Assignment-03 (Hypothesis Testing)

In [2]:
```
import pandas as pd
import numpy as np
from scipy import stats
from scipy.stats import norm
from scipy.stats import chi2_contingency
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.filterwarnings("ignore")
```

Questions-1

A F&B manager wants to determine whether there is any significant difference in the diameter of the cutlet between two units. A randomly selected sample of cutlets was collected from both units and measured? Analyze the data and draw inferences at 5% significance level. Please state the assumptions and tests that you carried out to check validity of the assumptions.

Solution

We are going to conduct a 2 tailed t-Test on 2 Independent samples with Numerical Data

We need to check whether the mean of both samples are different and

Is there any significance difference between the two samples?

Step 1

Make two Hypothesis one contradicting to other

Null Hypothesis is want we want to prove

Null Hypothesis: μ1= μ2

Alternative Hypthosis: μ1 ≠ μ2

Step 2

Decide a cut-off value

Significance 5%

alpha = 0.05

As it is a two-tailed test

alpha/2 = 0.025

Step 3

Collect evidence

Importing Files

In [3]:
```
cutlets = pd.read_csv('Cutlets.csv')
cutlets
```

Out[3]:

	Unit A	Unit B
0	6.8090	6.7703
1	6.4376	7.5093
2	6.9157	6.7300
3	7.3012	6.7878
4	7.4488	7.1522
5	7.3871	6.8110
6	6.8755	7.2212
7	7.0621	6.6606
8	6.6840	7.2402
9	6.8236	7.0503
10	7.3930	6.8810
11	7.5169	7.4059
12	6.9246	6.7652
13	6.9256	6.0380
14	6.5797	7.1581
15	6.8394	7.0240
16	6.5970	6.6672
17	7.2705	7.4314
18	7.2828	7.3070
19	7.3495	6.7478
20	6.9438	6.8889
21	7.1560	7.4220
22	6.5341	6.5217
23	7.2854	7.1688
24	6.9952	6.7594
25	6.8568	6.9399
26	7.2163	7.0133
27	6.6801	6.9182
28	6.9431	6.3346
29	7.0852	7.5459
30	6.7794	7.0992
31	7.2783	7.1180
32	7.1561	6.6965

	Unit A	Unit B
33	7.3943	6.5780
34	6.9405	7.3875

Applying Descriptive Statistics

In [4]:
```
cutlets.describe()
```

Out[4]:

	Unit A	Unit B
count	35.000000	35.000000
mean	7.019091	6.964297
std	0.288408	0.343401
min	6.437600	6.038000
25%	6.831500	6.753600
50%	6.943800	6.939900
75%	7.280550	7.195000
max	7.516900	7.545900

Checking for Null Values

In [5]:
```
cutlets.isnull().sum()
```

Out[5]:
```
Unit A    0
Unit B    0
dtype: int64
```

Checking for Duplicate Values

In [6]:
```
cutlets[cutlets.duplicated()].shape
```

Out[6]:
```
(0, 2)
```

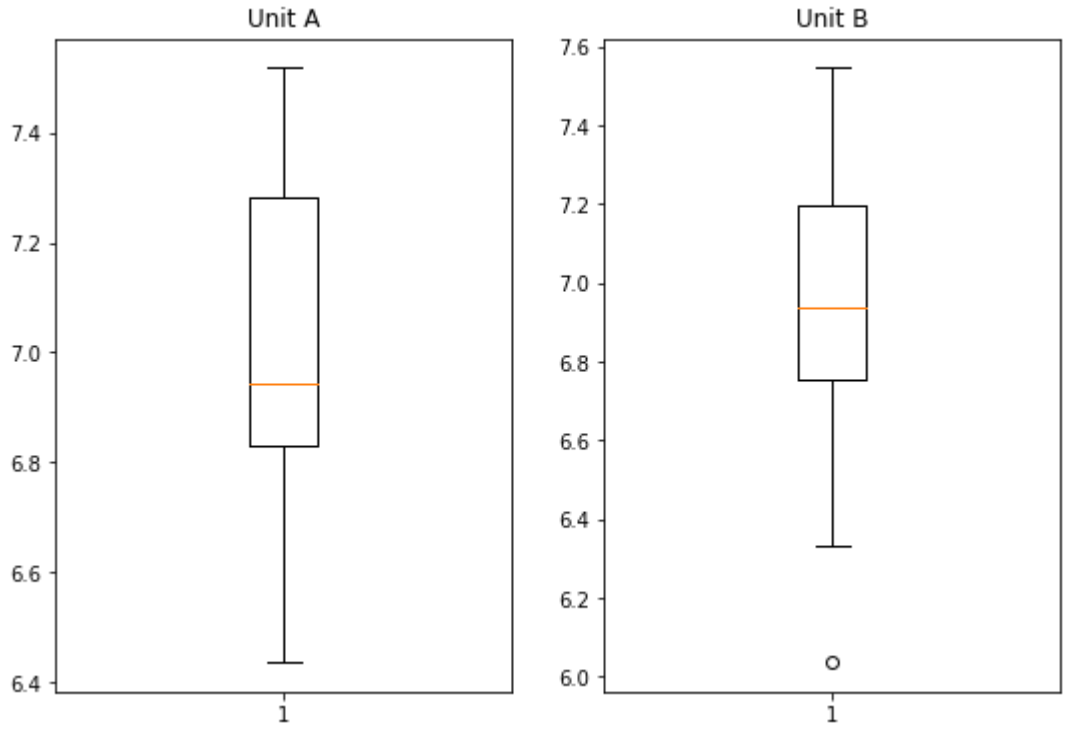
Checking the data type

In [7]:
```
cutlets.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 35 entries, 0 to 34
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype  
---  ------  --------------  -----  
 0   Unit A  35 non-null     float64
 1   Unit B  35 non-null     float64
dtypes: float64(2)
memory usage: 688.0 bytes
```

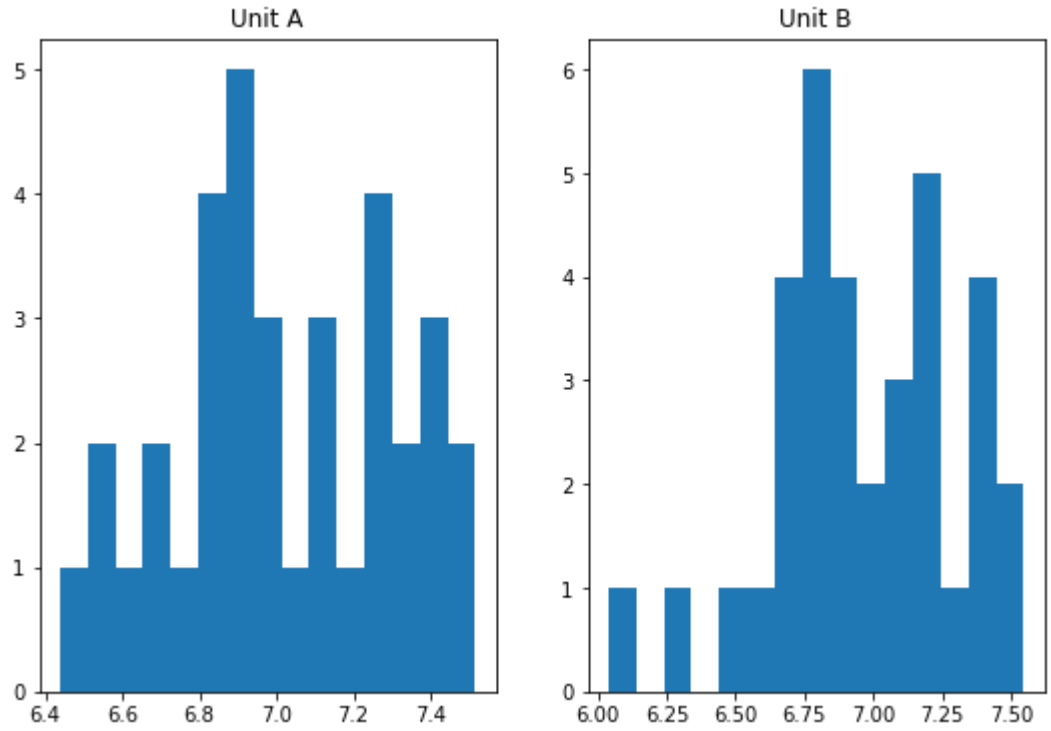
Plotting the data

In [8]:
```
plt.subplots(figsize = (9,6))
plt.subplot(121)
plt.boxplot(cutlets['Unit A'])
plt.title('Unit A')
plt.subplot(122)
plt.boxplot(cutlets['Unit B'])
plt.title('Unit B')
plt.show()
```



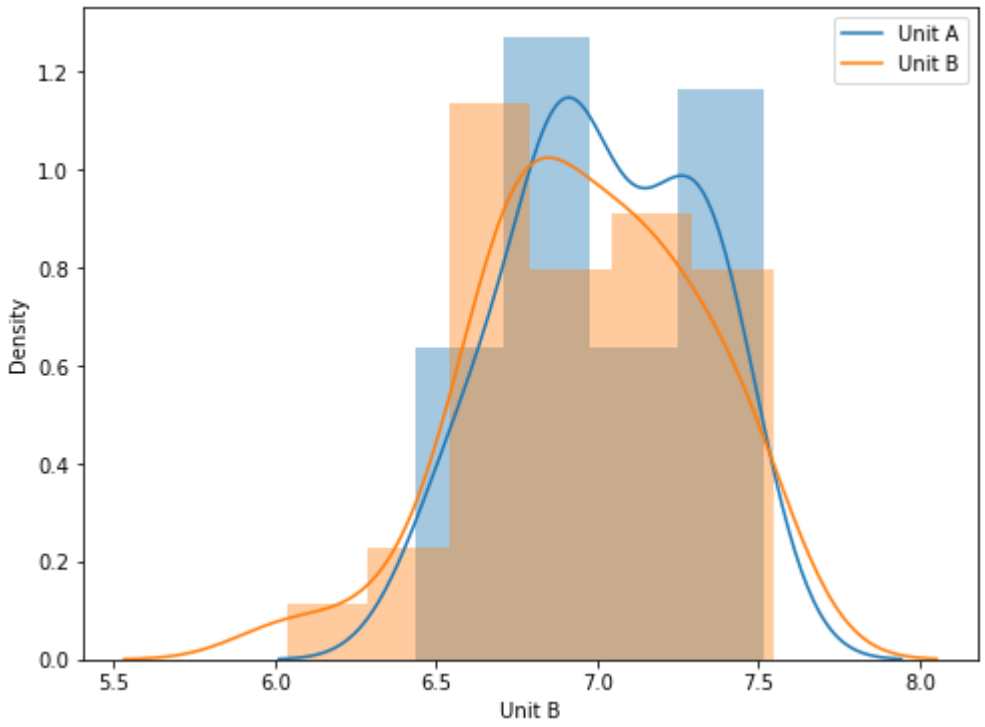
In [9]:

```
plt.subplots(figsize = (9,6))
plt.subplot(121)
plt.hist(cutlets['Unit A'], bins = 15)
plt.title('Unit A')
plt.subplot(122)
plt.hist(cutlets['Unit B'], bins = 15)
plt.title('Unit B')
plt.show()
```



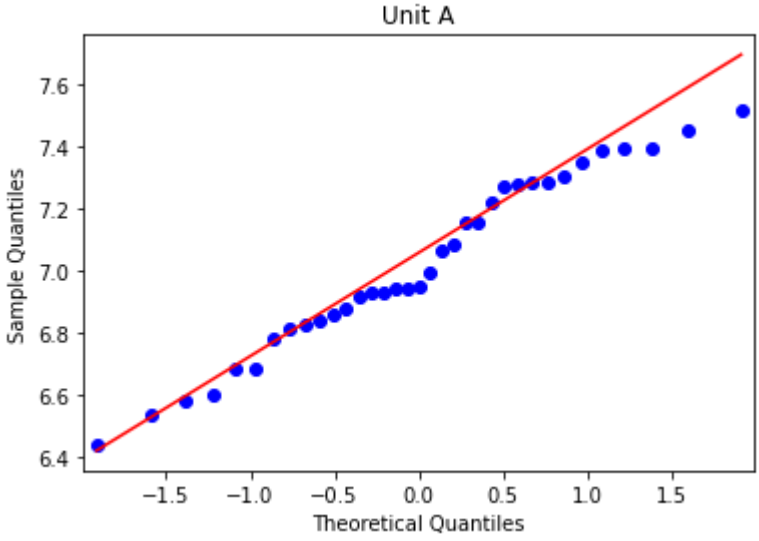
In [10]:
```
plt.figure(figsize = (8,6))
labels = ['Unit A', 'Unit B']
sns.distplot(cutlets['Unit A'], kde = True)
sns.distplot(cutlets['Unit B'],hist = True)
plt.legend(labels)
```

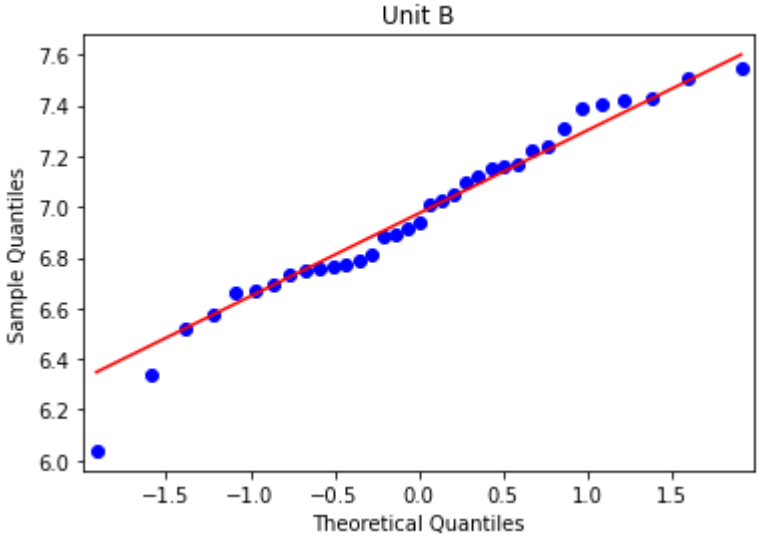
Out[10]: <matplotlib.legend.Legend at 0x258c1934d60>



Plotting Q-Q plot to check whether the distribution follows normal distribution or not

In [11]:
```
import statsmodels.api as sm
sm.qqplot(cutlets["Unit A"], line = 'q')
plt.title('Unit A')
sm.qqplot(cutlets["Unit B"], line = 'q')
plt.title('Unit B')
plt.show()
```





Step 4

Compare Evidences with Hypothesis using t-statistics

In [12]:
```
statistic,p_value = stats.ttest_ind(cutlets['Unit A'],cutlets['Unit B'],alter
print('P_value:',p_value)
```

```
P_value: 0.4722394724599501
```

Compare p_value with 'α '(Significane Level)

If p_value is ≠'α ' we failed to reject Null Hypothesis because of lack of evidence

If p_value is = 'α ' we reject Null Hypothesis

interpreting p-value

In [13]:
```
alpha = 0.025
print('Significnace=%.3f, p=%.3f' % (alpha, p_value))
if p_value <= alpha:
 print('We reject Null Hypothesis there is a significance difference between
else:
    print('We fail to reject Null hypothesis')
```

```
Significnace=0.025, p=0.472
We fail to reject Null hypothesis
```

Hence, We fail to reject Null Hypothesis because of lack of evidence, there is no significant difference between the two samples

Questions-2

A hospital wants to determine whether there is any difference in the average Turn Around Time (TAT) of reports of the laboratories on their preferred list. They collected a random sample and recorded TAT for reports of 4 laboratories. TAT is defined as sample collected to report dispatch.

Analyze the data and determine whether there is any difference in average TAT among the different laboratories at 5% significance level.

Solution:

We are going to conduct a ANOVA Test on 4 Independent samples with Numerical Data

We need to check whether the mean of any of these samples are different or the same?

Step 1

Make two Hypothesis one contradicting to other

Null Hypothesis is want we want to prove

Null Hypothesis: μ1=μ2 =μ3=μ4

Alternative Hypthosis: Atleast One of them is Differente

Step 2

Decide a cut-off value

Significance 5%

alpha = 0.05

Step 3

Collect evidence

Importing Files

In [14]:
```
labtat =pd.read_csv('LabTAT.csv')
labtat
```

Out[14]:

	Laboratory 1	Laboratory 2	Laboratory 3	Laboratory 4
0	185.35	165.53	176.70	166.13
1	170.49	185.91	198.45	160.79
2	192.77	194.92	201.23	185.18
3	177.33	183.00	199.61	176.42
4	193.41	169.57	204.63	152.60
...	...	...	...	...
115	178.49	170.66	193.80	172.68
116	176.08	183.98	215.25	177.64
117	202.48	174.54	203.99	170.27
118	182.40	197.18	194.52	150.87
119	182.09	215.17	221.49	162.21

120 rows × 4 columns

Applying Descriptive Statistics

In [15]:
```
labtat.describe()
```

Out[15]:

	Laboratory 1	Laboratory 2	Laboratory 3	Laboratory 4
count	120.000000	120.000000	120.000000	120.00000
mean	178.361583	178.902917	199.913250	163.68275
std	13.173594	14.957114	16.539033	15.08508
min	138.300000	140.550000	159.690000	124.06000
25%	170.335000	168.025000	188.232500	154.05000
50%	178.530000	178.870000	199.805000	164.42500
75%	186.535000	189.112500	211.332500	172.88250
max	216.390000	217.860000	238.700000	205.18000

Checking for Null Values

In [16]:
```
labtat.isnull().sum()
```

Out[16]:
```
Laboratory 1    0
Laboratory 2    0
Laboratory 3    0
Laboratory 4    0
dtype: int64
```

Checking for Duplicate Values

In [17]:
```
labtat[labtat.duplicated()].shape
```

Out[17]:
```
(0, 4)
```

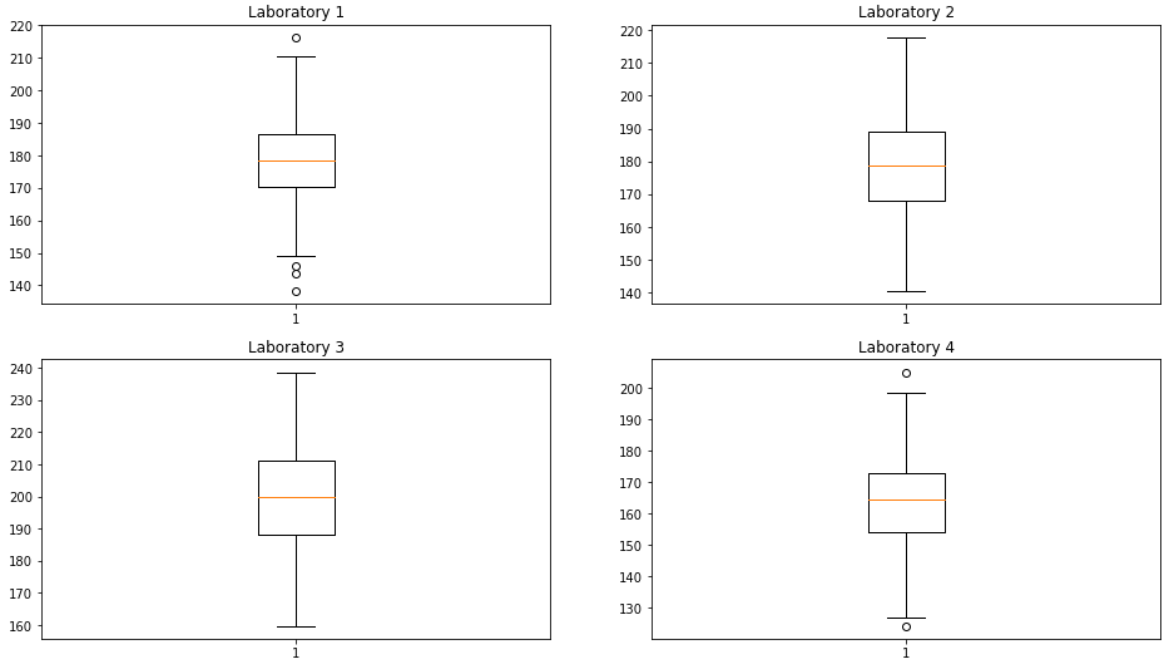
Checking the data type

In [18]:
```
labtat.info()
```

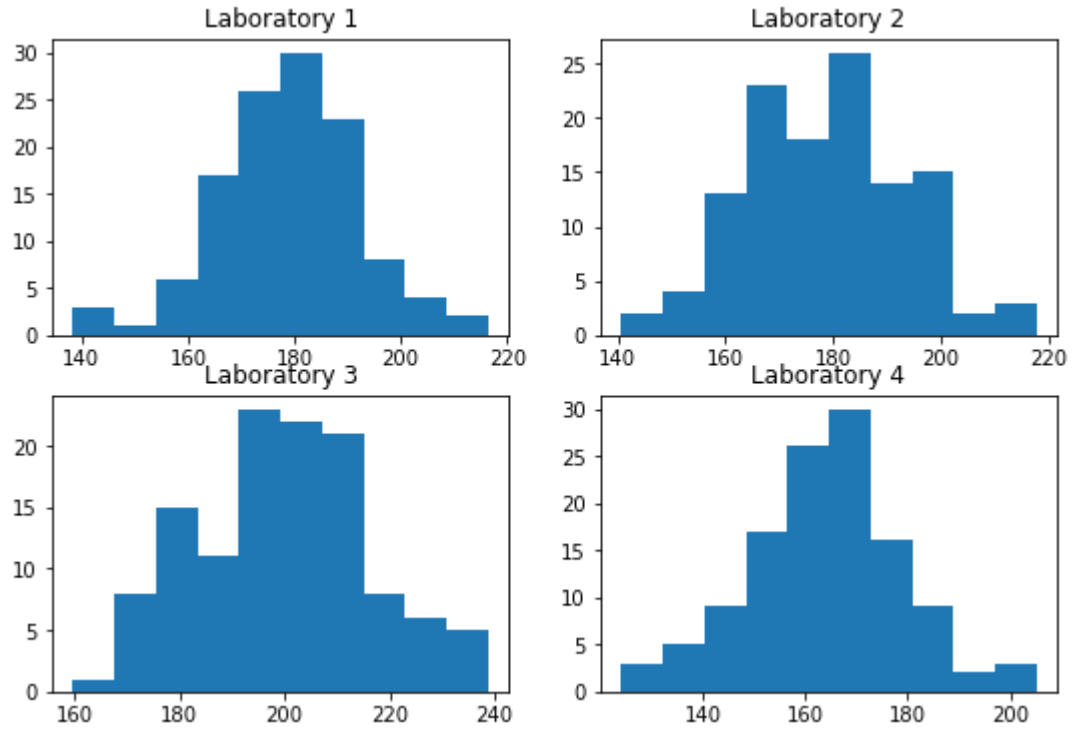
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 120 entries, 0 to 119
Data columns (total 4 columns):
 #   Column        Non-Null Count  Dtype  
---  ------        --------------  -----  
 0   Laboratory 1  120 non-null    float64
 1   Laboratory 2  120 non-null    float64
 2   Laboratory 3  120 non-null    float64
 3   Laboratory 4  120 non-null    float64
dtypes: float64(4)
memory usage: 3.9 KB
```

Plotting the data

In [19]:
```
plt.subplots(figsize = (16,9))
plt.subplot(221)
plt.boxplot(labtat['Laboratory 1'])
plt.title('Laboratory 1')
plt.subplot(222)
plt.boxplot(labtat['Laboratory 2'])
plt.title('Laboratory 2')
plt.subplot(223)
plt.boxplot(labtat['Laboratory 3'])
plt.title('Laboratory 3')
plt.subplot(224)
plt.boxplot(labtat['Laboratory 4'])
plt.title('Laboratory 4')
plt.show()
```

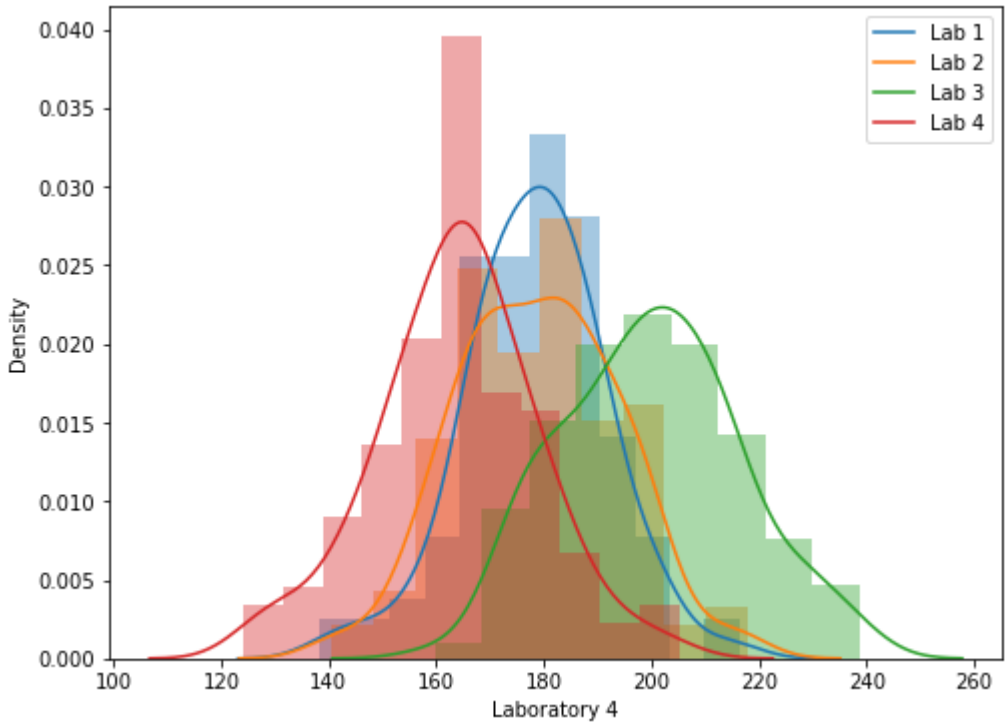


In [20]:
```
plt.subplots(figsize = (9,6))
plt.subplot(221)
plt.hist(labtat['Laboratory 1'])
plt.title('Laboratory 1')
plt.subplot(222)
plt.hist(labtat['Laboratory 2'])
plt.title('Laboratory 2')
plt.subplot(223)
plt.hist(labtat['Laboratory 3'])
plt.title('Laboratory 3')
plt.subplot(224)
plt.hist(labtat['Laboratory 4'])
plt.title('Laboratory 4')
plt.show()
```



In [21]:
```
plt.figure(figsize = (8,6))
labels = ['Lab 1', 'Lab 2','Lab 3', 'Lab 4']
sns.distplot(labtat['Laboratory 1'], kde = True)
sns.distplot(labtat['Laboratory 2'],hist = True)
sns.distplot(labtat['Laboratory 3'],hist = True)
sns.distplot(labtat['Laboratory 4'],hist = True)
plt.legend(labels)
```

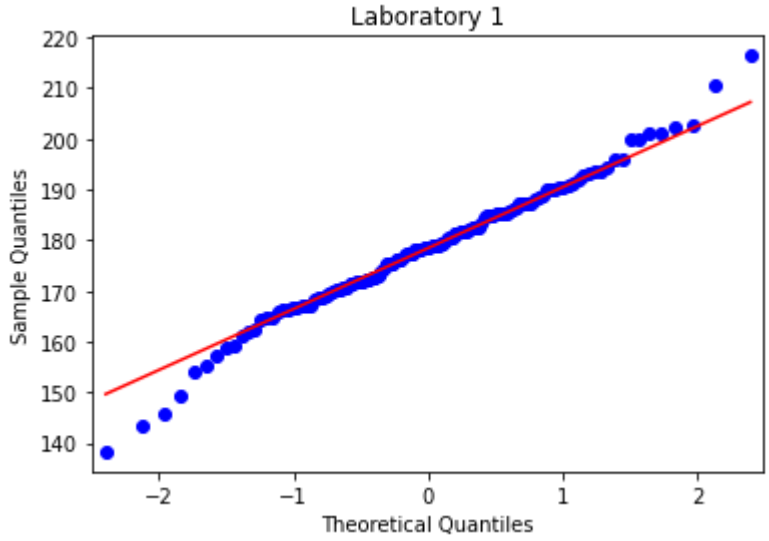
Out[21]: <matplotlib.legend.Legend at 0x258bda45df0>

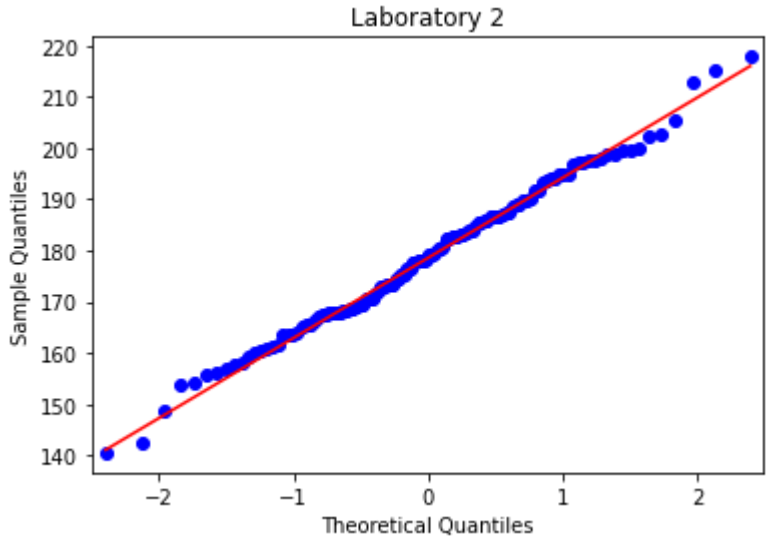


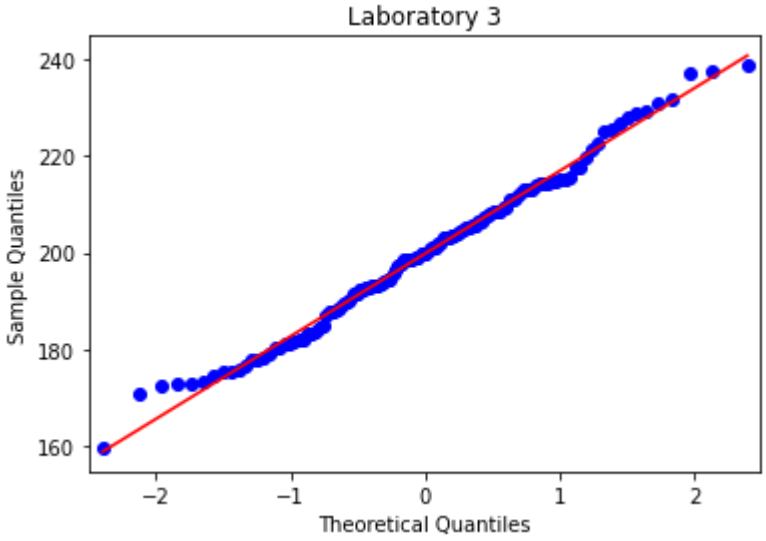
Plotting Q-Q plot to check whether the distribution follows normal distribution or not

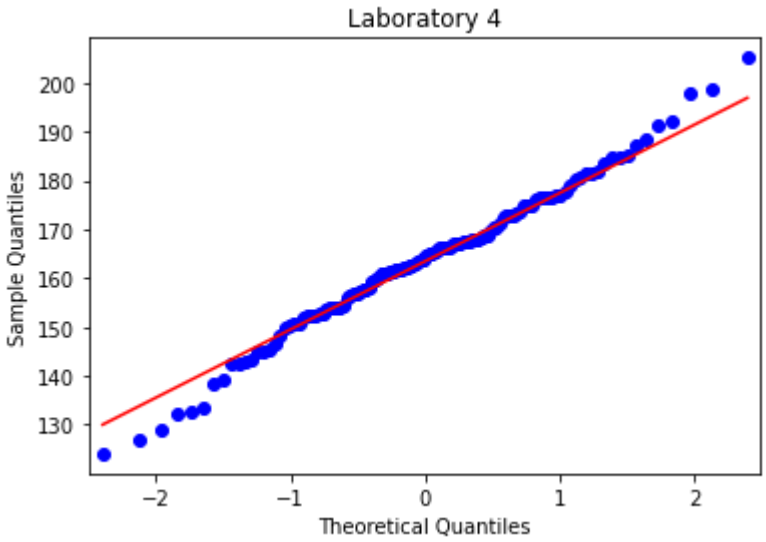
In [27]:

```
sm.qqplot(labtat['Laboratory 1'], line = 'q')

plt.title('Laboratory 1')

sm.qqplot(labtat['Laboratory 2'], line = 'q')

plt.title('Laboratory 2')

sm.qqplot(labtat['Laboratory 3'], line = 'q')
plt.title('Laboratory 3')
sm.qqplot(labtat['Laboratory 4'], line = 'q')
plt.title('Laboratory 4')
plt.show()
```









Step 4

Compare Evidences with Hypothesis using t-statictic

In [28]:
```
test_statistic , p_value = stats.f_oneway(labtat.iloc[:,0],labtat.iloc[:,1],l
print('p_value =',p_value)
```

```
p_value = 2.1156708949992414e-57
```

Compare p_value with 'α '(Significane Level)

If p_value is ≠'α ' we failed to reject Null Hypothesis because of lack of evidence

If p_value is = ' α' we reject Null Hypothesis

interpreting p-value

In [29]:
```
alpha = 0.05
print('Significnace=%.3f, p=%.3f' % (alpha, p_value))
if p_value <= alpha:
    print('We reject Null Hypothesis there is a significance difference betwe
else:
    print('We fail to reject Null hypothesis')
```

```
Significnace=0.050, p=0.000
We reject Null Hypothesis there is a significance difference between TAT of
reports of the laboratories
```

Hence, We fail to reject Null Hypothesis because of lack evidence, there is no significant difference between the samples

Questions-3

In [33]:
```
#from PIL import ImageGrab
#ImageGrab.grabclipboard()
```

Sales of products in four different regions is tabulated for males and females. Find if male-female buyer rations are similar across regions.

We are going to conduct a Test of Independence using Chi-Square $\chi 2$ test with Contingency table

We need to check whether the proportion of any of these samples are different or the same?

Step 1

Make two Hypothesis one contradicting to other

Null Hypothesis is want we want to prove

Null Hypothesis: There is no association or dependency between the gender based buyer rations across regions

Alternative Hypthosis: There is a significant association or dependency between the gender based buyer rations across regions

Step 2

Decide a cut-off value

Significance 5%

alpha = 0.05

As it is a one-tailed test

alpha = 1-0.95 = 0.05

Step 3

Collect evidence

Importing Files

In [34]:
```
buyer = pd.read_csv('BuyerRatio.csv')
buyer
```

Out[34]:

	Observed Values	East	West	North	South
0	Males	50	142	131	70
1	Females	435	1523	1356	750

In [39]:
```
table = [[50,142,131,70],
         [435,1523,1356,750]]
```

Applying Chi-Square $\chi 2$ contingency table to convert

observed value into expected value

In [42]:
```
stat, p, dof, exp = stats.chi2_contingency(table)
print(stat,"\n", p,"\n", dof,"\n", exp)
```

```
1.595945538661058
 0.6603094907091882
 3
 [[  42.76531299  146.81287862  131.11756787   72.30424052]
 [ 442.23468701 1518.18712138 1355.88243213  747.69575948]]
```

In [43]:
```
stats.chi2_contingency(table)
```

Out[43]:
```
(1.595945538661058,
 0.6603094907091882,
 3,
 array([[  42.76531299,  146.81287862,  131.11756787,   72.30424052],
        [ 442.23468701, 1518.18712138, 1355.88243213,  747.69575948]]))
```

In [44]:
```
observed = np.array([50, 142, 131, 70, 435, 1523, 1356, 750])
expected = np.array([42.76531299,  146.81287862,  131.11756787, 72.30424052,
```

Step 4

Comparing Evidence with Hypothesis

In [45]:
```
statistics, p_value = stats.chisquare(observed, expected, ddof = 3)
print("Statistics = ",statistics,"\n",'P_Value = ', p_value)
```

```
Statistics =  1.5959455390914483
 P_Value =  0.8095206646905712
```

Compare p_value with "α '(Significane Level)

If p_value is ≠ 'α' we failed to reject Null Hypothesis because of lack of evidence

If p_value is = 'α ' we reject Null Hypothesis

interpreting p-value

In [46]:
```
alpha = 0.05
print('Significnace=%.3f, p=%.3f' % (alpha, p_value))
if p_value <= alpha:
    print('We reject Null Hypothesis there is a significance difference betwe
else:
    print('We fail to reject Null hypothesis')
```

```
Significnace=0.050, p=0.810
We fail to reject Null hypothesis
```

We fail to reject Null Hypothesis because of lack evidence. Therefore, there is no association or dependency between male-female buyers rations and are similar across regions. Hence, Independent samples

Questions 4

TeleCall uses 4 centers around the globe to process customer order forms. They audit a certain % of the customer order forms. Any error in order form renders it defective and has to be reworked before processing. The manager wants to check whether the defective % varies by centre. Please analyze the data at 5% significance level and help the manager draw appropriate inferences

Solution

We are going to conduct a Test of Independence using Chi-Square $\chi 2$ test with Contingency table

We need to check whether the mean of any of these samples are different or the same?

Step 1

Make two Hypothesis one contradicting to other

Null Hypothesis is want we want to prove

Null Hypothesis: μ1=μ2 =μ3=μ4

Alternative Hypthosis: Atleast One of them is Differente

Step 2

Decide a cut-off value

Significance 5%

alpha = 0.05

Step 3

Collect evidence

Importing Files

In [47]:
```
data = pd.read_csv('Costomer+OrderForm.csv') #load the data set
data
```

Out[47]:

	Phillippines	Indonesia	Malta	India
0	Error Free	Error Free	Defective	Error Free
1	Error Free	Error Free	Error Free	Defective
2	Error Free	Defective	Defective	Error Free
3	Error Free	Error Free	Error Free	Error Free
4	Error Free	Error Free	Defective	Error Free
...	...	...	...	...
295	Error Free	Error Free	Error Free	Error Free
296	Error Free	Error Free	Error Free	Error Free
297	Error Free	Error Free	Defective	Error Free
298	Error Free	Error Free	Error Free	Error Free
299	Error Free	Defective	Defective	Error Free

300 rows × 4 columns

Applying Descriptive Statistics

In [48]:
```
data.describe()
```

Out[48]:

	Phillippines	Indonesia	Malta	India
count	300	300	300	300
unique	2	2	2	2
top	Error Free	Error Free	Error Free	Error Free
freq	271	267	269	280

Checking for Null Values

In [49]:
```
data.isnull().sum()
```

Out[49]:
```
Phillippines    0
Indonesia       0
Malta           0
India           0
dtype: int64
```

Checking the data type

In [50]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 300 entries, 0 to 299
Data columns (total 4 columns):
 #   Column        Non-Null Count  Dtype 
---  ------        --------------  ----- 
 0   Phillippines  300 non-null    object
 1   Indonesia     300 non-null    object
 2   Malta         300 non-null    object
 3   India         300 non-null    object
dtypes: object(4)
memory usage: 9.5+ KB
```

Checking value counts in data

In [5]:
```
data.Phillippines.value_counts()
```

Out[5]:
```
Error Free    271
Defective      29
Name: Phillippines, dtype: int64
```

In [6]:
```
data.Indonesia.value_counts()
```

Out[6]:
```
Error Free    267
Defective      33
Name: Indonesia, dtype: int64
```

In [7]:
```
data.Malta.value_counts()
```

Out[7]:
```
Error Free    269
Defective      31
Name: Malta, dtype: int64
```

In [8]:
```
data.India.value_counts()
```

Out[8]:
```
Error Free    280
Defective      20
Name: India, dtype: int64
```

Creating Contingency table

In [53]:
```
#Make a contingency table

con_table = np.array([[271,267,269,280],[29,33,31,20]])
con_table
```

Out[53]:
```
array([[271, 267, 269, 280],
       [ 29,  33,  31,  20]])
```

array([[271, 267, 269, 280], [29, 33, 31, 20]]) Assume Null Hypothesis as Ho: Independence of categorical variables (customer order forms defective % does not varies by centre) Thus, Alternative hypothesis as Ha Dependence of categorical variables (customer order forms defective % varies by centre)

Calculating Expected Values for Observed data

In [54]:
```
# Chi2 contengency independence test
stat, p, df, exp = stats.chi2_contingency(con_table)
print("Statistics = ",stat,"\n",'P_Value = ', p,'\n', 'degree of freedom =',
```

```
Statistics =  3.858960685820355
 P_Value =  0.2771020991233135
 degree of freedom = 3
 Expected Values =  [[271.75 271.75 271.75 271.75]
 [ 28.25  28.25  28.25  28.25]]
```

Defining Expected values and observed values

In [55]:
```
observed = np.array([271, 267, 269, 280, 29, 33, 31, 20])
expected = np.array([271.75, 271.75, 271.75, 271.75, 28.25, 28.25, 28.25, 28.
```

Step 4

Compare Evidences with Hypothesis using t-statictic

In [56]:
```
test_statistic , p_value = stats.chisquare(observed, expected, ddof = df)
print("Test Statistic = ",test_statistic,'\n', 'p_value =',p_value)
```

```
Test Statistic =  3.858960685820355
 p_value = 0.4254298144535761
```

Plotting the data

Compare p_value with 'α '(Significane Level)

If p_value is ≠' α' we failed to reject Null Hypothesis because of lack of evidence

If p_value is = 'α ' we reject Null Hypothesis

interpreting p-value

In [57]:
```
alpha = 0.05
print('Significnace=%.3f, p=%.3f' % (alpha, p_value))
if p_value <= alpha:
    print('We reject Null Hypothesis there is a significance difference betwe
else:
    print('We fail to reject Null hypothesis')
```

```
Significnace=0.050, p=0.425
We fail to reject Null hypothesis
```

We fail to reject Null Hypothesis because of lack of evidence

In [ ]:
```

```

In [ ]:

In [ ]:

In [ ]: