Problem Statement:

An important quality characteristic used by the manufacturers of ABC asphalt shingles is the amount of moisture the shingles contain when they are packaged. Customers may feel that they have purchased a product lacking in quality if they find moisture and wet shingles inside the packaging. In some cases, excessive moisture can cause the granules attached to the shingles for texture and colouring purposes to fall off the shingles resulting in appearance problems. To monitor the amount of moisture present, the company conducts moisture tests. A shingle is weighed and then dried. The shingle is then reweighed, and based on the amount of moisture taken out of the product, the pounds of moisture per 100 square feet are calculated. The company would like to show that the mean moisture content is less than 0.35 pound per 100 square feet.

Exploratory Data Analysis:

	A	B
0	0.44	0.14
1	0.61	0.15
2	0.47	0.31
3	0.30	0.16
4	0.15	0.37

Dataset has 2 variables A and B, which has the measurement of moisture present per 100 sq. ft.

Both variables are float in data types.

Descriptive Statistics for both variable:

A		*B*	
Mean	0.316666667	**Mean**	0.273548
Standard Error	0.022621804	**Standard Error**	0.024659
Median	0.29	**Median**	0.23
Mode	0.2	**Mode**	0.11
Standard Deviation	0.135730826	**Standard Deviation**	0.137296
Sample Variance	0.018422857	**Sample Variance**	0.01885
Kurtosis	0.979774347	**Kurtosis**	-0.90955
Skewness	0.950618572	**Skewness**	0.513424
Range	0.59	**Range**	0.48
Minimum	0.13	**Minimum**	0.1
Maximum	0.72	**Maximum**	0.58
Sum	11.4	**Sum**	8.48
Count	36	**Count**	31

Standard Deviation for both variables are almost identical.

The file (ABC shingles) includes 36 measurements (in pounds per 100 square feet) for A shingles and 31 for B shingles.

For the A shingles, the null and alternative hypothesis to test whether the population mean moisture content is less than 0.35 pound per 100 square feet is given:

Variable A has the mean of 0.32 that means the Variable A has moisture 0.32 per 100 sq. ft. on an average. Variable B has moisture of 0.27 per 100 sq. ft. on an average.

3.1 Do you think there is evidence that mean moisture contents in both types of shingles are within the permissible limits? State your conclusions clearly showing all steps.

To check whether the mean moisture control for A shingles is within permissible limits, the following null and alternative hypotheses are formulated

H_0 <= 0.35

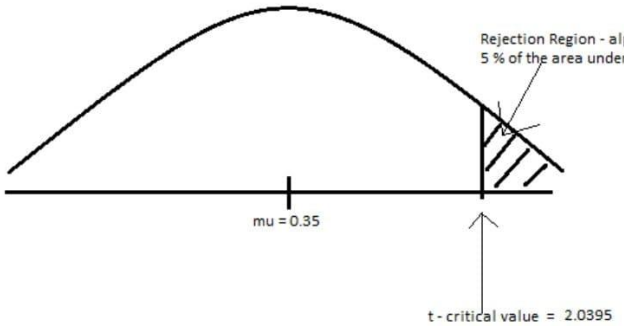
H_A > 0.35

```
t_statistic,p_value=stats.ttest_1samp(data.A,0.35) #by default t-test is a two sided ttest in python
#t-distribution moves left to right (-ve to +ve side)
print('The test statistic is {}'.format(t_statistic))
p_value_greater= 1-(p_value/2) #p_value given will be two sided p-value
#hence dividing pvalue by 2 and subtracting it by 1 will give pvalue of right side of t-distribution, since alternate lies on right side
if p_value_greater>0.05:
    print('The p-value is {} which is greater than the level of significance , hence, we fail to reject the Null Hypothesis'.format(p_value_greater))
else:     print('The p-value is {} which is less than the level of significance , hence, we reject the Null Hypothesis'.format(p_value_greater))
```

```
The test statistic is -1.4735046253382782
The p-value is 0.9252236685509249 which is greater than the level of significance , hence, we fail to reject the Null Hypothesis
```

Since p-value of the test is greater than $\alpha = 0.05$, H_0 is not rejected. We may conclude that for A shingles the mean moisture content is within the permissible limits

Q3.1. Solution explanation using graphical representation for A shingles



Python Code:

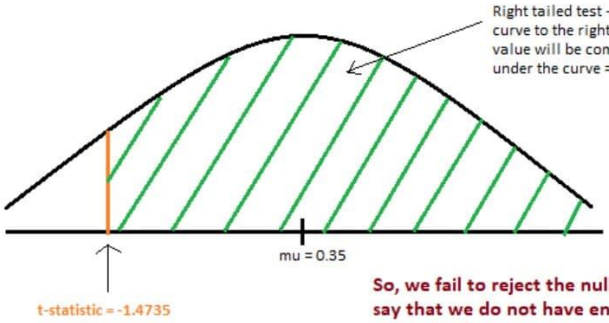
```
mu = 0.35
xbar = df['A'].mean()
samp_std_dev = np.std(df['A'],ddof=1)
n = len(df['A'])
t_stat = (xbar - mu) / (samp_std_dev/np.sqrt(n))
t_crit = stats.t.isf(0.05,n-1,loc = 0.35)
pvalue = stats.t.sf(t_stat,n-1)
alpha = stats.t.sf(t_crit,n-1,0.35)
print("t-critical value:",t_crit)
print("t-statistic value:",t_stat)
print("p-value:",pvalue)
print("alpha:",alpha)
```

Output:

```
t-critical value: 2.0395724539637716
t-statistic value: -1.4735046253382809
p-value: 0.9252236685509252
alpha: 0.05000000036859592
```

H0 : mean moisture content (mu) <= 0.35
Ha : mean moisture content (mu) > 0.35

Its a right tailed test as the alternative hypothesis consists of a ">" thus it refer to the right side.



The t-statistic value < t-critical value as -1.4735 < 2.0395
Also, the pvalue(=0.92) > alpha(=0.05)

So, we fail to reject the null hypothesis and can say that we do not have enough evidence to reject the fact that mean moisture content is less than or equal to 0.35 for A shingles.

We can use a similar representation for B shingles as well.

For the B shingles, the null and alternative hypothesis to test whether the population mean moisture content is less than 0.35 pound per 100 square feet is given:

H_0<=0.35

H_A>0.35

```
[ ] t_statistic,p_value=stats.ttest_1samp(data.B.dropna(),0.35) #by default t-test is a two sided ttest in python
    print('The test statistic is {}'.format(t_statistic))
    p_value_greater= 1-(p_value/2) #hence dividing pvalue by 2 and subtracting it by 1 will give pvalue of right side of t-distribution
    if p_value_greater>0.05:
        print('The p-value is {} which is greater than the level of significance , hence, we fail to reject the Null Hypothesis'.format(p_value_greater))
    else:     print('The p-value is {} which is less than the level of significance , hence, we reject the Null Hypothesis'.format(p_value_greater))
```

```
The test statistic is -3.1003313069986995
The p-value is 0.9979095225996808 which is greater than the level of significance , hence, we fail to reject the Null Hypothesis
```

Since p-value of the test is greater than $\alpha = 0.05$, H_0 is not rejected. We may conclude that for A shingles the mean moisture content is within the permissible limits

3.2 Do you think that the population means for shingles A and B are equal? Form the hypothesis and conduct the test of the hypothesis. State the assumptions you need to check before the test for equality of means is performed?

Denote, the population mean for shingles A by μ_A and the population mean for shingles B by μ_B

Null hypothesis states that the population means of Shingles A and B are equal,
X
Alternative hypothesis states that the population means of Shingles A and B are not equal,

H_0: μA = μB
H_A: $\mu_A \neq \mu_B$

To perform the hypothesis testing, the following **assumptions** must hold

- The variables must follow continuous distribution.
- The sample must be randomly collected from the population.
- The underlying distribution must be normal. Alternatively, if the data is continuous, but may not be assumed to follow a normal distribution, a reasonably large sample size is required. Central Limit Theorem (CLT) asserts that sample mean follows a normal distribution, even if the population distribution is not normal, when sample size is at least 30.
- For 2-sample t-test the population variances of the two distributions must be equal.

```
]: t_statistic, p_value =  ttest_ind(data['A'], data['B'], axis=0, equal_var=True, nan_policy='omit')

print('Our t test \nt statistic: {0} p value: {1} '.format(t_statistic, p_value))

# p_value > 0.05 => Null hypothesis:
# p_value < 0.05 => Alternate hypothesis:
# the population means for shingles A and B are equal

alpha_value = 0.05 # Level of significance
print('Level of significance: %.2f' %alpha_value)
print ("Our t-test p-value=", p_value)

if p_value < alpha_value:
    print('We have evidence to reject the null hypothesis since p value < Level of significance')
else:
    print('We have no evidence to reject the null hypothesis since p value > Level of significance')
```

```
Our t test
t statistic: 1.2896282719661123 p value: 0.2017496571835306
Level of significance: 0.05
Our t-test p-value= 0.2017496571835306
We have no evidence to reject the null hypothesis since p value > Level of significance
```

t statistic: 1.2885080295255027 p value: 0.2017496571835306
Level of significance: 0.05

Our t-test p-value= 0. 0.2017496571835306
Conclusion: We have no evidence to reject the null hypothesis, since p value > Level of significance

Appendix Code

A & B shingles

Basic python packages load

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns

import  scipy.stats as stats
import  math
from    scipy.stats import   ttest_1samp, ttest_ind
from    statsmodels.stats.power import   ttest_power
```

To set the working directory

```
#import os
#os.chdir("D:\\Academic Operations\\DSBA - Python\\Online\\SMDM\\Project")
```

Load the dataset

```
data = pd.read_csv("C:/Users/Vatsla Issar/Downloads/A+&+B+shingles.csv")
```

Exploratory Data Analysis

Let us check if the data has been loaded.

```
data.head()
```

	A	B
0	0.44	0.14
1	0.61	0.15
2	0.47	0.31
3	0.30	0.16
4	0.15	0.37

Let us check the types of variables in the data frame

```
data.dtypes
```

```
A    float64
B    float64
dtype: object
```

For the A shingles, the null and alternate hypothesis to test whether the population mean moisture content is less than 0.35 pound per 100 square feet.

The company claims that moisture content is less than 0.35 lbs/100 sq ft. Null hypothesis is the claim or the status quo. Only under strong evidence, the null hypothesis is to be rejected.

Null hypothesis states that mean moisture content is , $\mu \leq$ 0.35 pound per 100 square feet

Alternative hypothesis states that the mean moisture content, μ > 0.35 pound per 100 square feet

H_0: $\mu \leq$ 0.35

H_A: μ > 0.35

Always remember that '=' sign MUST be included in the null hypothesis and NEVER in alternative hypothesis.

For the B shingles, the null and alternate hypothesis to test whether the population mean moisture content is less than 0.35 pound per 100 square feet.

Null hypothesis states that mean moisture content is , $\mu \leq$ 0.35 pound per 100 square feet

Alternative hypothesis states that the mean moisture content, μ > 0.35 pound per 100 square feet

H_0: $\mu \leq$ 0.35

H_A: μ > 0.35

Always remember that '=' sign MUST be included in the null hypothesis and NEVER in alternative hypothesis.

Note: You may have noticed that for both A and B shingles, sample mean is less than 0.35. It is natural to wonder, if the sample mean is less than the null value, whether the rejection region will be on the left-hand side. Always remember that, the null and the alternative hypotheses are set up according to the nature of the problem, NOT according to the value of the sample mean. The sample means will differ from one sample to the next, but the null and alternative hypotheses do not. The rejection region depends on the alternative hypothesis. Therefore, the rejection region is also fixed and does not change according to the value of the sample mean.

3.1 Do you think there is evidence that mean moisture contents in both types of shingles are within the permissible limits? State your conclusions clearly showing all steps.

For A Shingles

To check whether the mean moisture control for A shingles is within permissible limits, the following null and alternative hypotheses are formulated

H_0 <= 0.35

H_A > 0.35

```
t_statistic, p_value = stats.ttest_1samp(data['A'], 0.35) #by default t-test if two sided in Python

print("The test statistic is :" + str(t_statistic))

#Since t distribution moves from left to right (-ve to +ve), we shall use 1-pvalue/2,
#since our Alternate Hypothesis refers to the right side
p_value_greater = 1-(p_value/2)

if p_value_greater > 0.05:
    print("The p-value is {} which is greater than the significance level, so we fail to reject the Nul
l Hypothesis".format(p_value_greater))
else:
    print("The p-value is {} which is less than the significance level, so we reject the Null Hypothesi
s".format(p_value_greater))
```

```
The test statistic is :-1.4735046253382782
The p-value is 0.9252236685509249 which is greater than the significance level, so we fail to reject
the Null Hypothesis
```

For B Shingles

For the B shingles, the null and alternative hypothesis to test whether the population mean moisture content is less than 0.35 pound per 100 square feet is given:

H_0<=0.35

H_A>0.35

```
t_statistic, p_value = stats.ttest_1samp(data['B'].dropna(), 0.35) #by default t-test if two sided in P
ython

print("The test statistic is :" + str(t_statistic))

#Since t distribution moves from left to right (-ve to +ve), we shall use 1-pvalue/2,
#since our Alternate Hypothesis refers to the right side
p_value_greater = 1-(p_value/2)

if p_value_greater > 0.05:
    print("The p-value is {} which is greater than the significance level, so we fail to reject the Nul
l Hypothesis".format(p_value_greater))
else:
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```

```
The test statistic is :-3.1003313069986995
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Alternative hypthesis states that the population mean of Shingles A and B is not equal, $\mu_A \neq \mu_B$

$H_0 : \mu_A = \mu_B$

$H_A : \mu_A \neq \mu_B$

Assumptions for t-test

To perform the hypothesis testing, the following assumptions must hold:

• The variables must follow continuous distribution.

• The sample must be randomly collected from the population.

• The underlying distribution must be normal. Alternatively, if the data is continuous, but may not be assumed to follow a normal distribution, a reasonably large sample size is required. Central Limit Theorem (CLT) asserts that sample mean follows a normal distribution, even if the population distribution is not normal, when sample size is at least 30.

• For 2-sample t-test the population variances of the two distributions must be equal.

:
```
t_statistic, p_value =  ttest_ind(data['A'], data['B'], axis=0, equal_var=True, nan_policy='omit')

print('Our t test \nt statistic: {0} p value: {1} '.format(t_statistic, p_value))

# p_value > 0.05 => Null hypothesis:
# p_value < 0.05 => Alternate hypothesis:
# the population means for shingles A and B are equal

alpha_value = 0.05 # Level of significance
print('Level of significance: %.2f' %alpha_value)
print ("Our t-test p-value=", p_value)

if p_value < alpha_value:
    print('We have evidence to reject the null hypothesis since p value < Level of significance')
else:
    print('We have no evidence to reject the null hypothesis since p value > Level of significance')
```

```
Our t test
t statistic: 1.2896282719661123 p value: 0.2017496571835306
Level of significance: 0.05
Our t-test p-value= 0.2017496571835306
We have no evidence to reject the null hypothesis since p value > Level of significance
```

:
```

```

The END