Hypothesis Testing Exercise

Question 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.

Minitab File : Cutlets. Tw

ANS :-

IMPORTING LIBRARIES

```
In [*]:
1  import scipy.stats as stats
2  import statsmodel.api as sm
3  import numpy as np
4  import pandas as pd
5  import warnings
6  warning.filterwarning ("ignore")
7  from PIL import imageGrab
8  import matplotlib.pyplot as plt
9  import seaborn as sns
```

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:** meu1=meu2
- **Alternative Hypthosis:** meu1≠meu2

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 [5]:
```
cutlets = pd.read_csv('..\Documents\EXcelR Study and Assignment Material\Data Science Assignments\Hypothesis testing 3\Cu
cutlets.head(10)
```

Out[5]:

	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

Applying Descriptive Statistics

In [18]:
```
cutlets.describe()
```

Out[18]:

	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 [53]:
```
cutlets.isnull().sum()
```

Out[53]:
```
Unit A    0
Unit B    0
dtype: int64
```

Checking for Duplicate Values

In [55]:
```
cutlets[cutlets.duplicated()].shape
```

Out[55]:
```
(0, 2)
```

In [56]:
```
cutlets[cutlets.duplicated()]
```

Out[56]:

	Unit A	Unit B

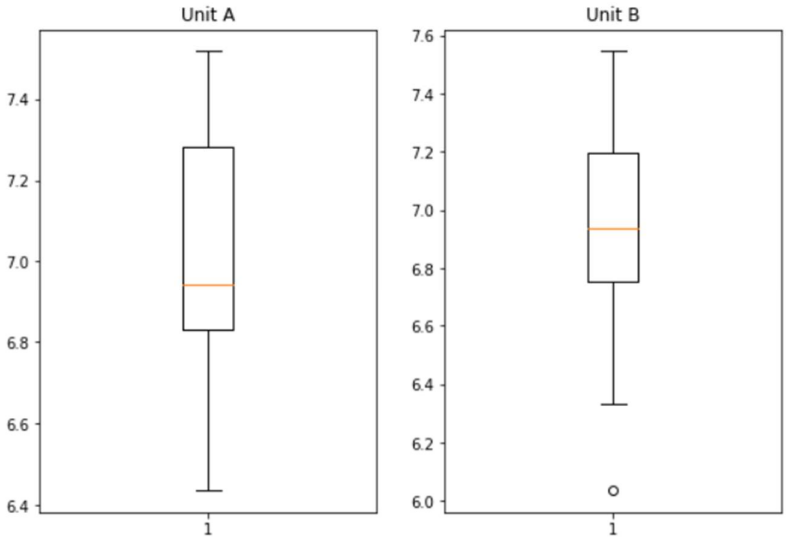
Checking the data type

In [41]:
```
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
```

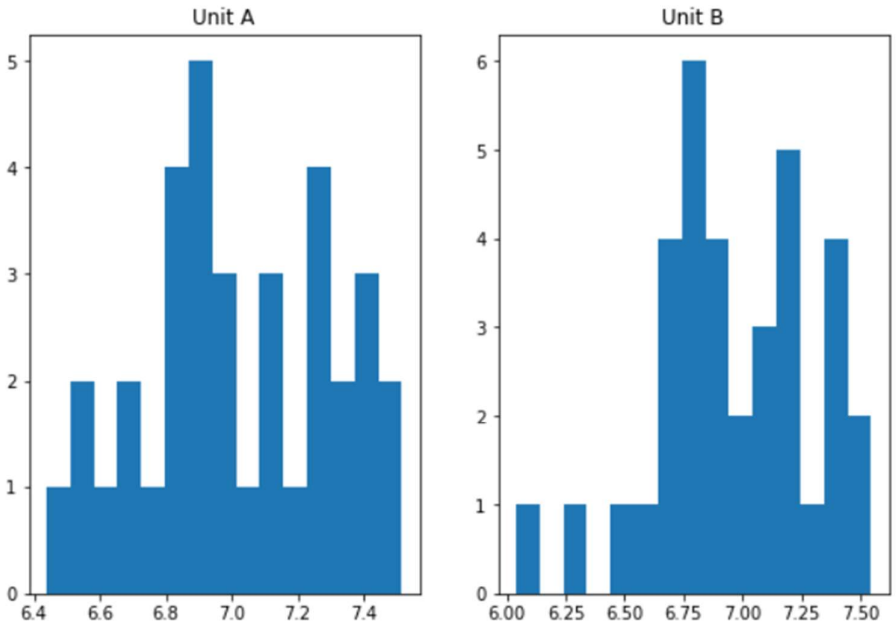
Plotting the data

In [34]:
```
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 [35]:

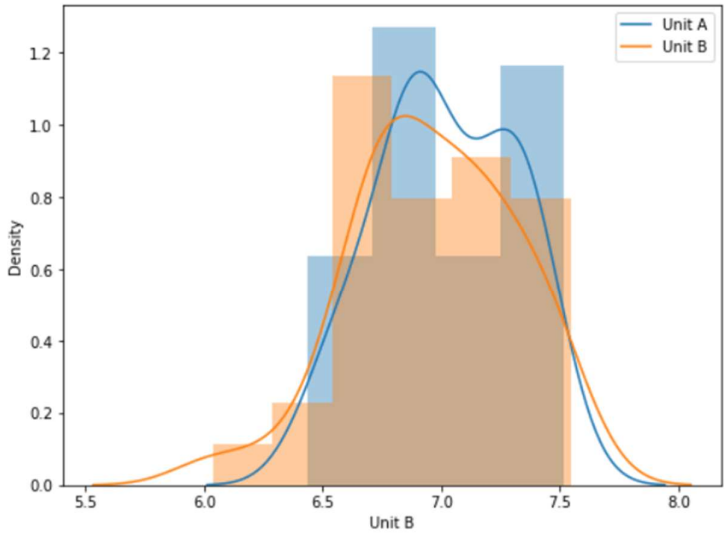
```
plt.subplots(figsize = (9,6))
plt.subplot(121)
plt.hist(cutlets['Unit A'], bins = 15)
plt.title('Unit A')
plt.subplot(122)
plt.hist(cutlets['Unit B'], bins = 15)
plt.title('Unit B')
plt.show()
```



In [67]:

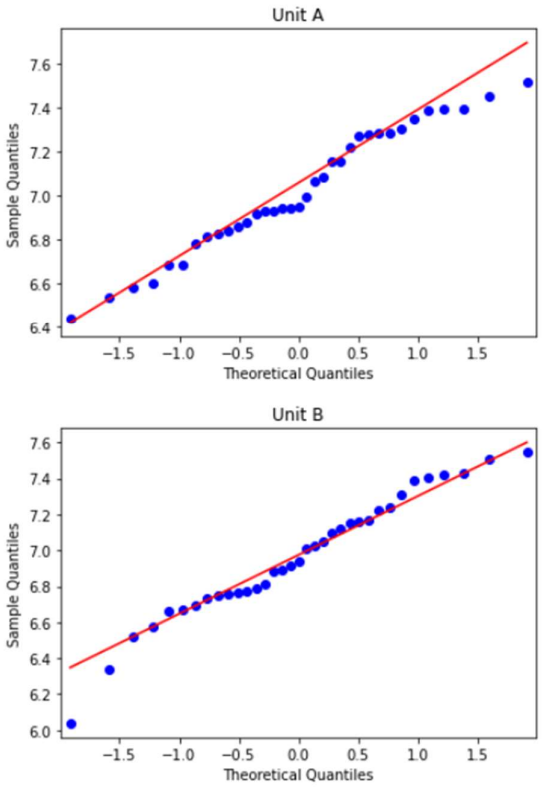
```
plt.figure(figsize = (8,6))
labels = ['Unit A', 'Unit B']
sns.distplot(cutlets['Unit A'], kde = True)
sns.distplot(cutlets['Unit B'],hist = True)
plt.legend(labels)
```

Out[67]: <matplotlib.legend.Legend at 0x21629013580>



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

In [19]:
```
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 [90]:
```
statistic , p_value = stats.ttest_ind(cutlets['Unit A'],cutlets['Unit B'], alternative = 'two-sided')
print('p_value=',p_value)
```

```
p_value= 0.4722394724599501
```

Compare p_value with 'alfa '(Significane Level)

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

If p_value is = 'alfa ' we reject Null Hypothesis

interpreting p-value

In [74]:
```
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 two Units A and B')
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

Question 2

Hypothesis Testing Exercise

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.

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: meu1= meu 2 = meu 3 = meu 4
- 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 [2]:
```
labtat = pd.read_csv('..\Documents\EXcelR Study and Assignment Material\Data Science Assignments\Hypothesis testing 3\LabTAT
labtat.head()
```

Out[2]:

	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

Applying Descriptive Statistics

In [77]:
```
labtat.describe()
```

Out[77]:

	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 [78]:
```
labtat.isnull().sum()
```

Out[78]:
```
Laboratory 1    0
Laboratory 2    0
Laboratory 3    0
Laboratory 4    0
dtype: int64
```

Checking for Duplicate Values

In [79]:
```
labtat[labtat.duplicated()].shape
```

Out[79]:
```
(0, 4)
```

In [80]:
```
labtat[labtat.duplicated()]
```

Out[80]:

	Laboratory 1	Laboratory 2	Laboratory 3	Laboratory 4

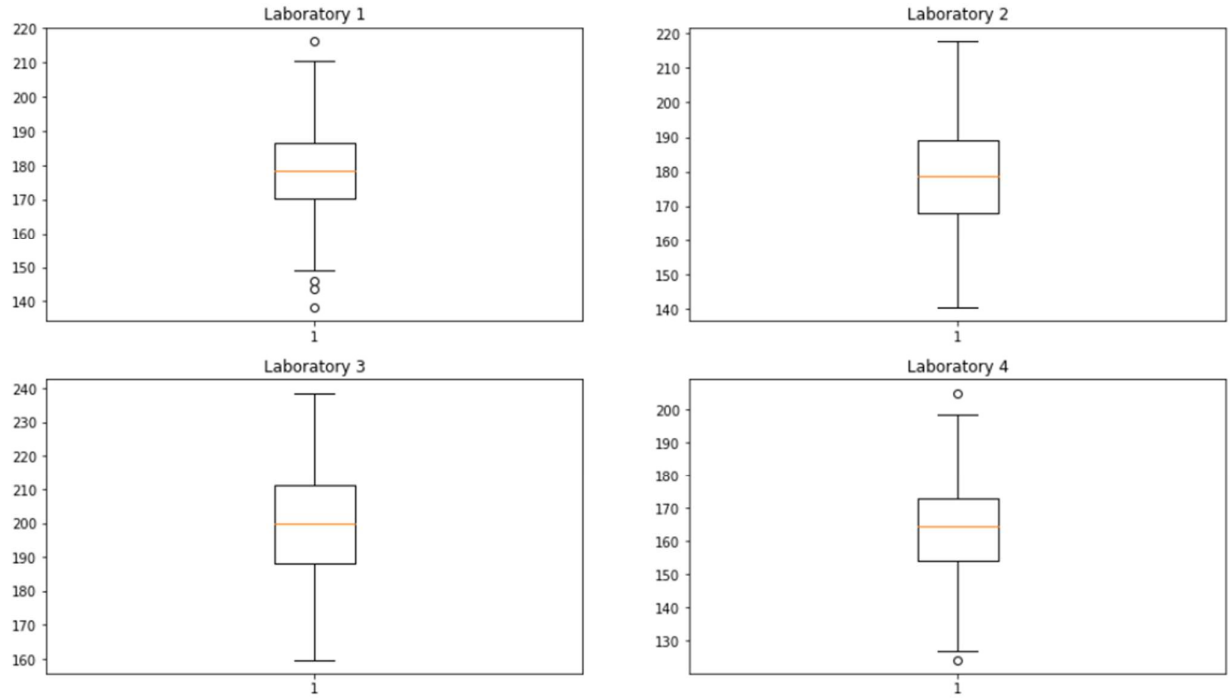
Checking the data type

In [81]:
```
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
```

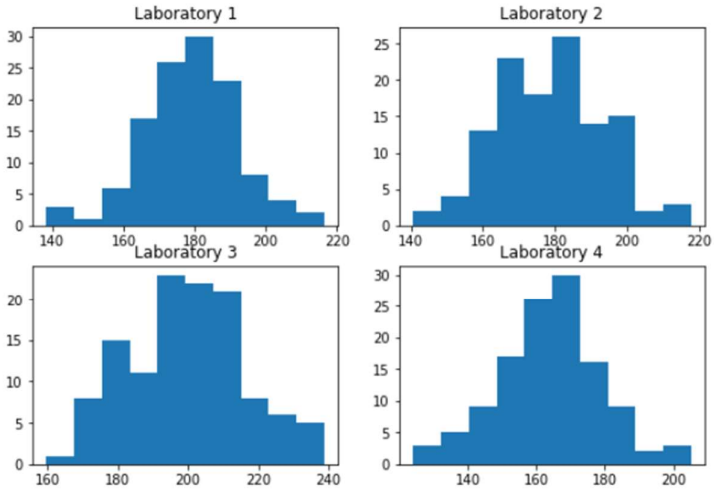
Plotting the data

In [84]:
```
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 [85]:

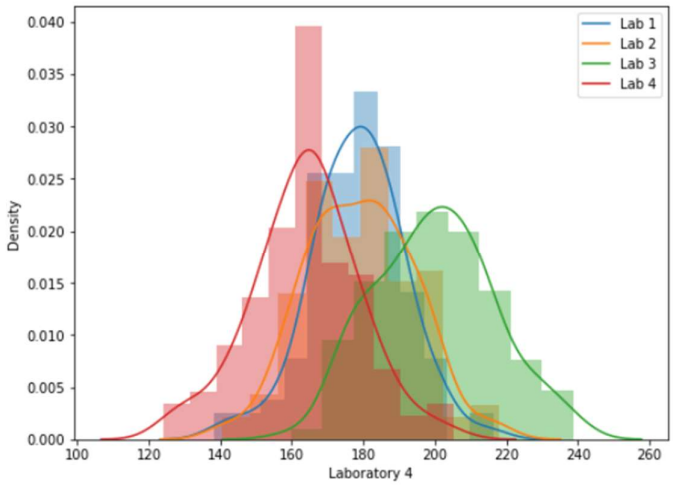
```
plt.subplots(figsize = (9,6))
plt.subplot(221)
plt.hist(labtat['Laboratory 1'])
plt.title('Laboratory 1')
plt.subplot(222)
plt.hist(labtat['Laboratory 2'])
plt.title('Laboratory 2')
plt.subplot(223)
plt.hist(labtat['Laboratory 3'])
plt.title('Laboratory 3')
plt.subplot(224)
plt.hist(labtat['Laboratory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



In [86]:

```
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)
```

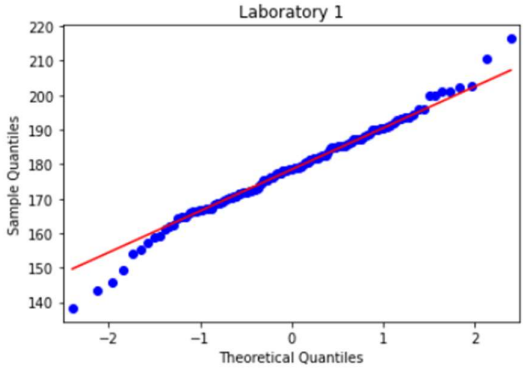
Out[86]: <matplotlib.legend.Legend at 0x21629597b20>

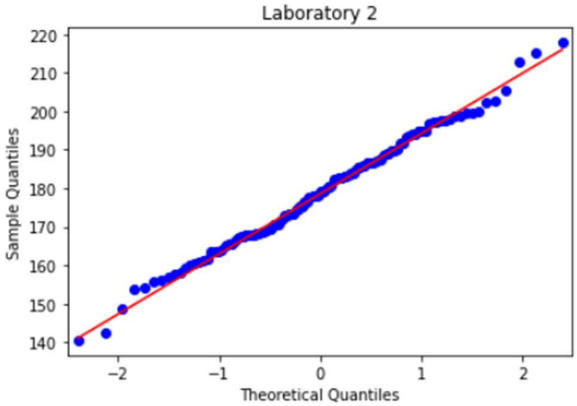


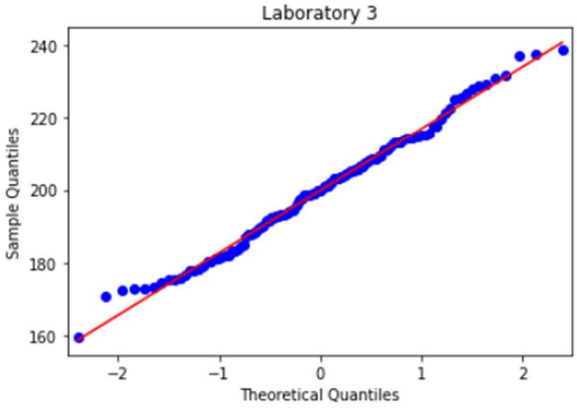
Plotting Q-Q plot to check whether the distribution follows normal distribution or not

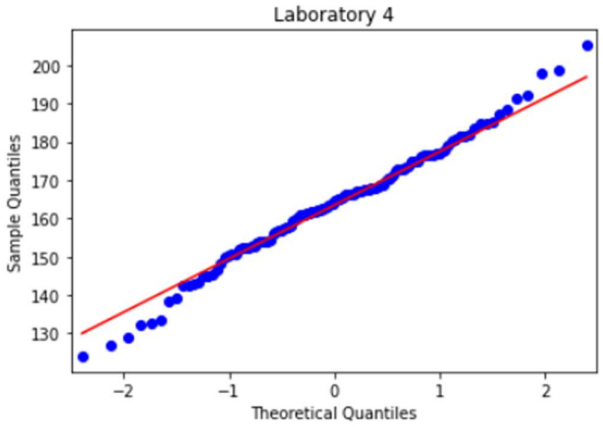
In [4]:

```
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 [3]:
```
test_statistic , p_value = stats.f_oneway(labtat.iloc[:,0],labtat.iloc[:,1],labtat.iloc[:,2],labtat.iloc[:,3])
print('p_value =',p_value)
```

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

Compare p_value with 'α '(Significane Level)

If p_value is $\neq$ '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 [4]:
```
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 between TAT of reports of the laboratories')
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

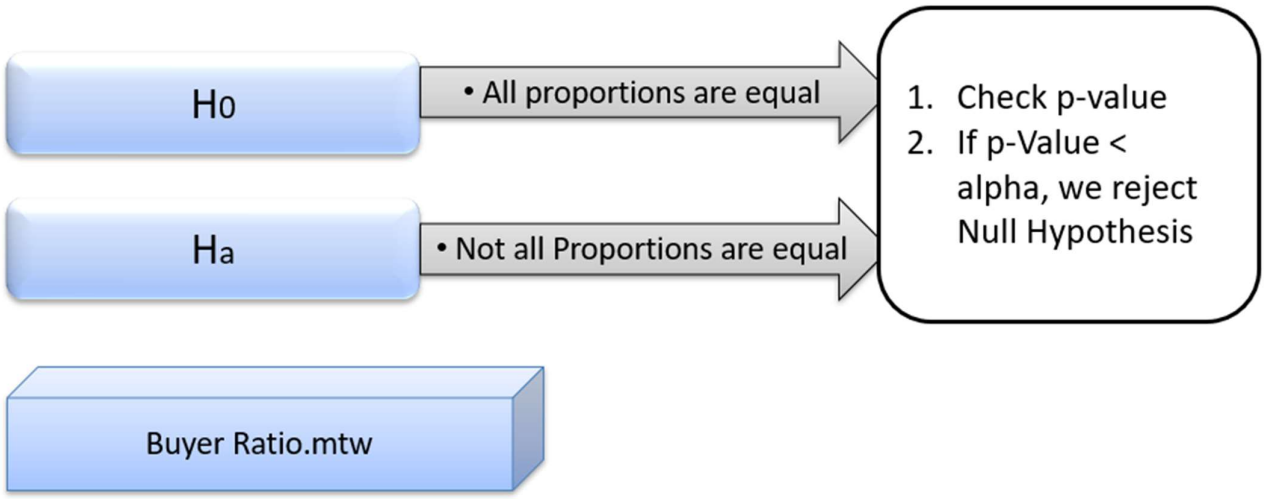
Question 3

Hypothesis Testing Exercise

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

	East	West	North	South
Males	50	142	131	70

Females	**550**	**351**	**480**	**350**



We are going to conduct a Test of Independence using Chi-Square χ^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 [21]:
```
buyer = pd.read_csv('..\Documents\EXcelR Study and Assignment Material\Data Science Assignments\Hypothesis testing 3\BuyerRa
buyer
```

Out[21]:

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

In [22]:
```
table = [[50,142,131,70],
         [435,1523,1356,750]]
```

Applying Chi-Square χ_2 contingency table to convert observed value into expected value

In [31]:
```
stat, p, dof, exp = stats.chi2_contingency(buyer)
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 [24]:
```
stats.chi2_contingency(table)
```

Out[24]:
```
(1.595945538661058,
 0.6603094907091882,
 3,
 array([[  42.76531299,  146.81287862,  131.11756787,   72.30424052],
        [ 442.23468701, 1518.18712138, 1355.88243213,  747.69575948]]))
```

In [5]:
```
observed = np.array([50, 142, 131, 70, 435, 1523, 1356, 750])
expected = np.array([42.76531299,  146.81287862,  131.11756787, 72.30424052, 442.23468701, 1518.18712138, 1355.88243213, 747
```

Step 4

Comparing Evidence with Hypothesis

In [6]:
```
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 $\neq$ '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 [7]:
```
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 between TAT of reports of the laboratories')
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

Question 4

Hypothesis Testing Exercise

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

We are going to conduct a Test of Independence using Chi-Square X_2

- **Null Hypothesis:** $\mu_1 = \mu_2 = \mu_3 = \mu_4$
- **Alternative Hypthosis:** Atleast One of them is Differente

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:** $\mu_1 = \mu_2 = \mu_3 = \mu_4$
- **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 [62]:
```
centers = pd.read_csv('..\Documents\EXcelR Study and Assignment Material\Data Science Assignments\Hypothesis testing 3\Custc
centers.head(10)
```

Out[62]:

	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
5	Error Free	Error Free	Error Free	Error Free
6	Error Free	Defective	Error Free	Error Free
7	Error Free	Error Free	Error Free	Error Free
8	Error Free	Error Free	Error Free	Error Free
9	Error Free	Error Free	Error Free	Error Free

Applying Descriptive Statistics

In [34]:
```
centers.describe()
```

Out[34]:

	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 [35]:
```
centers.isnull().sum()
```

Out[35]:
```
Phillippines    0
Indonesia       0
Malta           0
India           0
dtype: int64
```

In [45]:
```
centers[centers.isnull().any(axis=1)]
```

Out[45]:

	Phillippines	Indonesia	Malta	India

Checking the data type

In [37]:
```
centers.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 [86]:
```
print(centers['Phillippines'].value_counts(),'\n',centers['Indonesia'].value_counts(),'\n',centers['Malta'].value_counts(),'
```

```
Error Free    271
Defective      29
Name: Phillippines, dtype: int64
 Error Free    267
Defective      33
Name: Indonesia, dtype: int64
 Error Free    269
Defective      31
Name: Malta, dtype: int64
 Error Free    280
Defective      20
Name: India, dtype: int64
```

Creating Contingency table

In [1]:
```
contingency_table = [[271,267,269,280],
                     [29,33,31,20]]
print(contingency_table)
```

```
[[271, 267, 269, 280], [29, 33, 31, 20]]
```

Calculating Expected Values for Observed data

In [9]:
```
stat, p, df, exp = stats.chi2_contingency(contingency_table)
print("Statistics = ",stat,"\n",'P_Value = ', p,'\n', 'degree of freedom =', df,'\n', 'Expected Values = ', exp)
```

```
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 [8]:
```
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, 28.25])
```

Step 4

Compare Evidences with Hypothesis using t-statictic

In [30]:
```
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 $\neq$ '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 [9]:
```
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 between TAT of reports of the laboratories')
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 of evidence.

In [ ]:
```

```