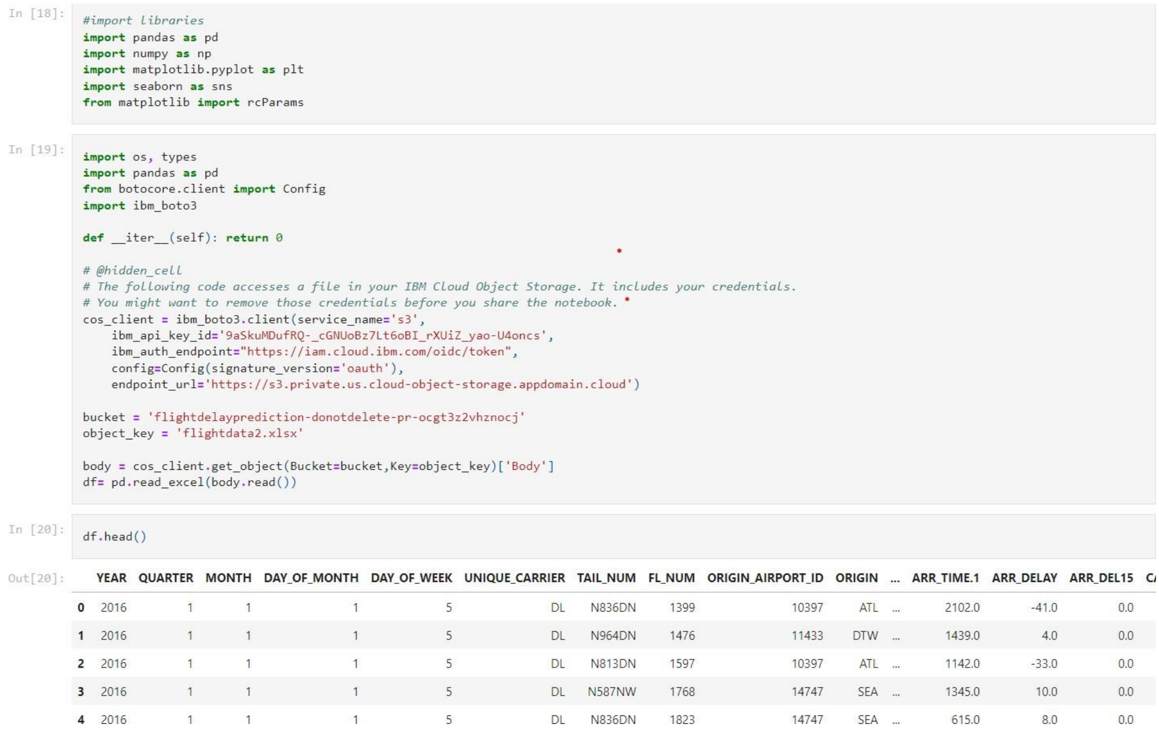
Project Development Phase

Sprint-1-Data Prepossessing

Date	9 November 2022
Team ID	PNT2022TMID16605
Project Name	Project – Flight Delay Prediction Using Machine Learning
Maximum Marks	8 Marks

We have created a model with the help of Pre-processed data. We have used Decision Tree Classifier algorithm for model development. Also we have implemented the model to check the accuracy of our model. With the help of pickle model file the prediction is performed by flask app

Screenshots



In [18]:

```
#import libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from matplotlib import rcParams
```

In [19]:

```
import os, types
import pandas as pd
from botocore.client import Config
import ibm_boto3

def __iter__(self): return 0

# @hidden_cell
# The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
# You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
    ibm_api_key_id='9aSkuMDufRQ-_cGNUoBz7Lt6oBI_rXUiZ_yao-U4oncs',
    ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
    config=Config(signature_version='oauth'),
    endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')

bucket = 'flightdelayprediction-donotdelete-pr-ocgt3z2vhznocj'
object_key = 'flightdata2.xlsx'

body = cos_client.get_object(Bucket=bucket,Key=object_key)['Body']
df= pd.read_excel(body.read())
```

In [20]:

```
df.head()
```

Out[20]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	UNIQUE_CARRIER	TAIL_NUM	FL_NUM	ORIGIN_AIRPORT_ID	ORIGIN	...	ARR_TIME.1	ARR_DELAY	ARR_DEL15	CA
0	2016	1	1	1	5	DL	N836DN	1399	10397	ATL	...	2102.0	-41.0	0.0	
1	2016	1	1	1	5	DL	N964DN	1476	11433	DTW	...	1439.0	4.0	0.0	
2	2016	1	1	1	5	DL	N813DN	1597	10397	ATL	...	1142.0	-33.0	0.0	
3	2016	1	1	1	5	DL	N587NW	1768	14747	SEA	...	1345.0	10.0	0.0	
4	2016	1	1	1	5	DL	N836DN	1823	14747	SEA	...	615.0	8.0	0.0	

In [21]:
```
from datetime import datetime
```

In [22]:
```
import datetime as dt
```

In [23]:
```
from datetime import datetime
```

In [ ]:
```

```

In [61]:
```
pwd
```

Out[61]:
```
'/home/wsuser/work'
```

In [24]:
```
df.shape
```

Out[24]:
```
(11231, 31)
```

In [25]:
```
df.info()
```

```
RangeIndex: 11231 entries, 0 to 11230
Data columns (total 31 columns):
 #   Column               Non-Null Count  Dtype
---  ------               --------------  -----
 0   YEAR                 11231 non-null  int64
 1   QUARTER              11231 non-null  int64
 2   MONTH                11231 non-null  int64
 3   DAY_OF_MONTH         11231 non-null  int64
 4   DAY_OF_WEEK          11231 non-null  int64
 5   UNIQUE_CARRIER       11231 non-null  object
 6   TAIL_NUM             11231 non-null  object
 7   FL_NUM               11231 non-null  int64
 8   ORIGIN_AIRPORT_ID    11231 non-null  int64
 9   ORIGIN               11231 non-null  object
 10  DEST_AIRPORT_ID      11231 non-null  int64
 11  DEST                 11231 non-null  object
 12  CRS_DEP_TIME         11231 non-null  object
 13  CRS_DEP_TIME.1       11231 non-null  int64
 14  DEP_TIME             11124 non-null  object
 15  DEP_TIME.1           11124 non-null  float64
 16  DEP_DELAY            11124 non-null  float64
 17  DEP_DEL15            11124 non-null  float64
 18  CRS_ARR_TIME         11231 non-null  object
 19  CRS_ARR_TIME.1       11231 non-null  int64
 20  ARR_TIME             11116 non-null  object
 21  ARR_TIME.1           11116 non-null  float64
 22  ARR_DELAY            11043 non-null  float64
 23  ARR_DEL15            11043 non-null  float64
 24  CANCELLED            11231 non-null  int64
 25  DIVERTED             11231 non-null  int64
 26  CRS_ELAPSED_TIME1    11231 non-null  object
 27  ACTUAL_ELAPSED_TIME1 11231 non-null  object
 28  CRS_ELAPSED_TIME     11231 non-null  int64
 29  ACTUAL_ELAPSED_TIME  11043 non-null  float64
 30  DISTANCE             11231 non-null  int64
dtypes: float64(7), int64(14), object(10)
memory usage: 2.7+ MB
```

In [26]:
```
df.isnull().any()
```

Out[26]:
```
YEAR                    False
QUARTER                 False
MONTH                   False
DAY_OF_MONTH            False
DAY_OF_WEEK             False
UNIQUE_CARRIER          False
TAIL_NUM                False
FL_NUM                  False
ORIGIN_AIRPORT_ID       False
ORIGIN                  False
DEST_AIRPORT_ID         False
DEST                    False
CRS_DEP_TIME            False
CRS_DEP_TIME.1          False
DEP_TIME                 True
DEP_TIME.1               True
DEP_DELAY                True
DEP_DEL15                True
CRS_ARR_TIME            False
CRS_ARR_TIME.1          False
ARR_TIME                 True
ARR_TIME.1               True
ARR_DELAY                True
ARR_DEL15                True
CANCELLED               False
DIVERTED                False
CRS_ELAPSED_TIME1       False
ACTUAL_ELAPSED_TIME1    False
CRS_ELAPSED_TIME        False
ACTUAL_ELAPSED_TIME      True
DISTANCE                False
dtype: bool
```

In [31]:
```
df['DEP_DELAY'].fillna(df['DEP_DELAY'].median(),inplace=True)
```

In [32]:

```
df.describe()
```

Out[32]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_NUM	ORIGIN_AIRPORT_ID	DEST_AIRPORT_ID	CRS_DEP_TIME.1	DEP_TIME.1	...	DEP_DEL1
count	11231.0	11231.000000	11231.000000	11231.000000	11231.000000	11231.000000	11231.000000	11231.000000	11231.000000	11124.000000	...	11231.00000
mean	2016.0	2.544475	6.628973	15.790758	3.960199	1334.325617	12334.516695	12302.274508	1320.798326	1327.189410	...	0.14148
std	0.0	1.090701	3.354678	8.782056	1.995257	811.875227	1595.026510	1601.988550	490.737845	500.306462	...	0.34853
min	2016.0	1.000000	1.000000	1.000000	1.000000	7.000000	10397.000000	10397.000000	10.000000	1.000000	...	0.00000
25%	2016.0	2.000000	4.000000	8.000000	2.000000	624.000000	10397.000000	10397.000000	905.000000	905.000000	...	0.00000
50%	2016.0	3.000000	7.000000	16.000000	4.000000	1267.000000	12478.000000	12478.000000	1320.000000	1324.000000	...	0.00000
75%	2016.0	3.000000	9.000000	23.000000	6.000000	2032.000000	13487.000000	13487.000000	1735.000000	1739.000000	...	0.00000
max	2016.0	4.000000	12.000000	31.000000	7.000000	2853.000000	14747.000000	14747.000000	2359.000000	2400.000000	...	1.00000

8 rows × 21 columns

In [33]:

```
df.ORIGIN.value_counts()
```

Out[33]:

```
ATL    3100
MSP    2538
DTW    2201
SEA    2018
JFK    1374
Name: ORIGIN, dtype: int64
```

In [34]:

```
df.UNIQUE_CARRIER.value_counts()
```

Out[34]:

```
DL    11231
Name: UNIQUE_CARRIER, dtype: int64
```

In [35]:

```
df.ORIGIN_AIRPORT_ID.value_counts()
```

Out[35]:

```
10397    3100
13487    2538
11433    2201
14747    2018
12478    1374
Name: ORIGIN_AIRPORT_ID, dtype: int64
```

In [36]:

```
df.ORIGIN.unique()
```

Out[36]:

```
array(['ATL', 'DTW', 'SEA', 'MSP', 'JFK'], dtype=object)
```

In [37]:

```
df.ORIGIN_AIRPORT_ID.unique()
```

Out[37]:

```
array([10397, 11433, 14747, 13487, 12478])
```

In [38]:

```
df.UNIQUE_CARRIER.unique()
```

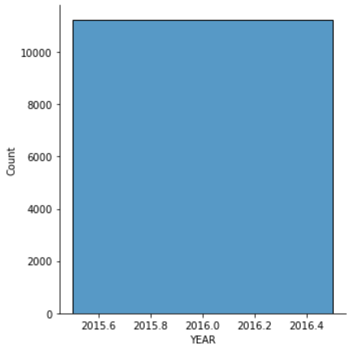
Out[38]:

```
array(['DL'], dtype=object)
```

In [39]:

```
sns.displot(df.YEAR)
```

Out[39]:

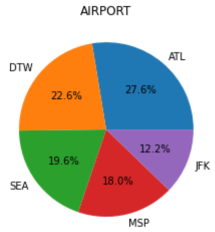


In [40]:

```
plt.pie(df.ORIGIN.value_counts(),labels=['ATL', 'DTW', 'SEA', 'MSP', 'JFK'],autopct="%1.1f%%")
plt.title('AIRPORT')
```

Out[40]:

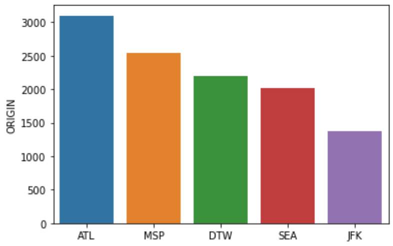
```
Text(0.5, 1.0, 'AIRPORT')
```



In [41]:

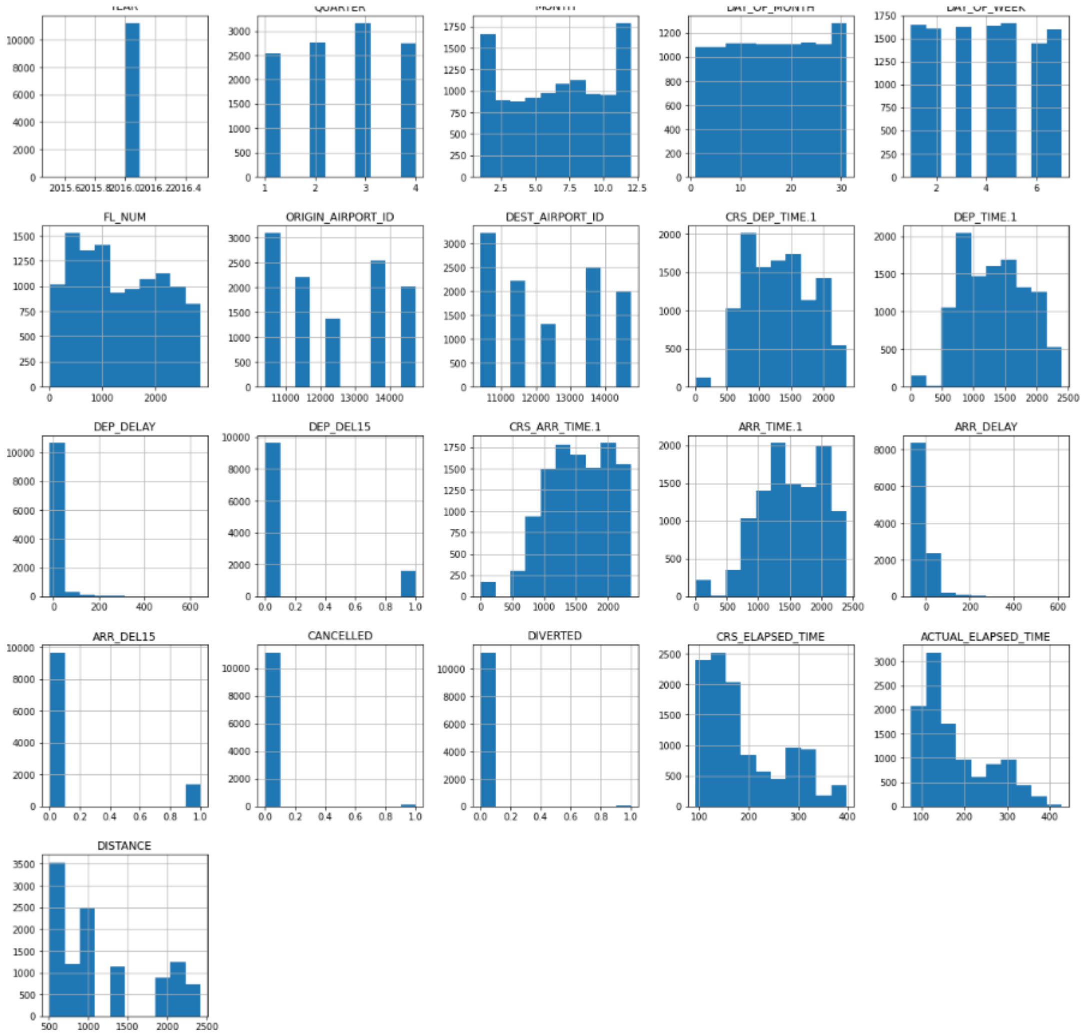
```
sns.barplot(df.ORIGIN.value_counts().index,df.ORIGIN.value_counts())
```

Out[41]:



In [42]:

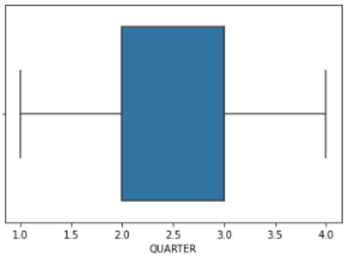
```
df.hist(figsize=(20,20))
```



In [43]:

```
sns.boxplot(df.QUARTER)
```

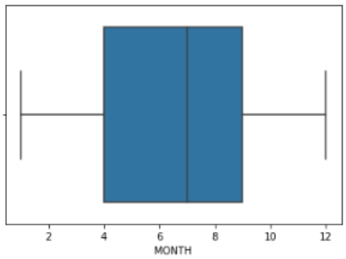
Out[43]:



In [44]:

```
sns.boxplot(df.MONTH)
```

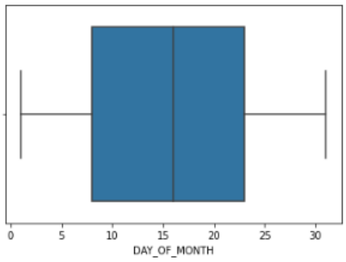
Out[44]:



In [45]:

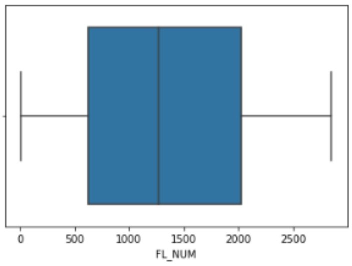
```
sns.boxplot(df.DAY_OF_MONTH)
```

Out[45]:



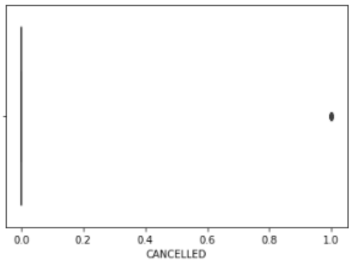
```
In [46]: sns.boxplot(df.FL_NUM)
```

Out[46]:



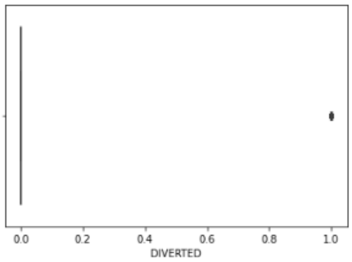
```
In [48]: sns.boxplot(df.CANCELLED)
```

Out[48]:



```
In [49]: sns.boxplot(df.DIVERTED)
```

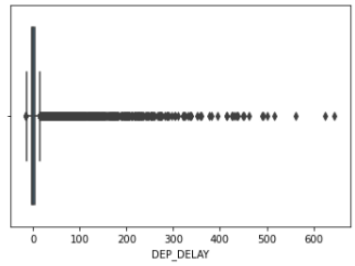
Out[49]:



In [54]:

```
sns.boxplot(df.DEP_DELAY)
```

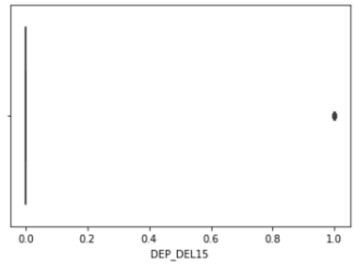
Out[54]:



In [55]:

```
sns.boxplot(df.DEP_DEL15)
```

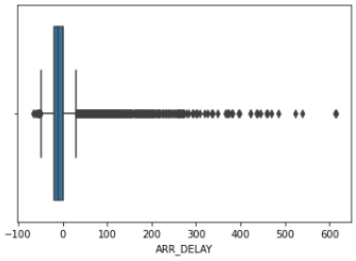
Out[55]:



In [129…

```
sns.boxplot(df.ARR_DELAY)
```

Out[129…

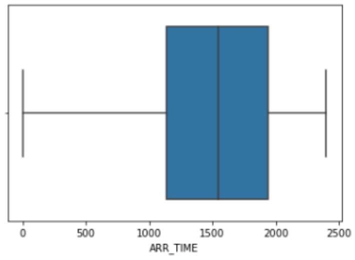


In [130…

```
sns.boxplot(df.ARR_TIME)
```

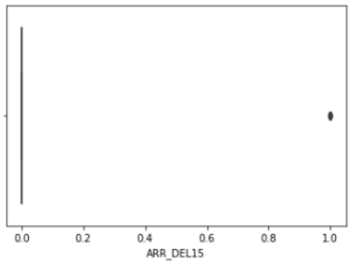
```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.1
2, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretat
ion.
  warnings.warn(
```

Out[130…



In [131…

```
sns.boxplot(df.ARR_DEL15)
```

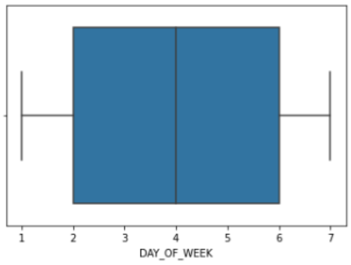


In [132…

```
sns.boxplot(df.DAY_OF_WEEK)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.1
2, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpret
ion.
  warnings.warn(
```

Out[132…



In [133…

```
sns.boxplot(df.ORIGIN_AIRPORT_ID)
```

In [56]:

```
df.groupby(by="DAY_OF_WEEK")["DEP_DEL15"].sum()
```

Out[56]:

```
DAY_OF_WEEK
1    253.0
2    213.0
3    204.0
4    245.0
5    250.0
6    198.0
7    226.0
Name: DEP_DEL15, dtype: float64
```

In [57]:

```
df.groupby(by="MONTH")["DEP_DEL15"].sum()
```

Out[57]:

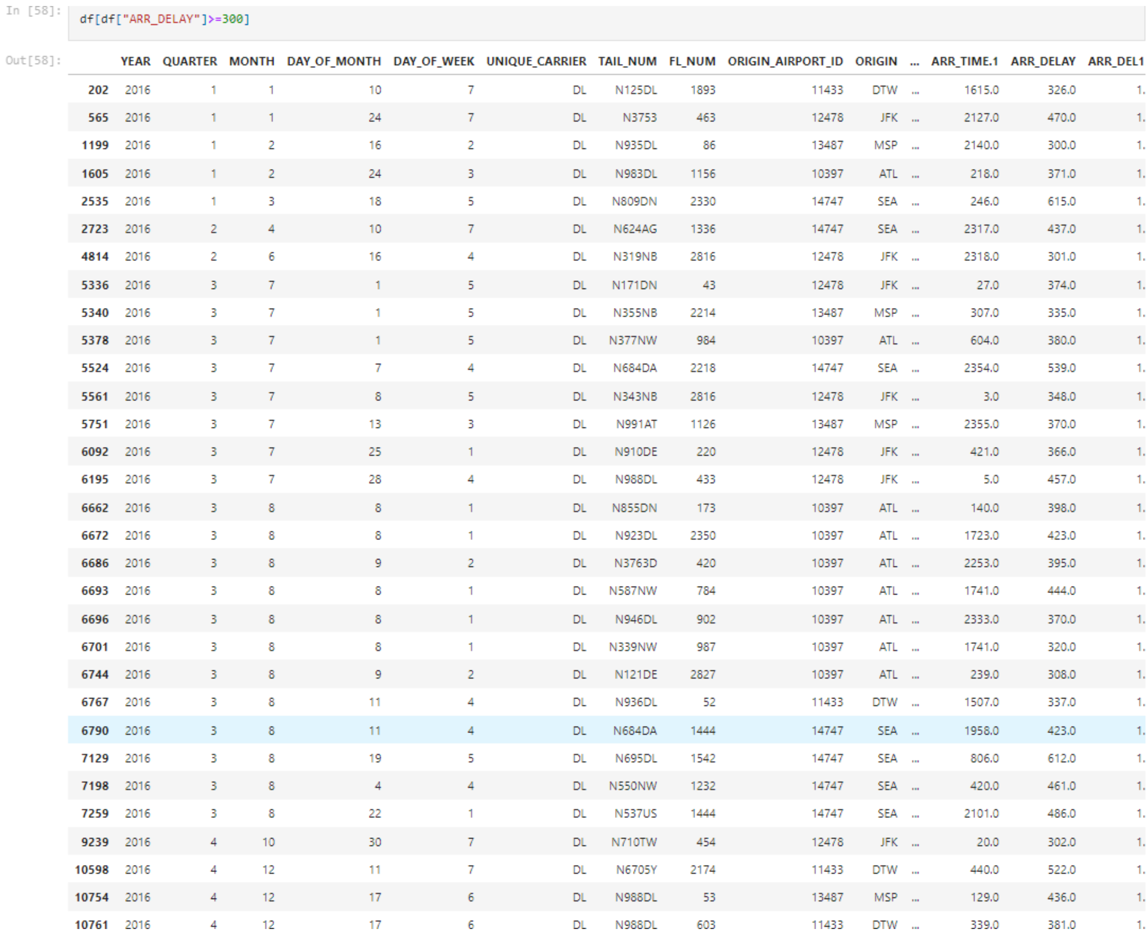
```
MONTH
1     113.0
2     115.0
3     104.0
4      96.0
5      86.0
6     168.0
7     219.0
8     246.0
9      88.0
10     86.0
11     66.0
12    202.0
Name: DEP_DEL15, dtype: float64
```

In [58]:

```
df[df["ARR_DELAY"]>=300]
```

Out[58]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	UNIQUE_CARRIER	TAIL_NUM	FL_NUM	ORIGIN_AIRPORT_ID	ORIGIN	...	ARR_TIME.1	ARR_DELAY	ARR_DEL1
202	2016	1	1	10	7	DL	N125DL	1893	11433	DTW	...	1615.0	326.0	1.
565	2016	1	1	24	7	DL	N3753	463	12478	JFK	...	2127.0	470.0	1.
1199	2016	1	2	16	2	DL	N935DL	86	13487	MSP	...	2140.0	300.0	1.
1605	2016	1	2	24	3	DL	N983DL	1156	10397	ATL	...	218.0	371.0	1.
2535	2016	1	3	18	5	DL	N809DN	2330	14747	SEA	...	246.0	615.0	1.
2723	2016	2	4	10	7	DL	N624AG	1336	14747	SEA	...	2317.0	437.0	1.
4814	2016	2	6	16	4	DL	N319NB	2816	12478	JFK	...	2318.0	301.0	1.
5336	2016	3	7	1	5	DL	N171DN	43	12478	JFK	...	27.0	374.0	1.
5340	2016	3	7	1	5	DL	N355NB	2214	13487	MSP	...	307.0	335.0	1.
5378	2016	3	7	1	5	DL	N377NW	984	10397	ATL	...	604.0	380.0	1.
5524	2016	3	7	7	4	DL	N684DA	2218	14747	SEA	...	2354.0	539.0	1.
5561	2016	3	7	8	5	DL	N343NB	2816	12478	JFK	...	3.0	348.0	1.
5751	2016	3	7	13	3	DL	N991AT	1126	13487	MSP	...	2355.0	370.0	1.
6092	2016	3	7	25	1	DL	N910DE	220	12478	JFK	...	421.0	366.0	1.



In [58]:

```
df[df["ARR_DELAY"]>=300]
```

Out[58]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	UNIQUE_CARRIER	TAIL_NUM	FL_NUM	ORIGIN_AIRPORT_ID	ORIGIN	...	ARR_TIME.1	ARR_DELAY	ARR_DEL1
202	2016	1	1	10	7	DL	N125DL	1893	11433	DTW	...	1615.0	326.0	1.
565	2016	1	1	24	7	DL	N3753	463	12478	JFK	...	2127.0	470.0	1.
1199	2016	1	2	16	2	DL	N935DL	86	13487	MSP	...	2140.0	300.0	1.
1605	2016	1	2	24	3	DL	N983DL	1156	10397	ATL	...	218.0	371.0	1.
2535	2016	1	3	18	5	DL	N809DN	2330	14747	SEA	...	246.0	615.0	1.
2723	2016	2	4	10	7	DL	N624AG	1336	14747	SEA	...	2317.0	437.0	1.
4814	2016	2	6	16	4	DL	N319NB	2816	12478	JFK	...	2318.0	301.0	1.
5336	2016	3	7	1	5	DL	N171DN	43	12478	JFK	...	27.0	374.0	1.
5340	2016	3	7	1	5	DL	N355NB	2214	13487	MSP	...	307.0	335.0	1.
5378	2016	3	7	1	5	DL	N377NW	984	10397	ATL	...	604.0	380.0	1.
5524	2016	3	7	7	4	DL	N684DA	2218	14747	SEA	...	2354.0	539.0	1.
5561	2016	3	7	8	5	DL	N343NB	2816	12478	JFK	...	3.0	348.0	1.
5751	2016	3	7	13	3	DL	N991AT	1126	13487	MSP	...	2355.0	370.0	1.
6092	2016	3	7	25	1	DL	N910DE	220	12478	JFK	...	421.0	366.0	1.
6195	2016	3	7	28	4	DL	N988DL	433	12478	JFK	...	5.0	457.0	1.
6662	2016	3	8	8	1	DL	N855DN	173	10397	ATL	...	140.0	398.0	1.
6672	2016	3	8	8	1	DL	N923DL	2350	10397	ATL	...	1723.0	423.0	1.
6686	2016	3	8	9	2	DL	N3763D	420	10397	ATL	...	2253.0	395.0	1.
6693	2016	3	8	8	1	DL	N587NW	784	10397	ATL	...	1741.0	444.0	1.
6696	2016	3	8	8	1	DL	N946DL	902	10397	ATL	...	2333.0	370.0	1.
6701	2016	3	8	8	1	DL	N339NW	987	10397	ATL	...	1741.0	320.0	1.
6744	2016	3	8	9	2	DL	N121DE	2827	10397	ATL	...	239.0	308.0	1.
6767	2016	3	8	11	4	DL	N936DL	52	11433	DTW	...	1507.0	337.0	1.
6790	2016	3	8	11	4	DL	N684DA	1444	14747	SEA	...	1958.0	423.0	1.
7129	2016	3	8	19	5	DL	N695DL	1542	14747	SEA	...	806.0	612.0	1.
7198	2016	3	8	4	4	DL	N550NW	1232	14747	SEA	...	420.0	461.0	1.
7259	2016	3	8	22	1	DL	N537US	1444	14747	SEA	...	2101.0	486.0	1.
9239	2016	4	10	30	7	DL	N710TW	454	12478	JFK	...	20.0	302.0	1.
10598	2016	4	12	11	7	DL	N6705Y	2174	11433	DTW	...	440.0	522.0	1.
10754	2016	4	12	17	6	DL	N988DL	53	13487	MSP	...	129.0	436.0	1.
10761	2016	4	12	17	6	DL	N988DL	603	11433	DTW	...	339.0	381.0	1.

```
In [59]:

sm=[6,7,8]
wt=[9,10,11]
sp=[12,1,2,3]
fl=[4,5]
```

```
In [60]:

df["SEASON"]=np.where(df["MONTH"].isin(sm),0,np.where(df["MONTH"].isin(wt),1,np.where(df["MONTH"].isin(sp),2,3)))
```

```
In [61]:

df["SEASON"].value_counts()
```

```
Out[61]: 2    3441
         0    3184
         1    2808
         3    1798
         Name: SEASON, dtype: int64
```

```
In [141…

#Encoding categorial columns into numerical
```

```
In [62]:

df["CANCELLED"]=np.where(df["CANCELLED"]==1,4,0)
```

```
In [63]:

df["DIVERTED"]=np.where(df["DIVERTED"]==1,3,0)
```

```
In [64]:

df.CANCELLED.unique(),df.DIVERTED.unique()
```

```
Out[64]: (array([0, 4]), array([0, 3]))
```

```
In [65]:

df["DELAY_15"]=df["ARR_DEL15"]+df["DEP_DEL15"]
df.DELAY_15.unique()
```

```
Out[65]: array([ 0.,  1.,  2., nan])
```

```
In [66]:

df["DELAY_15"].fillna(0,inplace=True)
df.DELAY_15.unique()
```

```
Out[66]: array([0., 1., 2.])
```

```
In [67]:

df["NDELAY"]=df["DELAY_15"]+df["CANCELLED"]+df["DIVERTED"]
```

```
In [68]:

df.NDELAY.unique()
```

```
Out[68]: array([0., 1., 2., 3., 4.])
```

```
In [69]:

len(df["TAIL_NUM"].value_counts()),len(df["FL_NUM"].value_counts())
```

```
Out[69]: (789, 690)
```

```
In [70]:

df.info()
```

```
RangeIndex: 11231 entries, 0 to 11230
Data columns (total 34 columns):
 #   Column               Non-Null Count  Dtype
---  ------               --------------  -----
 0   YEAR                 11231 non-null  int64
 1   QUARTER              11231 non-null  int64
 2   MONTH                11231 non-null  int64
 3   DAY_OF_MONTH         11231 non-null  int64
 4   DAY_OF_WEEK          11231 non-null  int64
 5   UNIQUE_CARRIER       11231 non-null  object
 6   TAIL_NUM             11231 non-null  object
 7   FL_NUM               11231 non-null  int64
 8   ORIGIN_AIRPORT_ID    11231 non-null  int64
 9   ORIGIN               11231 non-null  object
 10  DEST_AIRPORT_ID      11231 non-null  int64
 11  DEST                 11231 non-null  object
 12  CRS_DEP_TIME         11231 non-null  object
 13  CRS_DEP_TIME.1       11231 non-null  int64
 14  DEP_TIME             11124 non-null  object
 15  DEP_TIME.1           11124 non-null  float64
 16  DEP_DELAY            11231 non-null  float64
 17  DEP_DEL15            11231 non-null  float64
 18  CRS_ARR_TIME         11231 non-null  object
 19  CRS_ARR_TIME.1       11231 non-null  int64
 20  ARR_TIME             11116 non-null  object
 21  ARR_TIME.1           11116 non-null  float64
 22  ARR_DELAY            11043 non-null  float64
 23  ARR_DEL15            11043 non-null  float64
 24  CANCELLED            11231 non-null  int64
 25  DIVERTED             11231 non-null  int64
 26  CRS_ELAPSED_TIME1    11231 non-null  object
 27  ACTUAL_ELAPSED_TIME1 11231 non-null  object
 28  CRS_ELAPSED_TIME     11231 non-null  int64
 29  ACTUAL_ELAPSED_TIME  11043 non-null  float64
 30  DISTANCE             11231 non-null  int64
 31  SEASON               11231 non-null  int64
 32  DELAY_15             11231 non-null  float64
 33  NDELAY               11231 non-null  float64
dtypes: float64(9), int64(15), object(10)
memory usage: 2.9+ MB
```

In [73]:
```
df1.head()
```

Out[73]:

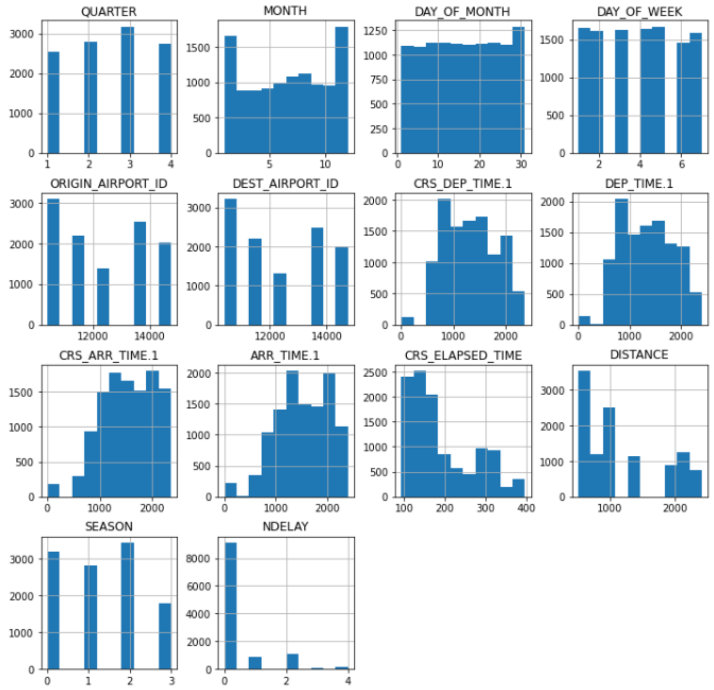
	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	TAIL_NUM	FL_NUM	ORIGIN_AIRPORT_ID	ORIGIN	DEST_AIRPORT_ID	DEST	...	DEP_TIME.1	CRS_ARR_TIME	CRS_ARR_TI
0	1	1	1	5	N836DN	1399	10397	ATL	14747	SEA	...	1907.0	21:43:00	
1	1	1	1	5	N964DN	1476	11433	DTW	13487	MSP	...	1344.0	14:35:00	
2	1	1	1	5	N813DN	1597	10397	ATL	14747	SEA	...	942.0	12:15:00	
3	1	1	1	5	N587NW	1768	14747	SEA	13487	MSP	...	820.0	13:35:00	
4	1	1	1	5	N836DN	1823	14747	SEA	11433	DTW	...	2256.0	06:07:00	

5 rows × 22 columns

In [74]:
```
df2=df1.drop(columns=["TAIL_NUM","FL_NUM"])
```

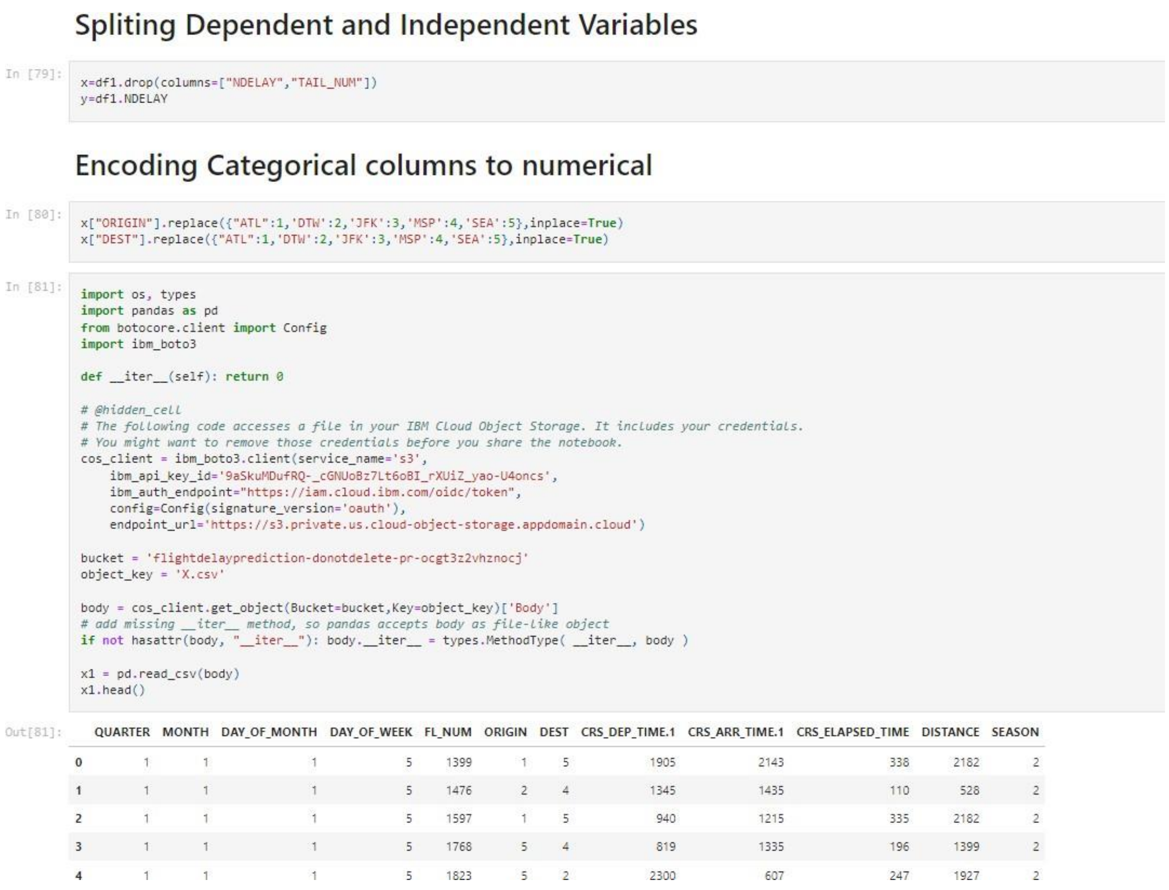
In [75]:
```
df2.info()
```

```
RangeIndex: 11231 entries, 0 to 11230
Data columns (total 20 columns):
 #   Column               Non-Null Count  Dtype  
---  ------               --------------  -----  
 0   QUARTER              11231 non-null  int64  
 1   MONTH                11231 non-null  int64  
 2   DAY_OF_MONTH         11231 non-null  int64  
 3   DAY_OF_WEEK          11231 non-null  int64  
 4   ORIGIN_AIRPORT_ID    11231 non-null  int64  
 5   ORIGIN               11231 non-null  object 
 6   DEST_AIRPORT_ID      11231 non-null  int64  
 7   DEST                 11231 non-null  object 
 8   CRS_DEP_TIME         11231 non-null  object 
 9   CRS_DEP_TIME.1       11231 non-null  int64  
 10  DEP_TIME.1           11124 non-null  float64
 11  CRS_ARR_TIME         11231 non-null  object 
 12  CRS_ARR_TIME.1       11231 non-null  int64  
 13  ARR_TIME.1           11116 non-null  float64
 14  CRS_ELAPSED_TIME1    11231 non-null  object 
 15  ACTUAL_ELAPSED_TIME1 11231 non-null  object 
 16  CRS_ELAPSED_TIME     11231 non-null  int64  
 17  DISTANCE             11231 non-null  int64  
 18  SEASON               11231 non-null  int64  
 19  NDELAY               11231 non-null  float64
dtypes: float64(3), int64(11), object(6)
memory usage: 1.7+ MB
```



In [77]:
```
df2.NDELAY.value_counts()
```

Out[77]:
```
0.0    9130
2.0    1035
1.0     878
4.0     114
3.0      74
Name: NDELAY, dtype: int64
```



Spliting Dependent and Independent Variables

In [79]:

```
x=df1.drop(columns=["NDELAY","TAIL_NUM"])
y=df1.NDELAY
```

Encoding Categorical columns to numerical

In [80]:

```
x["ORIGIN"].replace({"ATL":1,'DTW':2,'JFK':3,'MSP':4,'SEA':5},inplace=True)
x["DEST"].replace({"ATL":1,'DTW':2,'JFK':3,'MSP':4,'SEA':5},inplace=True)
```

In [81]:

```
import os, types
import pandas as pd
from botocore.client import Config
import ibm_boto3

def __iter__(self): return 0

# @hidden_cell
# The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
# You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
    ibm_api_key_id='9aSkuMDufRQ-_cGNUoBz7Lt6oBI_rXUiZ_yao-U4oncs',
    ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
    config=Config(signature_version='oauth'),
    endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')

bucket = 'flightdelayprediction-donotdelete-pr-ocgt3z2vhznocj'
object_key = 'X.csv'

body = cos_client.get_object(Bucket=bucket,Key=object_key)['Body']
# add missing __iter__ method, so pandas accepts body as file-like object
if not hasattr(body, "__iter__"): body.__iter__ = types.MethodType( __iter__, body )

x1 = pd.read_csv(body)
x1.head()
```

Out[81]:

	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_NUM	ORIGIN	DEST	CRS_DEP_TIME.1	CRS_ARR_TIME.1	CRS_ELAPSED_TIME	DISTANCE	SEASON
0	1	1	1	5	1399	1	5	1905	2143	338	2182	2
1	1	1	1	5	1476	2	4	1345	1435	110	528	2
2	1	1	1	5	1597	1	5	940	1215	335	2182	2
3	1	1	1	5	1768	5	4	819	1335	196	1399	2
4	1	1	1	5	1823	5	2	2300	607	247	1927	2

In [82]:

```
import os, types
import pandas as pd
from botocore.client import Config
import ibm_boto3

def __iter__(self): return 0

# @hidden_cell
# The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
# You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
    ibm_api_key_id='9aSkuMDufRQ-_cGNUoBz7Lt6oBI_rXUiZ_yao-U4oncs',
    ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
    config=Config(signature_version='oauth'),
    endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')

bucket = 'flightdelayprediction-donotdelete-pr-ocgt3z2vhznocj'
object_key = 'Y.csv'

body = cos_client.get_object(Bucket=bucket,Key=object_key)['Body']
# add missing __iter__ method, so pandas accepts body as file-like object
if not hasattr(body, "__iter__"): body.__iter__ = types.MethodType( __iter__, body )

y2 = pd.read_csv(body)
y2.head()
```

Out[82]:

	NDELAY
0	0.0
1	0.0
2	0.0
3	0.0
4	0.0

In [83]:

```
from sklearn.utils import shuffle
X,Y=shuffle(x1,y2,random_state=72)
X.head()
```

Out[83]:

	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_NUM	ORIGIN	DEST	CRS_DEP_TIME.1	CRS_ARR_TIME.1	CRS_ELAPSED_TIME	DISTANCE	SEASON
5816	3	8	16	2	786	2	1	1400	1603	123	594	0
475	1	1	25	1	1173	4	2	830	1114	104	528	2
10952	2	6	25	2	2547	5	4	1894	16	197	1399	0
8363	4	11	14	1	1247	5	1	900	1653	293	2182	1
11452	1	2	19	2	1232	1	4	2079	2209	149	744	2

Splitting Dataset as Training and Testing data

In [84]:

```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x1,y2,test_size=0.2,random_state=42)
```

In [85]:

```
x_train.shape,x_test.shape
```

Out[85]:

```
((9856, 12), (2464, 12))
```

Model Building

DecisionTree

In [86]:

```
from sklearn.tree import DecisionTreeClassifier
dc=DecisionTreeClassifier()
dc.fit(x_train,y_train)
dc.score(x_test,y_test)
```

Out[86]:

```
0.7568993506493507
```

RandomForest

In [87]:

```
from sklearn.ensemble import RandomForestClassifier
rf=RandomForestClassifier(n_estimators=50,random_state=42)
rf.fit(x_train,y_train.values.ravel())
rf.score(x_test,y_test)
```

Out[87]:

```
0.8368506493506493
```

In [88]:

```
x_train.shape,x_test.shape
```

Out[88]:

```
((9856, 12), (2464, 12))
```

Model Building

Decision Tree

In [89]:

```
from sklearn.tree import DecisionTreeClassifier
dc=DecisionTreeClassifier()
dc.fit(x_train,y_train)
dc.score(x_test,y_test)
```

Out[89]:

```
0.7495941558441559
```

Random Forest

In [90]:

```
from sklearn.ensemble import RandomForestClassifier
rf=RandomForestClassifier(n_estimators=50,random_state=42)
rf.fit(x_train,y_train)
rf.score(x_test,y_test)
```

```
/tmp/wsuser/ipykernel_164/905497165.py:3: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of
y to (n_samples,), for example using ravel().
  rf.fit(x_train,y_train)
```

Out[90]:

```
0.8368506493506493
```

In [89]:

```
pd.DataFrame(rf.predict(x_test)).value_counts()
```

Out[89]:

```
0.0    1881
1.0     223
2.0     213
4.0     106
3.0      41
dtype: int64
```

In [91]:

```
x_test.iloc[[99,21,22],:]
```

Out[91]:

	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_NUM	ORIGIN	DEST	CRS_DEP_TIME.1	CRS_ARR_TIME.1	CRS_ELAPSED_TIME	DISTANCE	SEASON
8817	4	11	3	4	2787	4	1	1935	2308	153	907	1
12270	3	7	26	4	43	3	1	1525	1814	169	760	0
2894	2	4	1	5	1991	4	1	520	845	145	907	3

In [92]:

```
y_test.iloc[[8,21,912]]
```

Out[92]:

	NDELAY
2318	0.0
12270	4.0
10061	1.0

In [93]:

```
rf.predict(x_test.iloc[[8,21,912],:])
```

Out[93]:

```
array([0., 4., 0.])
```

In [94]:

```
pd.DataFrame(dc.predict(x_test)).value_counts()
```

Out[94]:

```
0.0    1632
1.0     335
2.0     319
4.0     121
3.0      57
dtype: int64
```

Logistic Regression

In [95]:

```
from sklearn.linear_model import LogisticRegression
lr1=LogisticRegression(solver='sag')
lr1.fit(x_train,y_train.values.ravel())
lr1.score(x_test,y_test)
```

```
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages/sklearn/linear_model/_sag.py:352: ConvergenceWarning: The max_iter was reached which means the c
oef_ did not converge
  warnings.warn(
```

Out[95]:

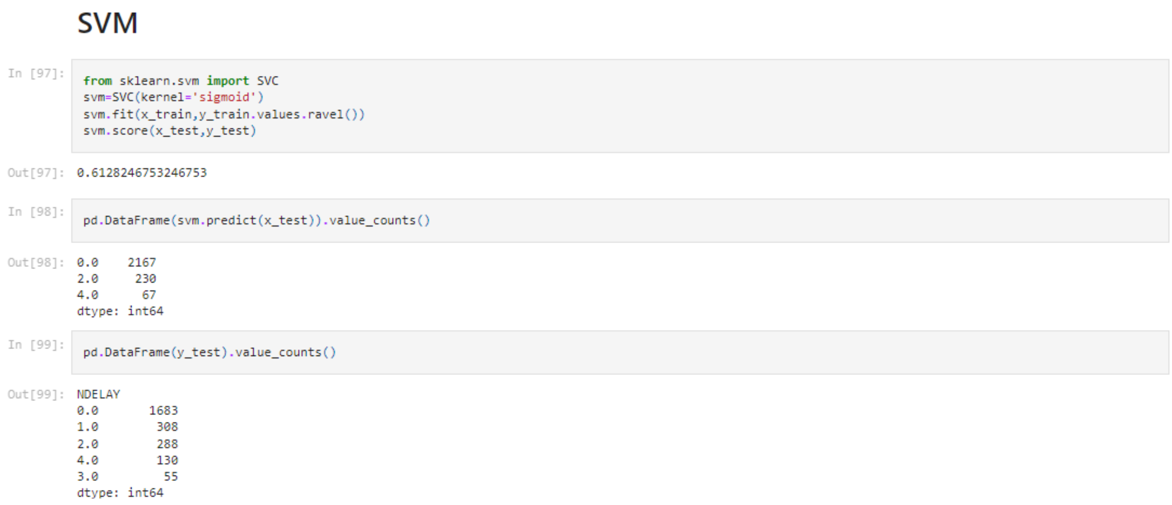
```
0.6830357142857143
```

In [96]:

```
lr1.predict(x_test).sum()
```

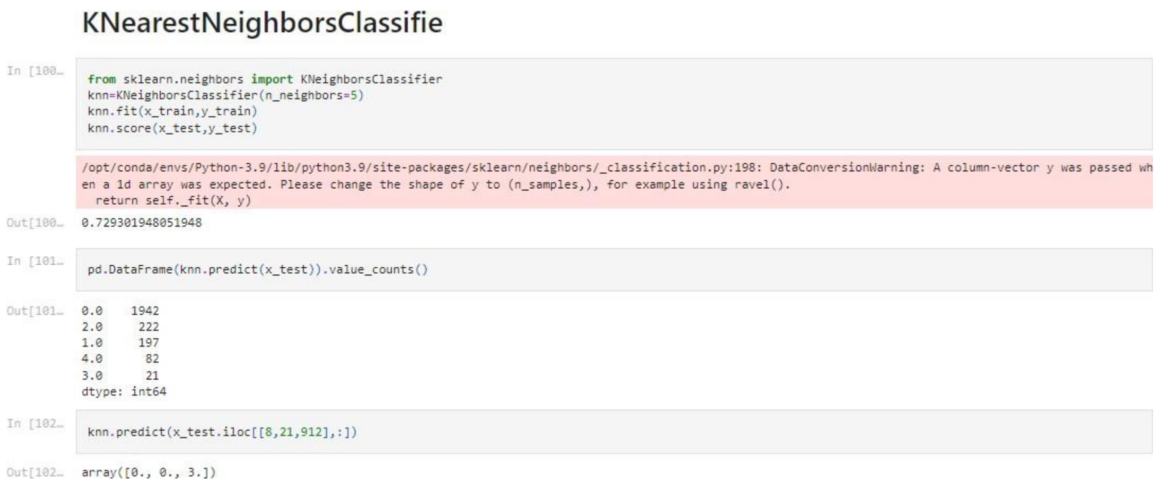
Out[96]:

```
0.0
```



SVM

```
In [97]: from sklearn.svm import SVC
         svm=SVC(kernel='sigmoid')
         svm.fit(x_train,y_train.values.ravel())
         svm.score(x_test,y_test)

Out[97]: 0.6128246753246753

In [98]: pd.DataFrame(svm.predict(x_test)).value_counts()

Out[98]: 0.0    2167
         2.0     230
         4.0      67
         dtype: int64

In [99]: pd.DataFrame(y_test).value_counts()

Out[99]: NDELAY
         0.0       1683
         1.0        308
         2.0        288
         4.0        130
         3.0         55
         dtype: int64
```



KNearestNeighborsClassifie

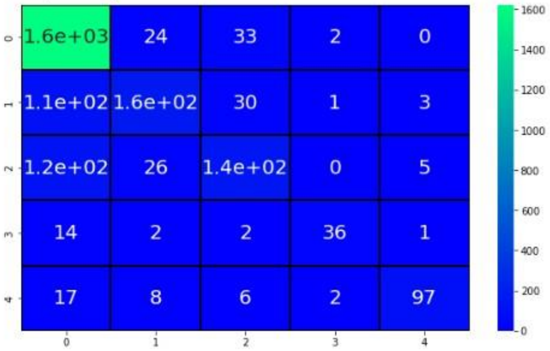
```
In [100… from sklearn.neighbors import KNeighborsClassifier
         knn=KNeighborsClassifier(n_neighbors=5)
         knn.fit(x_train,y_train)
         knn.score(x_test,y_test)

         /opt/conda/envs/Python-3.9/lib/python3.9/site-packages/sklearn/neighbors/_classification.py:198: DataConversionWarning: A column-vector y was passed wh
         en a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
           return self._fit(X, y)
Out[100… 0.729301948051948

In [101… pd.DataFrame(knn.predict(x_test)).value_counts()

Out[101… 0.0    1942
         2.0     222
         1.0     197
         4.0      82
         3.0      21
         dtype: int64

In [102… knn.predict(x_test.iloc[[8,21,912],:])

Out[102… array([0., 0., 3.])
```

Evaluation of Random Forest

In [103…

```python
from sklearn.metrics import confusion_matrix,accuracy_score,classification_report
pred=rf.predict(x_test)
cm=confusion_matrix(y_test, pred)
plt.figure(figsize=(10,6))
sns.heatmap(cm, annot=True,cmap='winter',linewidths=0.3, linecolor='black',annot_kws={"size": 20})
TP=cm[0][0]
TN=cm[1][1]
FN=cm[1][0]
FP=cm[0][1]
#print(round(accuracy_score(prediction3,y_test)*100,2))
#print('Testing Accuracy for knn',(TP+TN)/(TP+TN+FN+FP))
print('Testing Sensitivity for Random Forest',(TP/(TP+FN)))
print('Testing Specificity for Random Forest',(TN/(TN+FP)))
print('Testing Precision for Random Forest',(TP/(TP+FP)))
print('Testing accuracy for Random Forest',accuracy_score(y_test, pred))
```

```
Testing Sensitivity for Random Forest 0.9360230547550432
Testing Specificity for Random Forest 0.8716577540106952
Testing Precision for Random Forest 0.9854368932038835
Testing accuracy for Random Forest 0.8368506493506493
```



	0	1	2	3	4
0	1.6e+03	24	33	2	0
1	1.1e+02	1.6e+02	30	1	3
2	1.2e+02	26	1.4e+02	0	5
3	14	2	2	36	1
4	17	8	6	2	97

In [104…

```python
print(classification_report(y_test,pred))
```

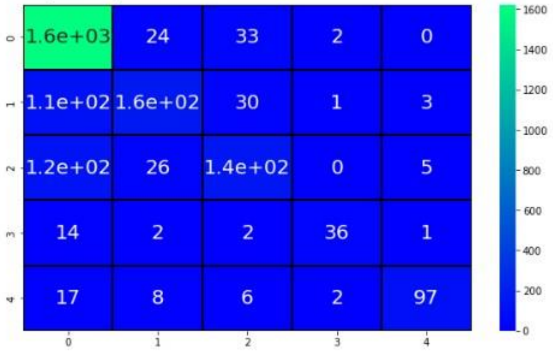
```
              precision    recall  f1-score   support

         0.0       0.86      0.96      0.91      1683
         1.0       0.73      0.53      0.61       308
         2.0       0.67      0.49      0.57       288
         3.0       0.88      0.65      0.75        55
         4.0       0.92      0.75      0.82       130

    accuracy                           0.84      2464
   macro avg       0.81      0.68      0.73      2464
weighted avg       0.83      0.84      0.83      2464
```

Evaluation of Decision Tree

In [105…

```
from sklearn.metrics import confusion_matrix,accuracy_score,classification_report
pred1=rf.predict(x_test)
cm=confusion_matrix(y_test, pred)
plt.figure(figsize=(10,6))
sns.heatmap(cm, annot=True,cmap='winter',linewidths=0.3, linecolor='black',annot_kws={"size": 20})
TP=cm[0][0]
TN=cm[1][1]
FN=cm[1][0]
FP=cm[0][1]
#print(round(accuracy_score(prediction3,y_test)*100,2))
#print('Testing Accuracy for knn',(TP+TN)/(TP+TN+FN+FP))
print('Testing Sensitivity for Random Forest',(TP/(TP+FN)))
print('Testing Specificity for Random Forest',(TN/(TN+FP)))
print('Testing Precision for Random Forest',(TP/(TP+FP)))
print('Testing accuracy for Random Forest',accuracy_score(y_test, pred1))
```

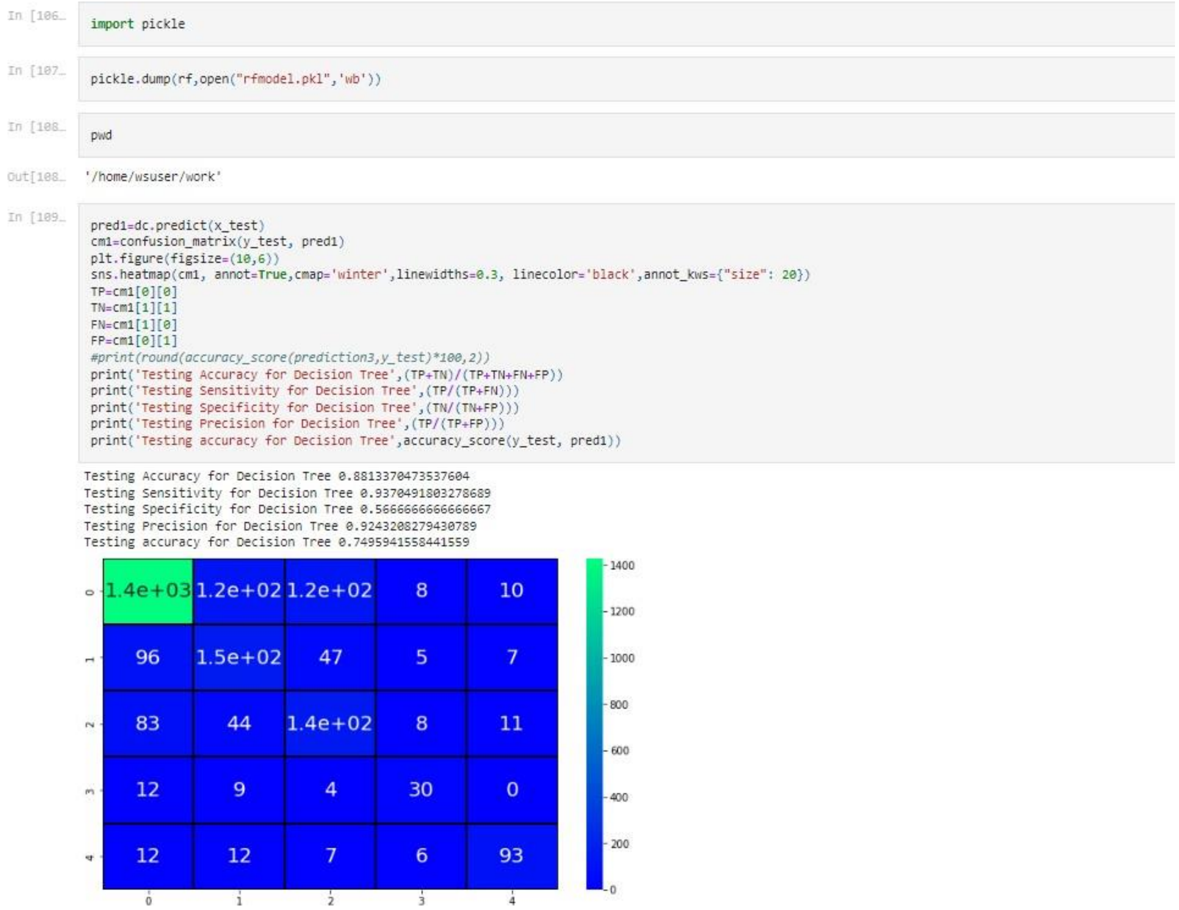
```
Testing Sensitivity for Random Forest 0.9360230547550432
Testing Specificity for Random Forest 0.8716577540106952
Testing Precision for Random Forest 0.9854368932038835
Testing accuracy for Random Forest 0.8368506493506493
```



In [112…

```
print(classification_report(y_test,pred1))
```

```
              precision    recall  f1-score   support

         0.0       0.86      0.96      0.91      1683
         1.0       0.73      0.53      0.61       308
         2.0       0.67      0.49      0.57       288
         3.0       0.88      0.65      0.75        55
         4.0       0.92      0.75      0.82       130

    accuracy                           0.84      2464
   macro avg       0.81      0.68      0.73      2464
weighted avg       0.83      0.84      0.83      2464
```



```
In [106…  import pickle
```

```
In [107…  pickle.dump(rf,open("rfmodel.pkl",'wb'))
```

```
In [108…  pwd
```

```
Out[108…  '/home/wsuser/work'
```

```
In [109…
pred1=dc.predict(x_test)
cm1=confusion_matrix(y_test, pred1)
plt.figure(figsize=(10,6))
sns.heatmap(cm1, annot=True,cmap='winter',linewidths=0.3, linecolor='black',annot_kws={"size": 20})
TP=cm1[0][0]
TN=cm1[1][1]
FN=cm1[1][0]
FP=cm1[0][1]
#print(round(accuracy_score(prediction3,y_test)*100,2))
print('Testing Accuracy for Decision Tree',(TP+TN)/(TP+TN+FN+FP))
print('Testing Sensitivity for Decision Tree',(TP/(TP+FN)))
print('Testing Specificity for Decision Tree',(TN/(TN+FP)))
print('Testing Precision for Decision Tree',(TP/(TP+FP)))
print('Testing accuracy for Decision Tree',accuracy_score(y_test, pred1))
```

```
Testing Accuracy for Decision Tree 0.8813370473537604
Testing Sensitivity for Decision Tree 0.9370491803278689
Testing Specificity for Decision Tree 0.5666666666666667
Testing Precision for Decision Tree 0.9243208279430789
Testing accuracy for Decision Tree 0.7495941558441559
```

	0	1	2	3	4
0	1.4e+03	1.2e+02	1.2e+02	8	10
1	96	1.5e+02	47	5	7
2	83	44	1.4e+02	8	11
3	12	9	4	30	0
4	12	12	7	6	93

In [110…

```
print(classification_report(y_test,pred))
```

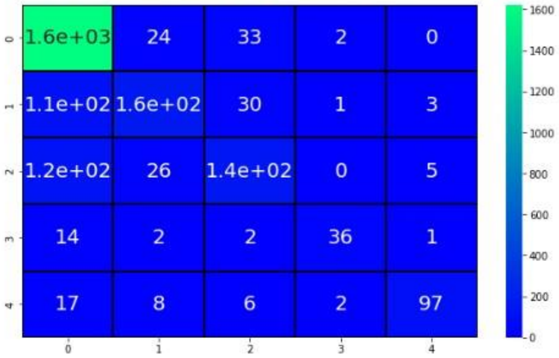
```
              precision    recall  f1-score   support

         0.0       0.86      0.96      0.91      1683
         1.0       0.73      0.53      0.61       308
         2.0       0.67      0.49      0.57       288
         3.0       0.88      0.65      0.75        55
         4.0       0.92      0.75      0.82       130

    accuracy                           0.84      2464
   macro avg       0.81      0.68      0.73      2464
weighted avg       0.83      0.84      0.83      2464
```

Evaluation of Decision Tree

In [111…

```
from sklearn.metrics import confusion_matrix,accuracy_score,classification_report
pred=rf.predict(x_test)
cm=confusion_matrix(y_test, pred)
plt.figure(figsize=(10,6))
sns.heatmap(cm, annot=True,cmap='winter',linewidths=0.3, linecolor='black',annot_kws={"size": 20})
TP=cm[0][0]
TN=cm[1][1]
FN=cm[1][0]
FP=cm[0][1]
#print(round(accuracy_score(prediction3,y_test)*100,2))
#print('Testing Accuracy for knn',(TP+TN)/(TP+TN+FN+FP))
print('Testing Sensitivity for Random Forest',(TP/(TP+FN)))
print('Testing Specificity for Random Forest',(TN/(TN+FP)))
print('Testing Precision for Random Forest',(TP/(TP+FP)))
print('Testing accuracy for Random Forest',accuracy_score(y_test, pred))
```

```
Testing Sensitivity for Random Forest 0.9360230547550432
Testing Specificity for Random Forest 0.8716577540106952
Testing Precision for Random Forest 0.9854368932038835
Testing accuracy for Random Forest 0.8368506493506493
```



	0	1	2	3	4
0	1.6e+03	24	33	2	0
1	1.1e+02	1.6e+02	30	1	3
2	1.2e+02	26	1.4e+02	0	5
3	14	2	2	36	1
4	17	8	6	2	97