flights_data
```

Out[ ]:

	MONTH	DAY	AIRLINE	ORIGIN_AIRPORT	DESTINATION_AIRPORT	SCHEDULED_DEPARTURE
0	1	1	AS	ANC	SEA	5
1	1	1	AA	LAX	PBI	10
2	1	1	US	SFO	CLT	20
3	1	1	AA	LAX	MIA	20
4	1	1	AS	SEA	ANC	25
...	...	...	...	...	...	...
469963	1	31	B6	JFK	BQN	2359
469964	1	31	DL	SEA	DTW	2359
469965	1	31	F9	DEN	TPA	2359
469966	1	31	F9	DEN	ATL	2359
469967	1	31	UA	ANC	DEN	2359

469968 rows × 27 columns

In [ ]:

```python
# The column names as indices.
# The two brackets are required because you are passing a list of columns
loc_data = airports_data[['LATITUDE', 'LONGITUDE']]
loc_data
```

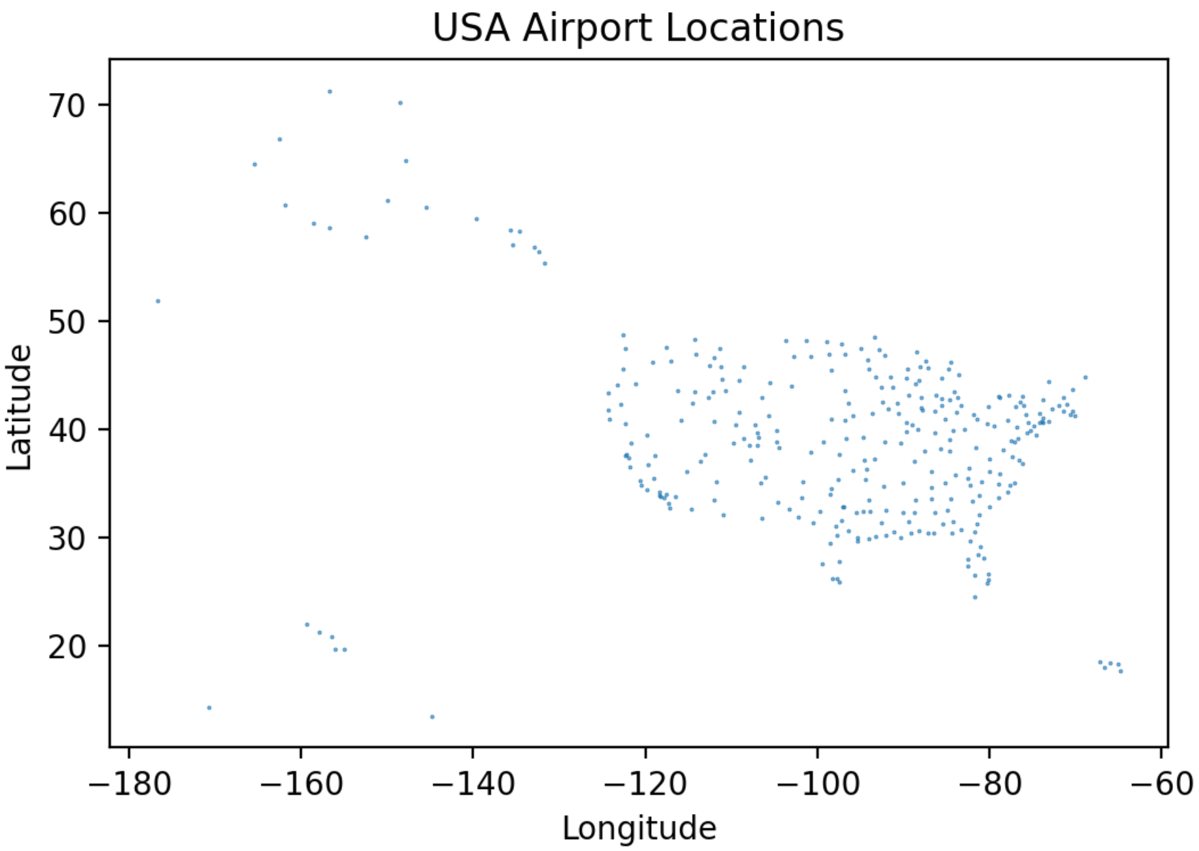
Out[ ]:

	LATITUDE	LONGITUDE
0	40.65236	-75.44040
1	32.41132	-99.68190
2	35.04022	-106.60919
3	45.44906	-98.42183
4	31.53552	-84.19447
...	...	...
317	56.48433	-132.36982
318	44.68840	-111.11764
319	36.28187	-94.30681
320	59.50336	-139.66023
321	32.65658	-114.60597

322 rows × 2 columns

In [ ]:

```python
fig, ax = plt.subplots()
# s=0.1 specifies the size
ax.scatter(loc_data.LONGITUDE, loc_data.LATITUDE, s=0.1)
ax.set_title('USA Airport Locations')
ax.set_xlabel('Longitude')
ax.set_ylabel('Latitude');
fig.set_dpi(200)
```



In [ ]:

```
# [['ARRIVAL_DELAY','DEPARTURE_DELAY']] shows dataframe of delays
df = flights_data[['DESTINATION_AIRPORT','ARRIVAL_DELAY','DEPARTURE_DELAY']]
# adding .DESTINATION_AIRPORT at the end creates the rows to be CALLABLE
airports = df.DESTINATION_AIRPORT
```

In [ ]:

```
# The following calculates the mean of all columns
# and groups all similar names i.e. airports under the same group
delay_mean = df.groupby(airports).mean()

delay_mean
```

Out[ ]:

	ARRIVAL_DELAY	DEPARTURE_DELAY
DESTINATION_AIRPORT		
ABE	4.166667	4.044586
ABI	12.361233	10.643172
ABQ	5.538857	8.567949
ABR	-3.716667	7.524590
ABY	6.812500	9.753086
...	...	...
VPS	3.793566	7.566489
WRG	9.300000	15.393443
XNA	14.845528	14.817568
YAK	-5.525424	-3.466667
YUM	6.484848	3.866667

312 rows × 2 columns

In [ ]:

```
# .sort_values will sort alphabetically the column specified in a csv file
key_array = flights_data.sort_values(['DESTINATION_AIRPORT'])
# adding .IATA_CODE at the end creates the rows to be CALLABLE
key_array = key_array.DESTINATION_AIRPORT

# .values allows for the mean values of arrival delay to be callable
mean_arr_array = delay_mean[['ARRIVAL_DELAY']].values[:,0]
# .around will round up values throughout the entire array
mean_arr_array = np.around(mean_arr_array, decimals=2)

# .values allows for the mean values of departure delay to be callable
mean_dep_array = delay_mean[['DEPARTURE_DELAY']].values[:,0]
# .around will round up values throughout the entire array
mean_dep_array = np.around(mean_dep_array, decimals=2)
```

In [ ]:

```
# .sort_values will sort alphabetically the column specified in a csv file
key_array = flights_data.sort_values(['DESTINATION_AIRPORT'])
# adding .IATA_CODE at the end creates the rows to be CALLABLE
key_array = key_array.DESTINATION_AIRPORT
# drops any duplicates
key_array = key_array.drop_duplicates(keep = 'last')
key_array
```

Out[ ]:

```
278297    ABE
117844    ABI
356705    ABQ
9034      ABR
303884    ABY
         ...
70454     VPS
150236    WRG
148691    XNA
461870    YAK
106376    YUM
Name: DESTINATION_AIRPORT, Length: 312, dtype: object
```

In [ ]:

```python
# airports_data['IATA_CODE'] and key_array should have the same # of airports
# printing both shows discrepancies of the two lists
airports_data['IATA_CODE']
```

Out[ ]:

```
0      ABE
1      ABI
2      ABQ
3      ABR
4      ABY
      ...
317    WRG
318    WYS
319    XNA
320    YAK
321    YUM
Name: IATA_CODE, Length: 322, dtype: object
```

In [ ]:

```python
# air_flightsdata and air_airportsdata creates a list of the airports from the csv fil
air_flightsdata = flights_data['DESTINATION_AIRPORT'].sort_values()
air_airportsdata = airports_data['IATA_CODE']
# coordinate data of airports
longitude_coor = airports_data['LONGITUDE']
latitude_coor = airports_data['LATITUDE']
```

In [ ]:

```python
# removal of duplications
air_flightsdata = air_flightsdata.drop_duplicates()
```

In [ ]:

```python
# the variables are created into lists
# a for loop goes through the data in the airport csv file and checks if
# it is amongst the flights csv file. Any airport that does not match has the index st
# .count(example) checks if the example is found in the list interested in
removeindex = []
air_airportsdata = list(air_airportsdata)
air_flightsdata = list(air_flightsdata)
longitude_coor = list(longitude_coor)
latitude_coor = list(latitude_coor)
for i in range(len(air_airportsdata)):
  if air_flightsdata.count(air_airportsdata[i]) < 1:
    removeindex.append(i)
removeindex
```

Out[ ]:

```
[5, 13, 29, 30, 89, 133, 147, 161, 219, 318]
```

In [ ]:

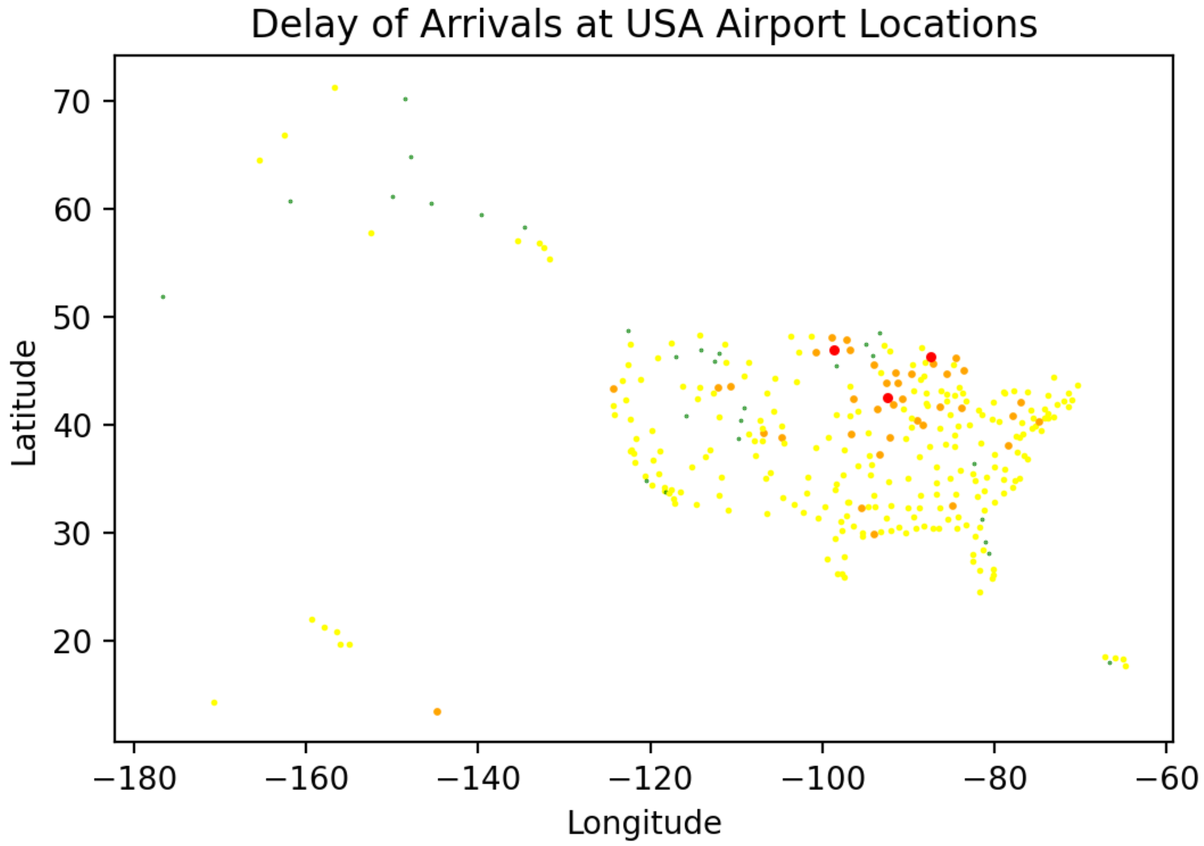
```
# the loop uses the stored index from the previous code block
# removing airports that are not shared between the two csv sheets
for i in range(len(removeindex)):
  k = removeindex[i] - i
  air_airportsdata.remove(air_airportsdata[k])
  longitude_coor.remove(longitude_coor[k])
  latitude_coor.remove(latitude_coor[k])
```

In [ ]:

```
# dictionary created for airport stats
airport_stats = {}
i = 0
for key in key_array:
  airport_stats[key] = {'Mean Arrival Delay': mean_arr_array[i], 'Mean Departure Delay
                        'LONGITUDE': longitude_coor[i], 'LATITUDE': latitude_coor[i]}
  i += 1
```

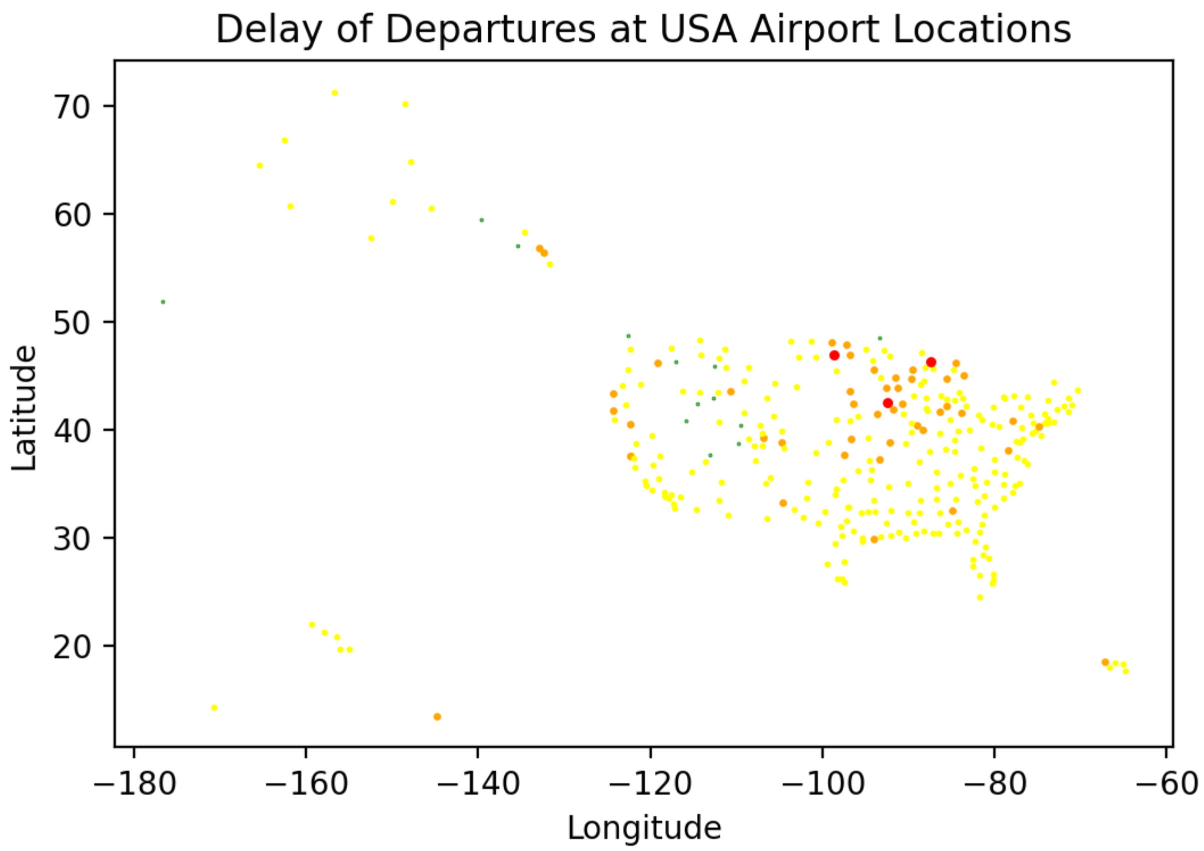
In [ ]:

```
# Arrival Delay Figure
fig, ax = plt.subplots()
# s=0.2 specifies the size
for key in key_array:
  if airport_stats[key]['Mean Arrival Delay'] <= 0:
    ax.scatter(airport_stats[key]['LONGITUDE'], airport_stats[key]['LATITUDE'], s=0.1,
  elif airport_stats[key]['Mean Arrival Delay'] <= 15:
    ax.scatter(airport_stats[key]['LONGITUDE'], airport_stats[key]['LATITUDE'], s=1,
  elif airport_stats[key]['Mean Arrival Delay'] <= 30:
    ax.scatter(airport_stats[key]['LONGITUDE'], airport_stats[key]['LATITUDE'], s=2,
  else:
    ax.scatter(airport_stats[key]['LONGITUDE'], airport_stats[key]['LATITUDE'], s=5,
ax.set_title('Delay of Arrivals at USA Airport Locations')
ax.set_xlabel('Longitude')
ax.set_ylabel('Latitude');
fig.set_dpi(200)
```



In [ ]:

```
# Departure Delay Figure
fig, ax = plt.subplots()
# s=0.2 specifies the size
for key in key_array:
  if airport_stats[key]['Mean Departure Delay'] <= 0:
    ax.scatter(airport_stats[key]['LONGITUDE'], airport_stats[key]['LATITUDE'], s=0.1,
  elif airport_stats[key]['Mean Departure Delay'] <= 15:
    ax.scatter(airport_stats[key]['LONGITUDE'], airport_stats[key]['LATITUDE'], s=1, c
  elif airport_stats[key]['Mean Departure Delay'] <= 30:
    ax.scatter(airport_stats[key]['LONGITUDE'], airport_stats[key]['LATITUDE'], s=2, c
  else:
    ax.scatter(airport_stats[key]['LONGITUDE'], airport_stats[key]['LATITUDE'], s=5, c
ax.set_title('Delay of Departures at USA Airport Locations')
ax.set_xlabel('Longitude')
ax.set_ylabel('Latitude');
fig.set_dpi(200)
```



```
In [ ]: # [['AIRLINE']] shows dataframe of airlines
        df = flights_data[['AIRLINE', 'DEPARTURE_DELAY']]

        # adding .AIRLINE at the end creates the rows to be CALLABLE
        airlines = df.AIRLINE
```

```
In [ ]: # The following calculates the mean of all columns
        # and groups all similar names i.e. airlines under the same group
        dep_delay_mean = df.groupby(airlines).mean()
```

```
In [ ]: # .sort_values will sort alphabetically the column specified in a csv file
        key_array = airlines_data.sort_values(['IATA_CODE'])
        # adding .IATA_CODE at the end creates the rows to be CALLABLE
        key_array = key_array.IATA_CODE

        # .values allows for the mean values of departure delay to be callable
        mean_val_array = dep_delay_mean[['DEPARTURE_DELAY']].values[:,0]
        # .around will round up values throughout the entire array
        mean_val_array = np.around(mean_val_array, decimals=2)
```

```
In [ ]: # The LHS creates a new column, restoring it with the cancelled flights from flights.c
        df['CANCELLED'] = flights_data['CANCELLED']
        # remove departure delay
        df = df.drop(['DEPARTURE_DELAY'], axis = 1)
```

```
<ipython-input-24-dc92ab280789>:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
er_guide/indexing.html#returning-a-view-versus-a-copy
  df['CANCELLED'] = flights_data['CANCELLED']
```

In [ ]:

```
# The following sums the total for all columns
# and groups all similar names i.e. airlines under the same group
canceled_flight_sum = df.groupby(airlines).sum()
```

In [ ]:

```
# .values allows for the sum values of cancelled flights to be callable
sum_val_array = canceled_flight_sum [['CANCELLED']].values[:,0]
# .around will round up values throughout the entire array
sum_val_array = np.around(sum_val_array, decimals=2)
```

In [ ]:

```
# Loop through each key and adds to an empty dictionary
# adding the appropriate stats for each key
airline_stats = {}
i = 0
for key in key_array:
  airline_stats[key] = {'Mean Departure Delay': mean_val_array[i],
            'Cancelled Flights': sum_val_array[i]}
  i += 1
```

In [ ]:

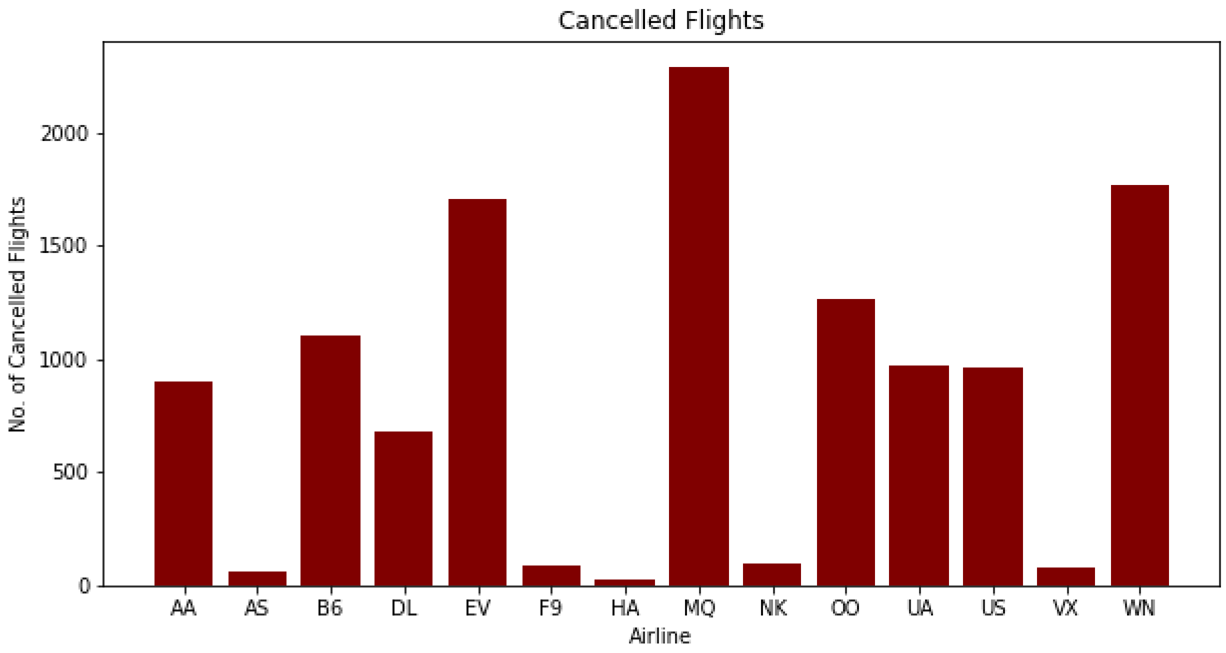
```
# Turn dictionary keys to a list
# Following can also be done list(key_arrays)
airlines_list = list(airline_stats.keys())
```

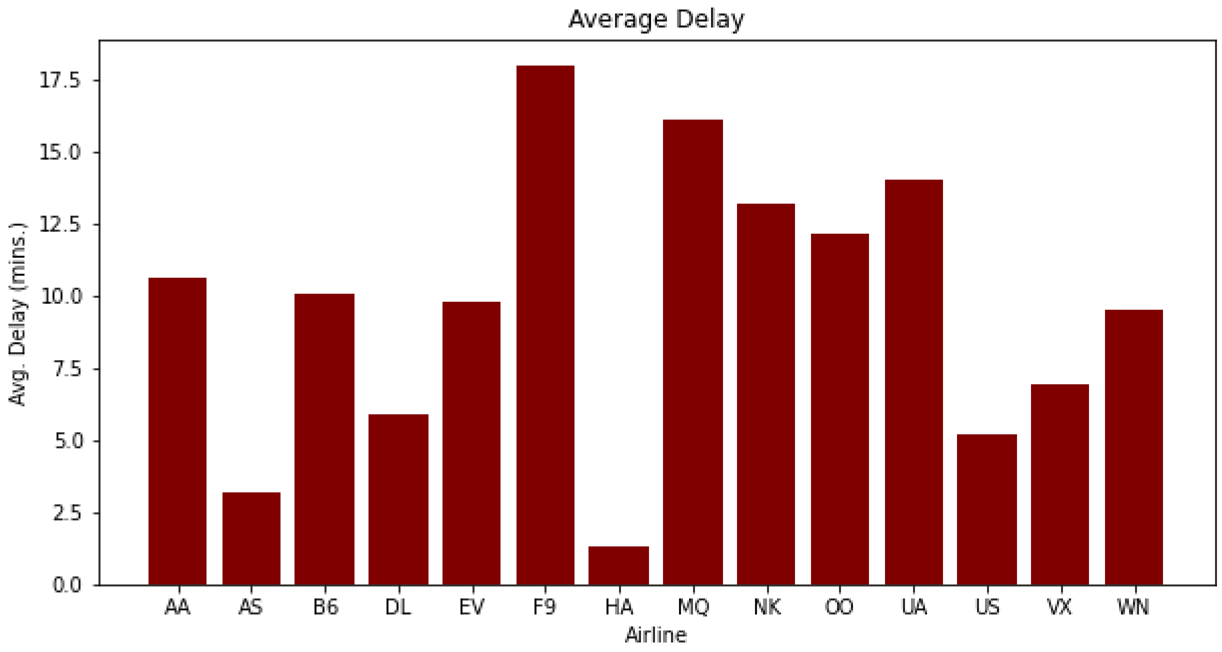
In [ ]:

```
fig1 = plt.figure(figsize = (10, 5))
# creating the bar plot
plt.bar(airlines_list, sum_val_array, color ='maroon')
plt.xlabel("Airline")
plt.ylabel("No. of Cancelled Flights")
plt.title("Cancelled Flights")
plt.show()

print()

fig2 = plt.figure(figsize = (10, 5))
# creating the bar plot
plt.bar(airlines_list, mean_val_array, color ='maroon')
plt.xlabel("Airline")
plt.ylabel("Avg. Delay (mins.)")
plt.title("Average Delay")
plt.show()
```





In [ ]:

```
# dftrain drops cols listed, keeping the cols we want to work with
dftrain = flights_data.drop(['MONTH', 'DAY','CANCELLATION_REASON', 'AIR_SYSTEM_DELAY',
                        'SECURITY_DELAY', 'AIRLINE_DELAY',
                        'LATE_AIRCRAFT_DELAY', 'WEATHER_DELAY'], axis = 1)
dftrain = dftrain.dropna()
# pred_input is all columns except the column being predicted
# pred is the column that will be predicted
pred_input = dftrain.drop('ARRIVAL_DELAY', axis = 1)
ydata = dftrain['ARRIVAL_DELAY']

# Train data
x_train, x_test, y_train, y_test = train_test_split(pred_input, ydata, test_size = 0.
```

In [ ]:

```
# .info() helps us see what is not an int or float which will then be removed
# this is necessary for standard scaling of data
dftrain.info()
```

```
# Airline, origin airport, and destination airport are dropped as they are not int or
x_train = x_train.drop(['AIRLINE','ORIGIN_AIRPORT','DESTINATION_AIRPORT'], axis = 1)
x_test = x_test.drop(['AIRLINE','ORIGIN_AIRPORT','DESTINATION_AIRPORT'], axis = 1)
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 457013 entries, 0 to 469967
Data columns (total 19 columns):
 #   Column               Non-Null Count   Dtype  
---  ------               --------------   -----  
 0   AIRLINE              457013 non-null  object 
 1   ORIGIN_AIRPORT       457013 non-null  object 
 2   DESTINATION_AIRPORT  457013 non-null  object 
 3   SCHEDULED_DEPARTURE  457013 non-null  int64  
 4   DEPARTURE_TIME       457013 non-null  float64
 5   DEPARTURE_DELAY      457013 non-null  float64
 6   TAXI_OUT             457013 non-null  float64
 7   WHEELS_OFF           457013 non-null  float64
 8   SCHEDULED_TIME       457013 non-null  int64  
 9   ELAPSED_TIME         457013 non-null  float64
 10  AIR_TIME             457013 non-null  float64
 11  DISTANCE             457013 non-null  int64  
 12  WHEELS_ON            457013 non-null  float64
 13  TAXI_IN              457013 non-null  float64
 14  SCHEDULED_ARRIVAL    457013 non-null  int64  
 15  ARRIVAL_TIME         457013 non-null  float64
 16  ARRIVAL_DELAY        457013 non-null  float64
 17  DIVERTED             457013 non-null  int64  
 18  CANCELLED            457013 non-null  int64  
dtypes: float64(10), int64(6), object(3)
memory usage: 69.7+ MB
```

In [ ]:

```
# train and test data is standardized. standard scaling is explained well here:
# https://www.digitalocean.com/community/tutorials/standardscaler-function-in-python

sc = StandardScaler()
X_train_sc = sc.fit_transform(x_train)
X_test_sc = sc.transform(x_test)
```

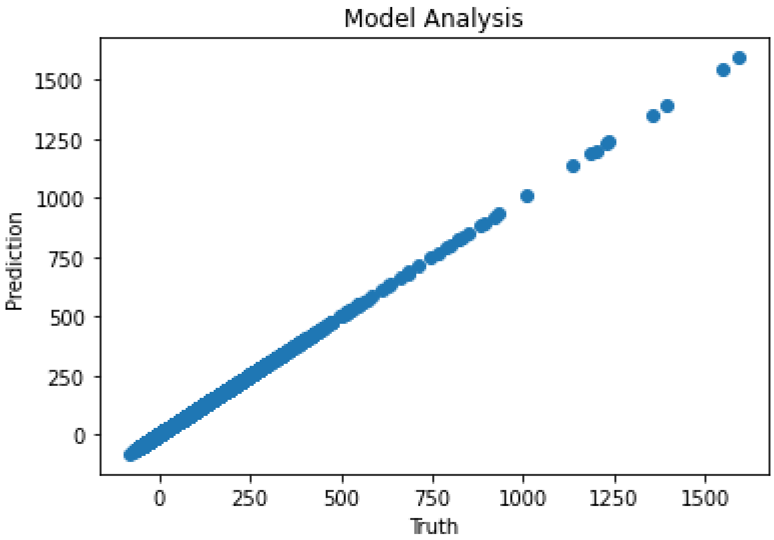
In [ ]:

```
# models used for training
LinR = LinearRegression()
Rid = Ridge()
```

In [ ]:

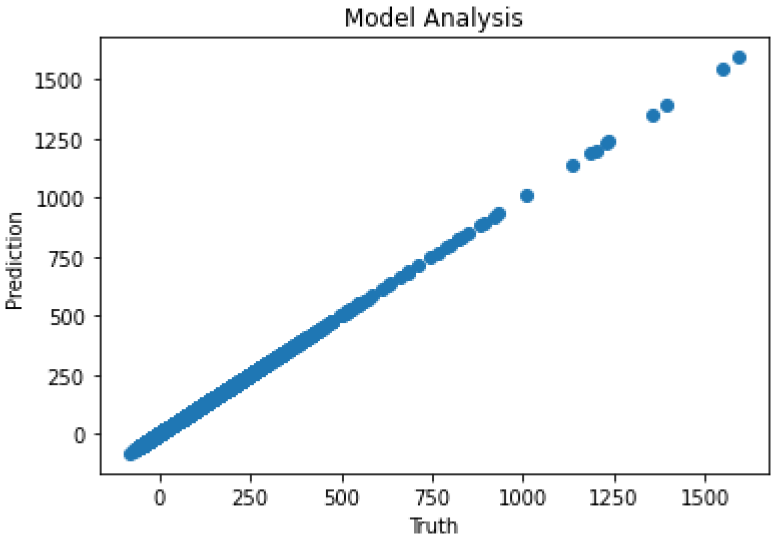
```
# Output of model prediction vs truth as well as MSE, MAE, Root MSE, and R2
for model, name in zip([LinR, Rid],  ['Linear Regression','Ridge']):
    model1 = model.fit(X_train_sc,y_train)
    Y_predict=model1.predict(X_test_sc)
    print(name)
    print()
    plt.scatter(y_test, Y_predict)
    plt.title("Model Analysis")
    plt.xlabel("Truth")
    plt.ylabel("Prediction")
    plt.show()
    print('Mean Absolute Error:', mean_absolute_error(y_test, Y_predict))
    print('Mean Squared Error:', mean_squared_error(y_test, Y_predict))
    print('Root Mean Squared Error:', np.sqrt(mean_squared_error(y_test, Y_predict)))
    print('R2 : ',r2_score(y_test, Y_predict))
    print()
```

```
Linear Regression
```



```
Mean Absolute Error: 8.068423394684439e-14
Mean Squared Error: 1.2526479352295827e-26
Root Mean Squared Error: 1.1192175549148533e-13
R2 :  1.0

Ridge
```



```
Mean Absolute Error: 0.0019259705131082696
Mean Squared Error: 6.526618509607398e-06
Root Mean Squared Error: 0.0025547247424345734
R2 :  0.9999999958602483
```