CS306: DATA ANALYSIS AND VISUALIZATION

LAB 3: Airline Data (Big) Analysis

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In [2]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import matplotlib.lines as mlines
%matplotlib inline
import scipy.stats as stats
import math
import warnings
warnings.simplefilter(action='ignore', category=FutureWarning)
```

Function to plot PDF & CDF and return the cumulative frequency distribution values for use in KSTest

In [3]:
```
def make_pdf_cdf(n_equal_bins,df_temp,attr):
    freq , bins= np.histogram(df_temp[attr],bins=n_equal_bins)
    norm_freq=pd.Series(freq/freq.sum())#normalizing the frequencies
    cumulative_freq=[];
    cumulative_freq.append(norm_freq[0]);
    for i in range(1,len(norm_freq)):
        cumulative_freq.append(norm_freq[i]+cumulative_freq[i-1]);

    cumulative_freq=pd.Series(cumulative_freq);#The frequencies in CDF plot
    freq=pd.Series(freq)
    bins=pd.Series(bins)
    fig = plt.figure()

    fig, axs = plt.subplots(1,2,figsize =(18, 5))
    N, bins, patches=axs[0].hist(df_temp[attr],color="pink",edgecolor="black",
                                  bins=bins,weights=np.zeros_like(df_temp[attr]) + 1. / le
n(df_temp[attr]))
    axs[0].set_xlabel(attr)
    axs[0].set_ylabel('Normalized Frequency');
    axs[0].set_title('PDF of '+ attr +' with Bins='+str(n_equal_bins))
    axs[0].grid()



    N, bins, patches=axs[1].hist(df_temp[attr],color="purple",edgecolor="black", bins=bins,w
eights=np.zeros_like(df_temp[attr]) + 1. / len(df_temp[attr]),cumulative=1)
    axs[1].set_xlabel(attr)
    axs[1].set_ylabel('Normalized Frequency');
    axs[1].set_title('CDF of '+attr+ ' with Bins='+str(n_equal_bins))
    axs[1].grid()
    return cumulative_freq
```

1) Excel has a limit of maximum row 1048576 by 16384 columns. The file loaded was of size 1048576x29.

In [4]:
```
df=pd.read_csv('2008.csv.bz2')
```

In [5]:
```
df.head()
```

Out[5]:

	Year	Month	DayofMonth	DayOfWeek	DepTime	CRSDepTime	ArrTime	CRSArrTime	UniqueCarrier	FlightNum	...	TaxiIn
0	2008	1	3	4	2003.0	1955	2211.0	2225	WN	335	...	4.0
1	2008	1	3	4	754.0	735	1002.0	1000	WN	3231	...	5.0
2	2008	1	3	4	628.0	620	804.0	750	WN	448	...	3.0
3	2008	1	3	4	926.0	930	1054.0	1100	WN	1746	...	3.0
4	2008	1	3	4	1829.0	1755	1959.0	1925	WN	3920	...	3.0

5 rows × 29 columns

2) Size of the file in python came out to be 7009728x29

In [8]:
```
rows=df.shape[0]
print('Rowcount: ',rows)
```

```
Rowcount:  7009728
```

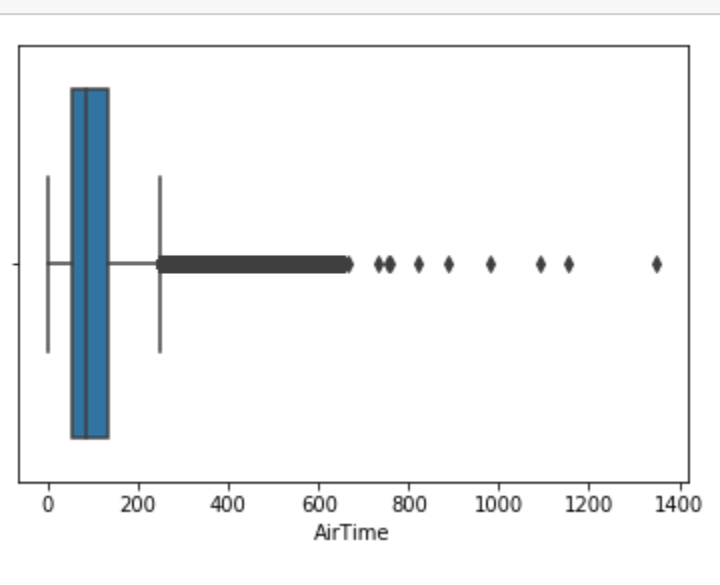
3) Filtering AirTime and Distance from the data

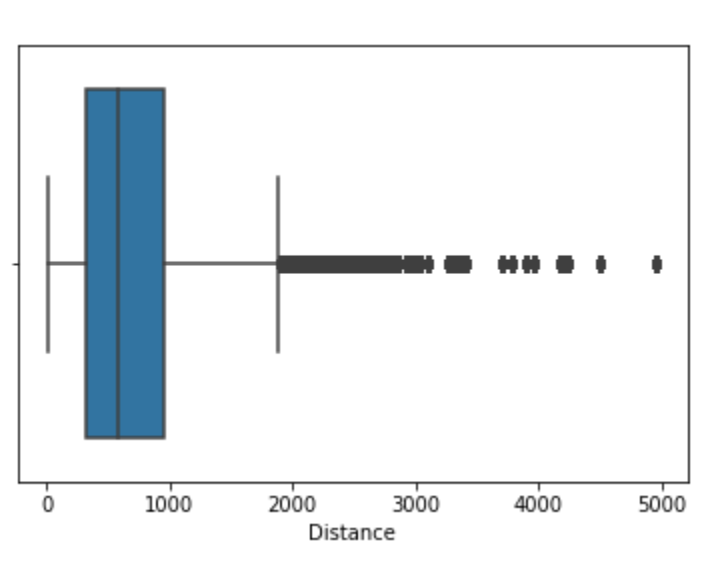
In [10]:
```
data=df[['AirTime','Distance']]
data=data.dropna()
for i in data.columns:
    data=data[data['{}'.format(i)].notnull()]
row_count=data.shape[0]
print(data.head())
```

```
   AirTime  Distance
0    116.0       810
1    113.0       810
2     76.0       515
3     78.0       515
4     77.0       515
```

Plotting data to check for outliers

In [11]:
```
sns.boxplot(data['AirTime'])
plt.show()
sns.boxplot(data['Distance'])
plt.show()
```



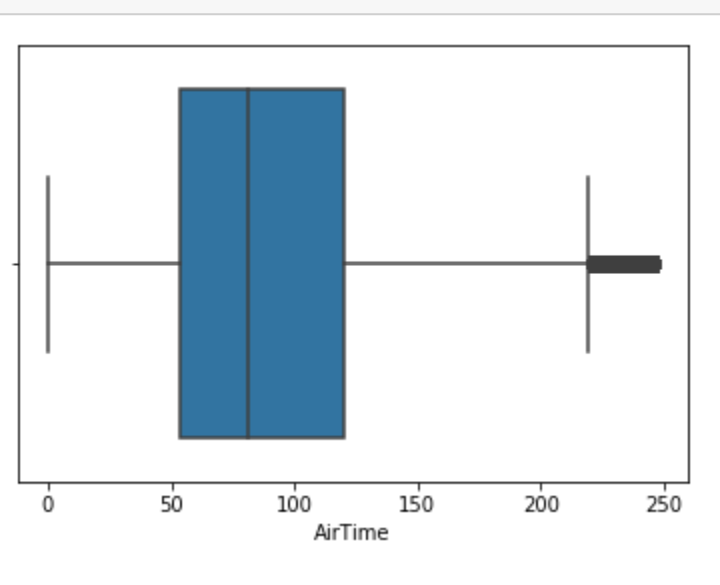


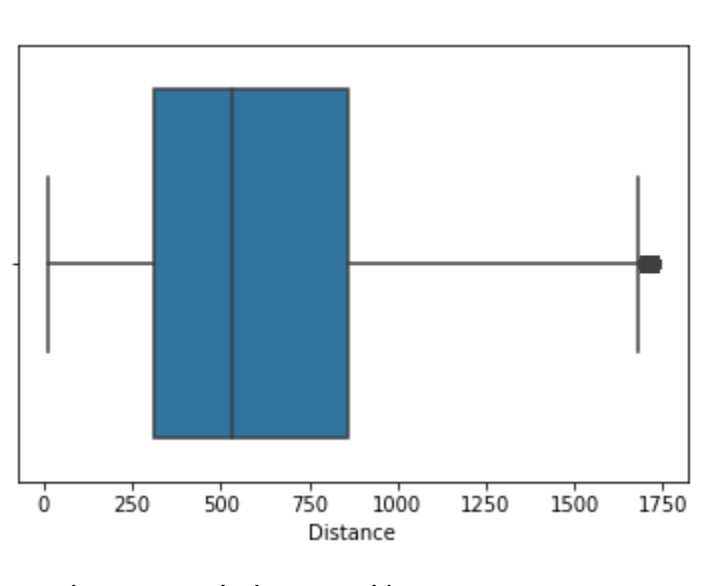
Handling outliers using the interquartile range method

In [12]:
```
cols=data.columns
for i in cols:
    Q1 = data['{}'.format(i)].quantile(0.25)
    Q3 = data['{}'.format(i)].quantile(0.75)
    IQR = Q3 - Q1
    m1=Q1 - (1.5 * IQR)
    m2=Q3 + (1.5 * IQR)
    #print(Q1,Q3,IQR,m1,m2)
    data=data[~((data['{}'.format(i)] < (Q1 - 1.5 * IQR)) |(data['{}'.format(i)] > (Q3 + 1.5
* IQR)))]

print('Airtime mean: ',data['AirTime'].mean())
print('Airtime standard deviation: ',data['AirTime'].std())
print('Distance mean: ',data['Distance'].mean())
print('Distance standard deviation: ',data['Distance'].std())
```

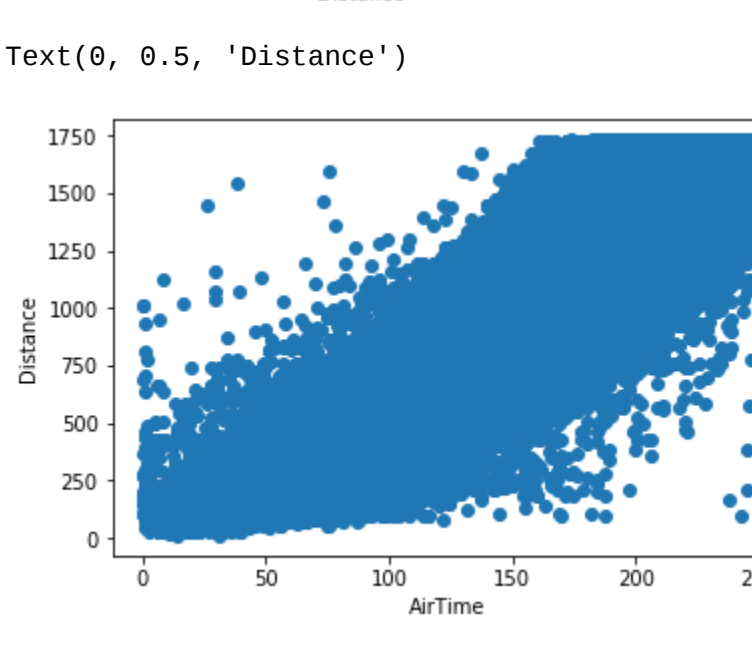
```
Airtime mean:  90.49131646668722
Airtime standard deviation:  46.709084701779965
Distance mean:  612.8610493100866
Distance standard deviation:  379.8788457114467
```

In [13]:
```
sns.boxplot(data['AirTime'])
plt.show()
sns.boxplot(data['Distance'])
plt.show()
plt.plot(data['AirTime'],data['Distance'],'o')
plt.xlabel('AirTime')
plt.ylabel('Distance')
```





Out[13]:
```
Text(0, 0.5, 'Distance')
```



Normalizing the data

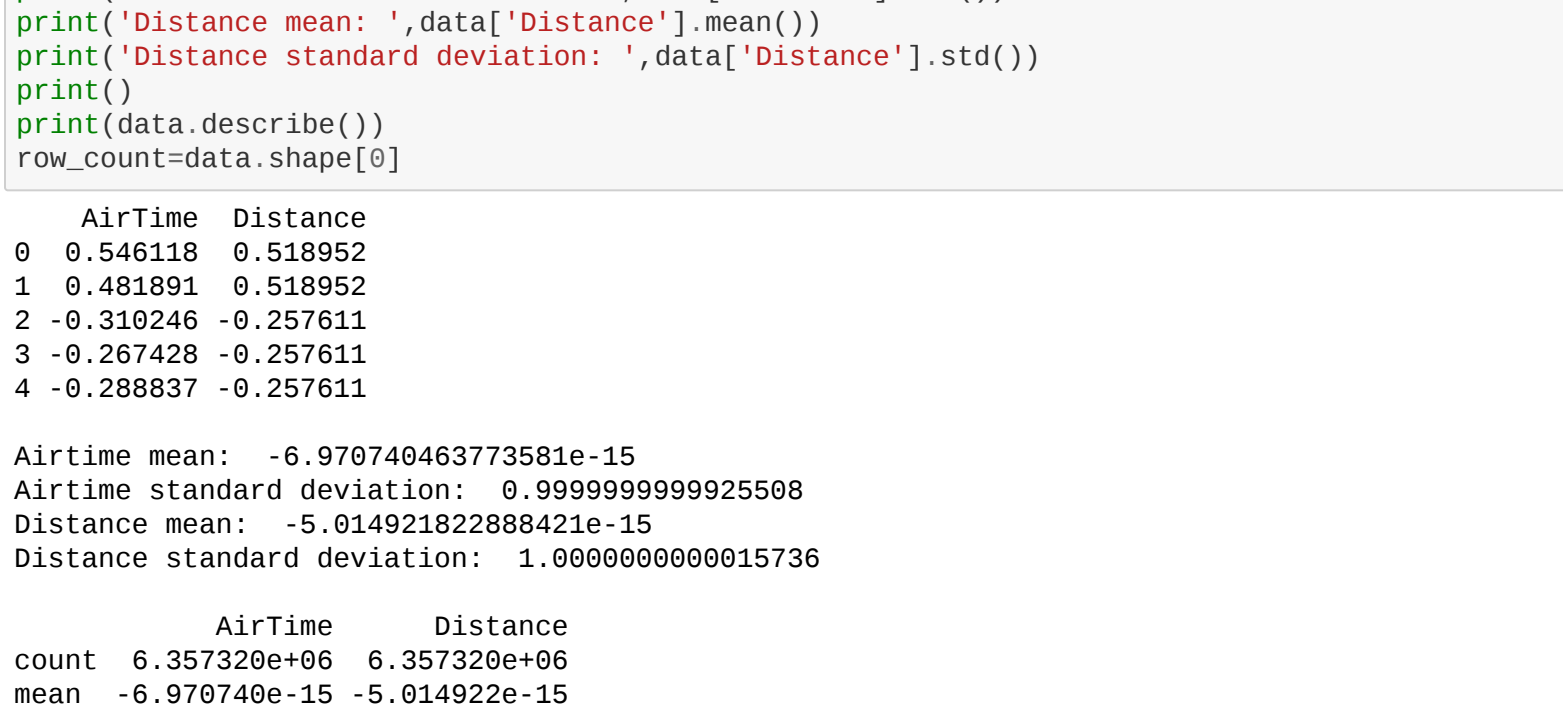
In [14]:
```
data=(data-data.mean())/data.std()
print(data.head())
print()
print('Airtime mean: ',data['AirTime'].mean())
print('Airtime standard deviation: ',data['AirTime'].std())
print('Distance mean: ',data['Distance'].mean())
print('Distance standard deviation: ',data['Distance'].std())
print()
print(data.describe())
row_count=data.shape[0]
```

```
    AirTime  Distance
0  0.546118  0.518952
1  0.481891  0.518952
2 -0.310246 -0.257611
3 -0.267428 -0.257611
4 -0.288837 -0.257611

Airtime mean:  -6.970740463773581e-15
Airtime standard deviation:  0.9999999999925508
Distance mean:  -5.014921822888421e-15
Distance standard deviation:  1.0000000000015736

            AirTime      Distance
count  6.357320e+06  6.357320e+06
mean  -6.970740e-15 -5.014922e-15
std    1.000000e+00  1.000000e+00
min   -1.937339e+00 -1.584350e+00
25%   -7.812467e-01 -7.998894e-01
50%   -2.032007e-01 -2.102277e-01
75%    6.317547e-01  6.532055e-01
max    3.350712e+00  2.948674e+00
```

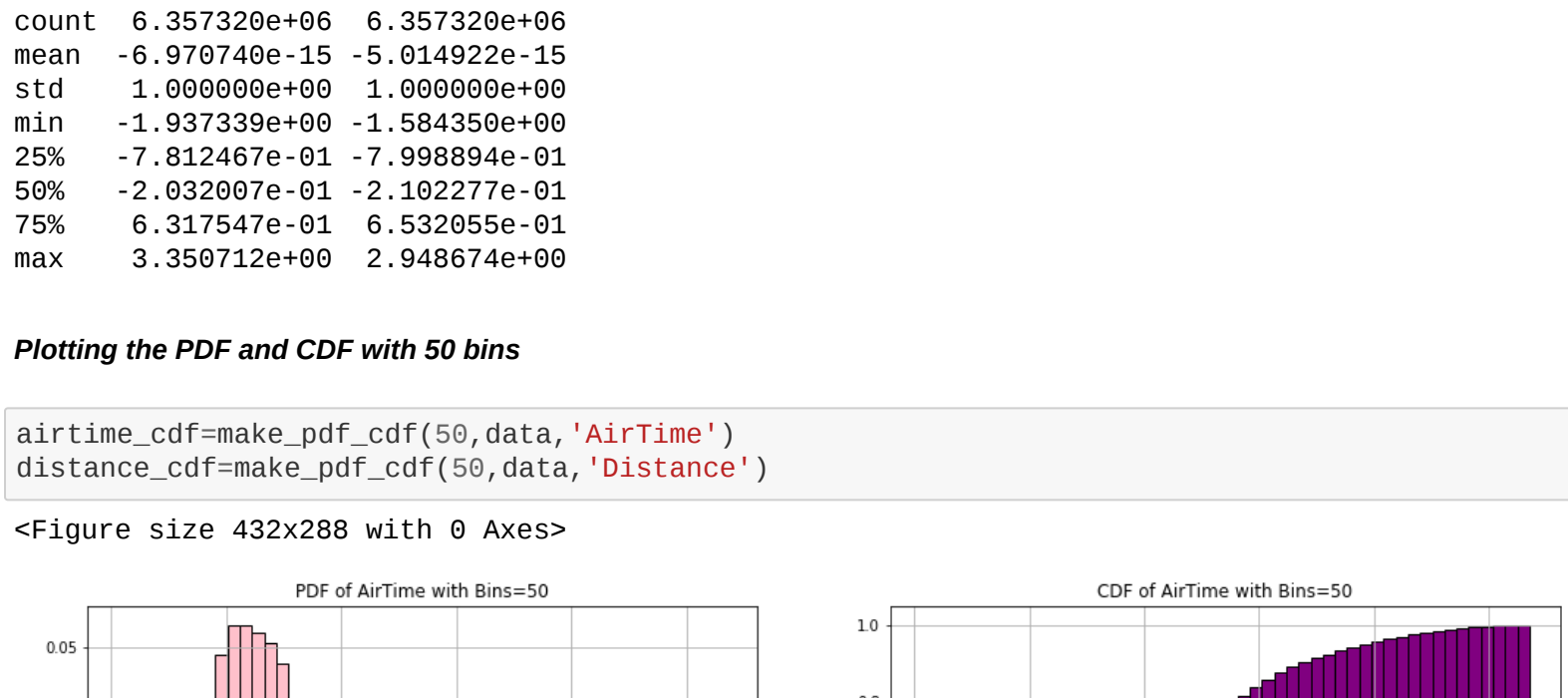
Plotting the PDF and CDF with 50 bins

In [15]:
```
airtime_cdf=make_pdf_cdf(50,data,'AirTime')
distance_cdf=make_pdf_cdf(50,data,'Distance')
```

```
<Figure size 432x288 with 0 Axes>
```




```
<Figure size 432x288 with 0 Axes>
```



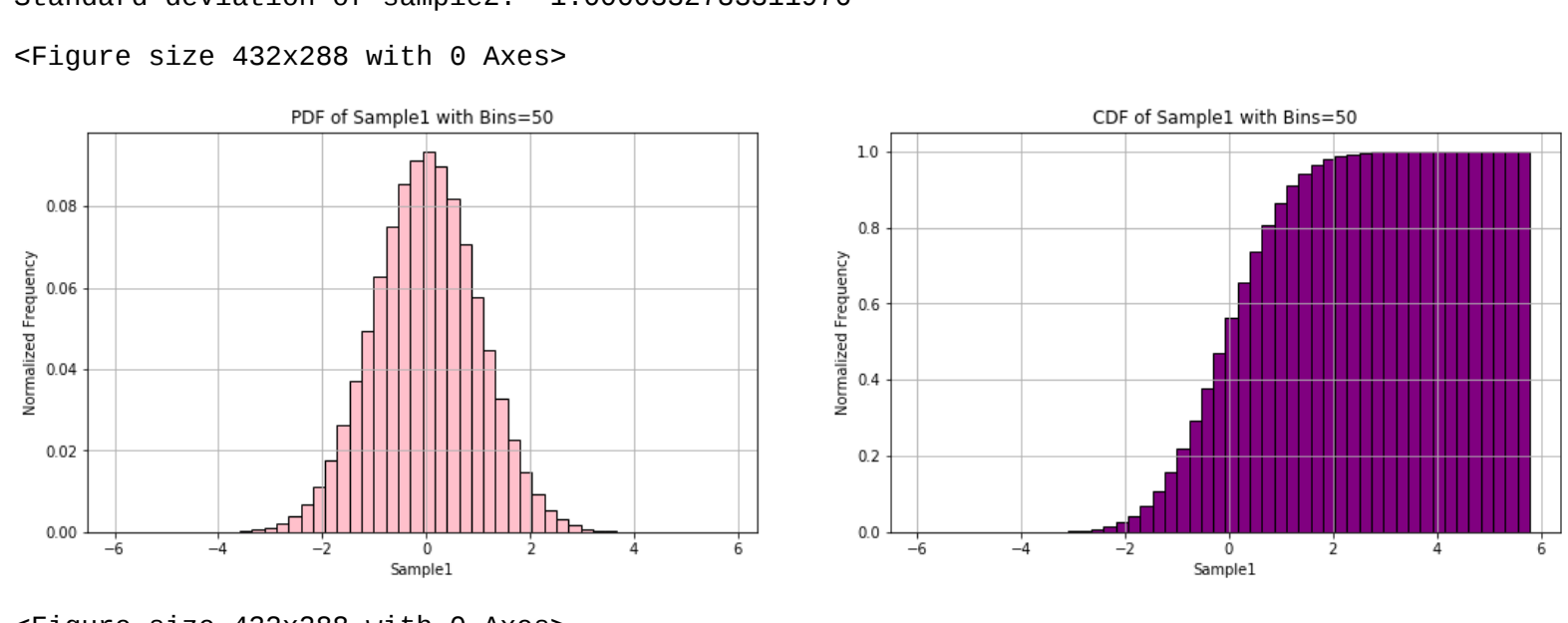
4) Generating random samples of Standard Normal distribution

In [17]:
```
df_norm=pd.DataFrame(np.random.randn(row_count, 2), columns=['Sample1','Sample2'])
```

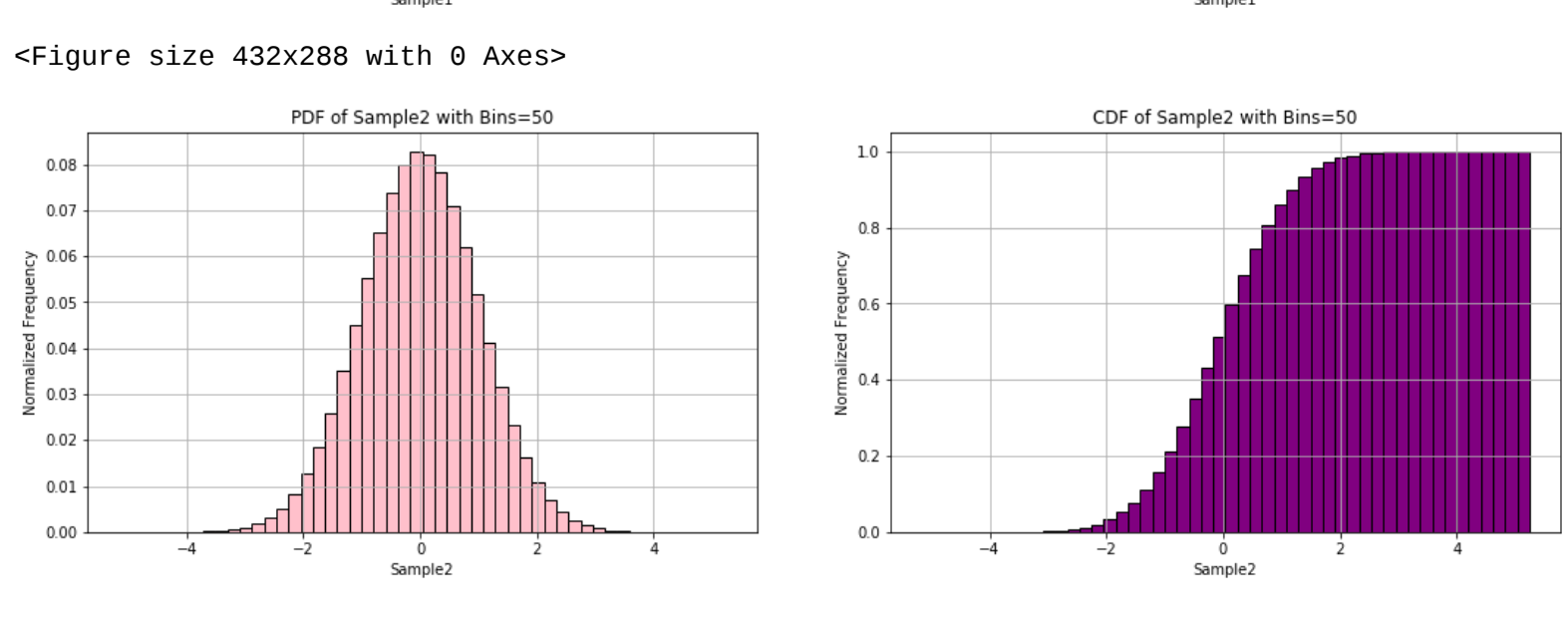
Verifying the correctness of the randomly generated data using plots and verifying mean, standard deviation = $N(0,1)$

In [18]:
```
sample1_cdf=make_pdf_cdf(50,df_norm,'Sample1')
sample2_cdf=make_pdf_cdf(50,df_norm,'Sample2')
print('Mean of sample1: ',df_norm['Sample1'].mean())
print('Standard deviation of sample1: ',df_norm['Sample1'].std())
print('Mean of sample2: ',df_norm['Sample2'].mean())
print('Standard deviation of sample2: ',df_norm['Sample2'].std())
```

```
Mean of sample1:  0.00040415601003072082
Standard deviation of sample1:  0.999527365952908
Mean of sample2:  0.00051905985833027
Standard deviation of sample2:  1.0000332783311976

<Figure size 432x288 with 0 Axes>
```



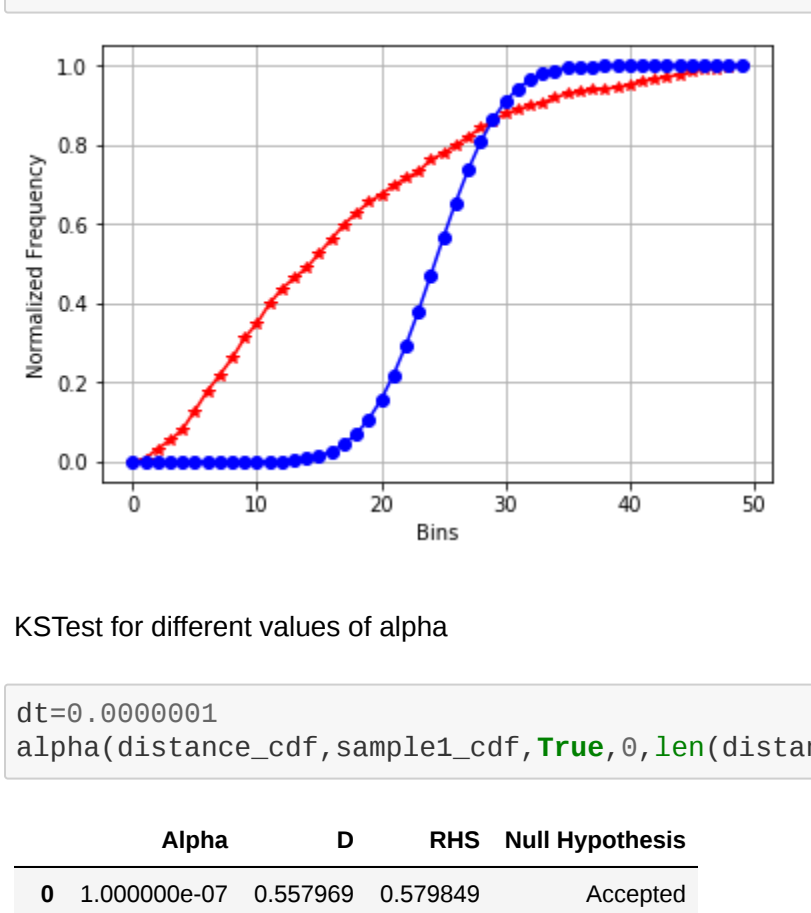

```
<Figure size 432x288 with 0 Axes>
```



5) \& 6) KSTest for $Distance$ feature to find out if it is normally distributed or not

In [19]:
```
#attributes:
# df1=dataframe1
# df4=dataframe2
# b=boolean for different functioning
# D=test statistic
# n=length of dataframe1
# m=length of dataframe2
# dt=step size for incrementing alpha value to find the critical value

def alpha(df1,df4,b,D,n,m,dt):
    if b==True:
        norm=df4.copy();
        dist=df1.copy();
        D = 0

        #finding the supremum for KS-test
        for i in range(len(dist)):
            if (D < abs(norm[i]-dist[i])):
                D = abs(norm[i]-dist[i])


    verdict=[];
    rhs=[];
    d=[]
    A=[];

    #Taking alpha to find the turning point in the status of hypothesis testing
    for a in np.arange(1,50,2):
        alpha=a*dt
        RHS = np.sqrt((n+m)/(n*m));
        RHS = RHS*np.sqrt(-0.5*np.log(alpha/2))
        rhs.append(RHS)
        d.append(D)
        A.append(alpha)
        if D>RHS:
            verdict.append('Rejected')#null-hypothesis is rejected when D>RHS is satisfied
        else:
            verdict.append('Accepted')#null-hypothesis is rejected when D<=RHS is satisfied

    A=pd.Series(A)
    rhs=pd.Series(rhs)
    verdict=pd.Series(verdict)
    d=pd.Series(d)
    frame={'Alpha':A,'D':d,'RHS':rhs,'Null Hypothesis':verdict}
    ans=pd.DataFrame(frame);
    return ans
```

In [21]:
```
#This is the plot of cdf of the data we wish to compare to
#the random sample of standard normal distribution that we generated
#This step has major approximations but it allows us to
#find the critical value of alpha with the given computational limitations of our PC
plt.plot(distance_cdf,'r-*')
plt.plot(sample1_cdf,'b-o')
plt.xlabel('Bins')
plt.ylabel('Normalized Frequency')
plt.grid()
```



KSTest for different values of alpha

In [22]:
```
dt=0.0000001
alpha(distance_cdf,sample1_cdf,True,0,len(distance_cdf),len(sample1_cdf),dt)
```

Out[22]:

	Alpha	D	RHS	Null Hypothesis
0	1.000000e-07	0.557969	0.579849	Accepted
1	3.000000e-07	0.557969	0.560582	Accepted
2	5.000000e-07	0.557969	0.551395	Rejected
3	7.000000e-07	0.557969	0.545258	Rejected
4	9.000000e-07	0.557969	0.540630	Rejected
5	1.100000e-06	0.557969	0.536905	Rejected
6	1.300000e-06	0.557969	0.533784	Rejected
7	1.500000e-06	0.557969	0.531097	Rejected
8	1.700000e-06	0.557969	0.528735	Rejected
9	1.900000e-06	0.557969	0.526627	Rejected
10	2.100000e-06	0.557969	0.524723	Rejected
11	2.300000e-06	0.557969	0.522987	Rejected
12	2.500000e-06	0.557969	0.521390	Rejected
13	2.700000e-06	0.557969	0.519912	Rejected
14	2.900000e-06	0.557969	0.518535	Rejected
15	3.100000e-06	0.557969	0.517248	Rejected
16	3.300000e-06	0.557969	0.516038	Rejected
17	3.500000e-06	0.557969	0.514896	Rejected
18	3.700000e-06	0.557969	0.513816	Rejected
19	3.900000e-06	0.557969	0.512790	Rejected
20	4.100000e-06	0.557969	0.511814	Rejected
21	4.300000e-06	0.557969	0.510882	Rejected
22	4.500000e-06	0.557969	0.509992	Rejected
23	4.700000e-06	0.557969	0.509138	Rejected
24	4.900000e-06	0.557969	0.508319	Rejected

The above methodology had many approximations and from the result we got critical value of alpha to be between 3 to 5e-07 and D=0.557969. From this we can say that for alpha>=5e-07 we **reject the null hypothesis i.e., the given data is not similar to the standard normal distribution.**

In [23]:
```
D,pval=stats.ks_2samp(np.array(data['Distance']),np.array(df_norm['Sample1']))
print('D: ',D)
print('pval: ',pval)
alpha(None,None,False,D,len(data),len(df_norm),dt)
```

```
D:  0.09585737386194182
pval:  0.0
```

Out[23]:

	Alpha	D	RHS	Null Hypothesis
0	1.000000e-07	0.095857	0.001626	Rejected
1	3.000000e-07	0.095857	0.001572	Rejected
2	5.000000e-07	0.095857	0.001546	Rejected
3	7.000000e-07	0.095857	0.001529	Rejected
4	9.000000e-07	0.095857	0.001516	Rejected
5	1.100000e-06	0.095857	0.001506	Rejected
6	1.300000e-06	0.095857	0.001497	Rejected
7	1.500000e-06	0.095857	0.001489	Rejected
8	1.700000e-06	0.095857	0.001483	Rejected
9	1.900000e-06	0.095857	0.001477	Rejected
10	2.100000e-06	0.095857	0.001472	Rejected
11	2.300000e-06	0.095857	0.001467	Rejected
12	2.500000e-06	0.095857	0.001462	Rejected
13	2.700000e-06	0.095857	0.001458	Rejected
14	2.900000e-06	0.095857	0.001454	Rejected
15	3.100000e-06	0.095857	0.001451	Rejected
16	3.300000e-06	0.095857	0.001447	Rejected
17	3.500000e-06	0.095857	0.001444	Rejected
18	3.700000e-06	0.095857	0.001441	Rejected
19	3.900000e-06	0.095857	0.001438	Rejected
20	4.100000e-06	0.095857	0.001435	Rejected
21	4.300000e-06	0.095857	0.001433	Rejected
22	4.500000e-06	0.095857	0.001430	Rejected
23	4.700000e-06	0.095857	0.001428	Rejected
24	4.900000e-06	0.095857	0.001426	Rejected

We can observe from the above data that the approximation of 50 bins to replace the continuous cdf and to do KStest on the 50 bins gives us poor results. When we did the same operation considering the whole array and then the inbuilt function of kstest we found pval=0.0 and D=0.09535. From this we can say that if $c(\alpha)\sqrt{\frac{n+m}{nm}}$ is less than D then we reject the null hypothesis where $c(\alpha)=\sqrt{\frac{-\ln(a/2)}{2}}$ and n,m are the size of the two data arrays into consideration.

From the inbuilt function be got D=0.09591 which is way less than the one obtained using the CDF thereby giving a tighter bound on the value of alpha. So, we can conclude that the value of alpha, above which we can reject the null hypothesis, is way less than 5e-07 which we got from above.

Second file

In [24]:
```
col=["Year", "Month", "DayofMonth", "DayOfWeek",
    "DepTime", "CRSDepTime", "ArrTime", "CRSArrTime", "UniqueCarrier",
    "FlightNum", "TailNum", "ActualElapsedTime", "CRSElapsedTime",
    "AirTime", "ArrDelay", "DepDelay", "Origin", "Dest", "Distance",
    "TaxiIn", "TaxiOut", "Cancelled", "CancellationCode", "Diverted",
    "CarrierDelay", "WeatherDelay", "NASDelay", "SecurityDelay",
    "LateAircraftDelay", "Age"];
T = np.fromfile('airline.bin',int);
t=pd.Series(T)
temp=t.values
data=temp.reshape((30,7009728))
df=pd.DataFrame(data)
df=df.transpose()

df.columns=col
df.head()
```

Out[24]:

	Year	Month	DayofMonth	DayOfWeek	DepTime	CRSDepTime	ArrTime	CRSArrTime	UniqueCarrier	FlightNum	...	TaxiOu
0	2008	1	3	4	2003	1955	2211	2225	-2147483648	335	...	
1	2008	1	3	4	754	735	1002	1000	-2147483648	3231	...	1
2	2008	1	3	4	628	620	804	750	-2147483648	448	...	1
3	2008	1	3	4	926	930	1054	1100	-2147483648	1746	...	
4	2008	1	3	4	1829	1755	1959	1925	-2147483648	3920	...	1

5 rows × 30 columns

In [25]:
```
newdata=df[['AirTime','Distance']]
newdata.head()
```

Out[25]:

	AirTime	Distance
0	116	810
1	113	810
2	76	515
3	78	515
4	77	515

The airline.bin file was loaded using integer datatype hence, the nan values will be converted to garbage values.

Otherwise on comparing the two dataFrames we could see that both the files are the same and hence the underlying analysis would give us the same output.