AS Extended Project – Guided

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INDEX

Problem 1

Context

The Student News Service at Clear Mountain State University (CMSU) has decided to gather data about the undergraduate students that attend CMSU. CMSU creates and distributes a survey of 14 questions and receives responses from 62 undergraduates (stored in the Survey data set).

Objective

Based on the given data, answer the following questions.

1. What is the probability that a randomly selected CMSU student will be male?
2. What is the probability that a randomly selected CMSU student will be female?
3. What is the conditional probability of different majors among male students in CMSU?
4. What is the conditional probability of different majors among the female students of CMSU?
5. What is the probability That a randomly chosen student is a male and intends to graduate?
6. What is the probability that a randomly selected student is a female and does NOT have a laptop?
7. What is the probability that a randomly chosen student is a male or has full-time employment?
8. What is the conditional probability that given a female student is randomly chosen, she is majoring in international business or management?
9. If a student is chosen randomly, what is the probability that his/her GPA is less than 3?
10. What is the conditional probability that a randomly selected male earns 50 or more?
11. What is the conditional probability that a randomly selected female earns 50 or more?
12. Are the continuous variables in the data normally distributed? Write a note summarizing your conclusions.

Note: Assume that the sample is representative of the population of CMSU.

Data Description

- ID: A unique identifier for each undergraduate student.
- Gender: The gender of the student.
- Age: The age of the student. It is a numeric value representing the student's age in years.
- Class: The student's current academic class or year.
- Major: The student's declared major field of study.
- Grad Intention: The student's intention regarding graduation. It can have categorical values such as "Yes" or "No" indicating whether the student intends to graduate or not.
- GPA: The student's grade point average. It is a numeric value representing the student's academic performance.
- Employment: The employment status of the student. It can have categorical values such as "Full-time," "Part-time," or "Unemployed."
- Salary: The student's monthly salary. It is a numeric value representing the amount in dollars.
- Social Networking: The amount of time the student spends on social networking per day. It is a numeric value representing the time in hours.
- Satisfaction: The student's satisfaction level with their college experience. It is a numeric value representing satisfaction on a scale.
- Spending: The amount of money the student spends per semester. It is a numeric value representing the amount in dollars.
- Computer: The type of device of the student.
- Text Messages: The number of text messages the student sends per day. It is a numeric value.

Overview of the Dataset

First 5 rows of the dataset

	ID	Gender	Age	Class	Major	Grad Intention	GPA	Employment	Salary	Social Networking	Satisfaction	Spending	Computer	Text Messages
0	1	Female	20	Junior	Other	Yes	2.9	Full-Time	50.0	1	3	350	Laptop	200
1	2	Male	23	Senior	Management	Yes	3.6	Part-Time	25.0	1	4	360	Laptop	50
2	3	Male	21	Junior	Other	Yes	2.5	Part-Time	45.0	2	4	600	Laptop	200
3	4	Male	21	Junior	CIS	Yes	2.5	Full-Time	40.0	4	6	600	Laptop	250
4	5	Male	23	Senior	Other	Undecided	2.8	Unemployed	40.0	2	4	500	Laptop	100

Last 5 rows of the dataset

	ID	Gender	Age	Class	Major	Grad Intention	GPA	Employment	Salary	Social Networking	Satisfaction	Spending	Computer	Text Messages
57	58	Female	21	Senior	International Business	No	2.4	Part-Time	40.0	1	3	1000	Laptop	10
58	59	Female	20	Junior	CIS	No	2.9	Part-Time	40.0	2	4	350	Laptop	250
59	60	Female	20	Sophomore	CIS	No	2.5	Part-Time	55.0	1	4	500	Laptop	500
60	61	Female	23	Senior	Accounting	Yes	3.5	Part-Time	30.0	2	3	490	Laptop	50
61	62	Female	23	Senior	Economics/Finance	No	3.2	Part-Time	70.0	2	3	250	Laptop	0

The shape of the dataset

```
(62, 14)
```

The data types of the columns for the dataset

```
ID                     int64
Gender                object
Age                    int64
Class                 object
Major                 object
Grad Intention        object
GPA                  float64
Employment            object
Salary               float64
Social Networking      int64
Satisfaction           int64
Spending               int64
Computer              object
Text Messages          int64
dtype: object
```

Check the missing values in the dataset

```
ID                  0
Gender              0
Age                 0
Class               0
Major               0
Grad Intention      0
GPA                 0
Employment          0
Salary              0
Social Networking   0
Satisfaction        0
Spending            0
Computer            0
Text Messages       0
dtype: int64
```

Check the statistical summary of the data

	ID	Age	GPA	Salary	Social Networking	Satisfaction	Spending	Text Messages
count	62.000000	62.000000	62.000000	62.000000	62.000000	62.000000	62.000000	62.000000
mean	31.500000	21.129032	3.129032	48.548387	1.516129	3.741935	482.016129	246.209677
std	18.041619	1.431311	0.377388	12.080912	0.844305	1.213793	221.953805	214.465950
min	1.000000	18.000000	2.300000	25.000000	0.000000	1.000000	100.000000	0.000000
25%	16.250000	20.000000	2.900000	40.000000	1.000000	3.000000	312.500000	100.000000
50%	31.500000	21.000000	3.150000	50.000000	1.000000	4.000000	500.000000	200.000000
75%	46.750000	22.000000	3.400000	55.000000	2.000000	4.000000	600.000000	300.000000
max	62.000000	26.000000	3.900000	80.000000	4.000000	6.000000	1400.000000	900.000000

1. What is the probability that a randomly selected CMSU student will be male?

find the number of Male Students in the CMSU Dataset

```
29
```

find the total number of students in the CMSU Dataset

```
62
```

the probability that a randomly selected CMSU student will be male is

```
The probability that a randomly selected CMSU student will be a male is: 0      0.000000
1      1.612903
2      1.612903
3      1.612903
4      1.612903
         ...
57     0.000000
58     0.000000
59     0.000000
60     0.000000
61     0.000000
Name: Gender, Length: 62, dtype: float64
```

2. **What is the probability that a randomly selected CMSU student will be female?**

   find the number of Female Students in the CMSU Dataset

```
33
```

The probability that a randomly selected CMSU student will be female is

```
The probability that a randomly selected CMSU student will be a female is: 0      1.612903
1      0.000000
2      0.000000
3      0.000000
4      0.000000
         ...
57     1.612903
58     1.612903
59     1.612903
60     1.612903
61     1.612903
Name: Gender, Length: 62, dtype: float64
```

3. **What is the conditional probability of different majors among male students in CMSU?**

```
Conditional Probability of Different Majors among Male Students in CMSU:
col_0                        count
Major
Management                0.206897
Retailing/Marketing       0.172414
Accounting                0.137931
Economics/Finance         0.137931
Other                     0.137931
Undecided                 0.103448
International Business    0.068966
CIS                       0.034483
```

4. **What is the conditional probability of different majors among the female students of CMSU?**

```
Conditional Probability of Different Majors among Female Students in CMSU:
col_0                        count
Major
Retailing/Marketing       0.272727
Economics/Finance         0.212121
International Business    0.121212
Management                0.121212
Accounting                0.090909
CIS                       0.090909
Other                     0.090909
```

5. **What is the probability That a randomly chosen student is a male and intends to graduate?**

```
Probability that a randomly chosen student is a male and intends to graduate: 58.62068965517240б
```

6. What is the probability that a randomly selected student is a female and does NOT have a laptop?

```
Probability that a randomly selected student is a female and does NOT have a laptop: 12.121212121212121
```

7. What is the probability that a randomly chosen student is a male or has full-time employment?

```
Probability that a randomly chosen student is a male or has full-time employment: 46.774193548387096
```

8. What is the conditional probability that given a female student is randomly chosen, she is majoring in international business or management?

```
Conditional probability that given a female student is randomly chosen, she is majoring in international business or managemen
t: 0.24242424242424243
```

9. If a student is chosen randomly, what is the probability that his/her GPA is less than 3?

```
Probability that a randomly chosen student has a GPA less than 3: 27.419354838709676
```

10. What is the conditional probability that a randomly selected male earns 50 or more?

```
Conditional probability that a randomly selected male earns 50 or more: 48.275862068965516
```

11. What is the conditional probability that a randomly selected female earns 50 or more?

```
Conditional probability that a randomly selected female earns 50 or more: 54.54545454545454
```

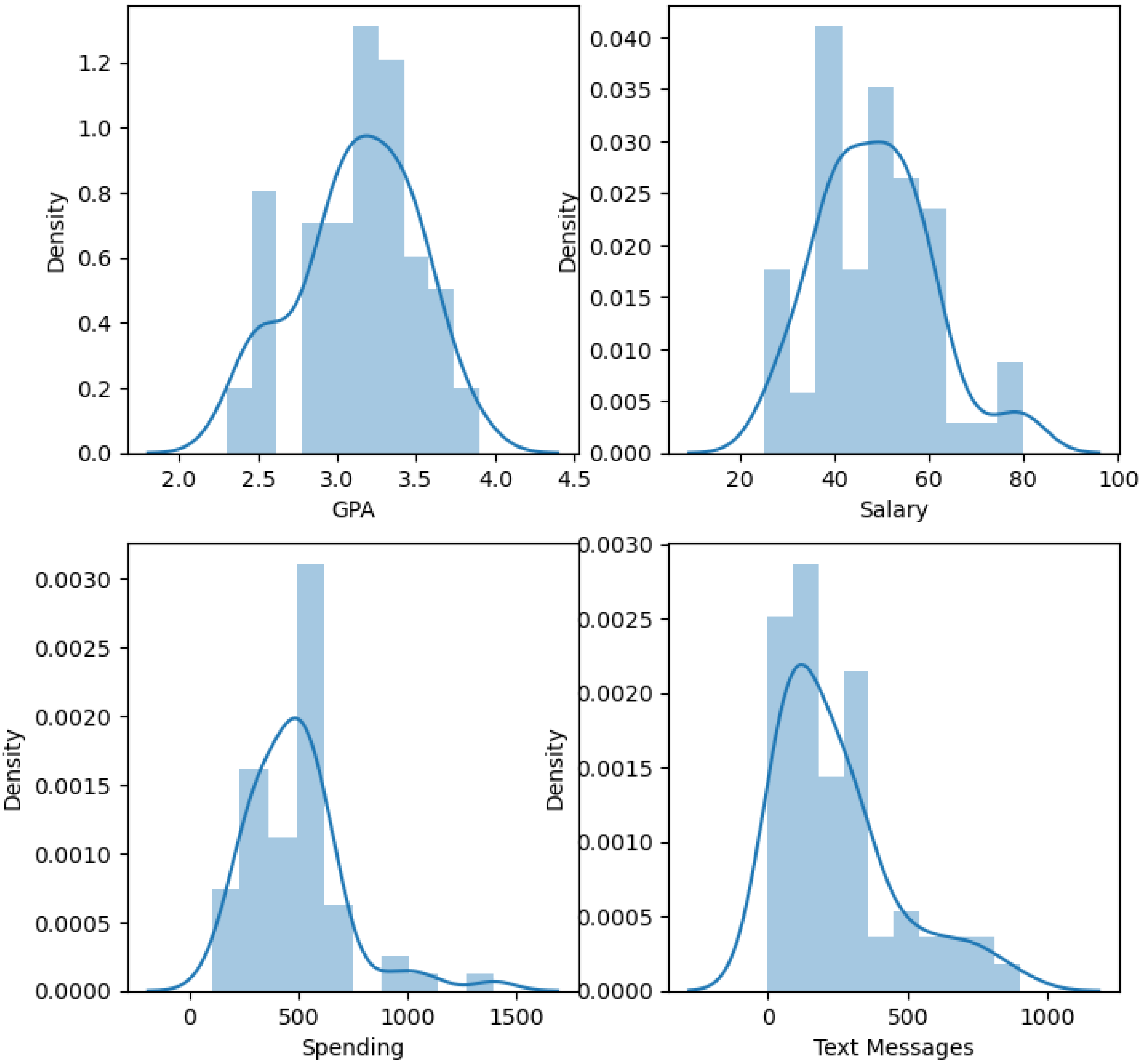
12. Are the continuous variables in the data normally distributed? Write a note summarizing your conclusions.

We have four numerical variables in the data - GPA, Salary, Spending, and Text Messages.

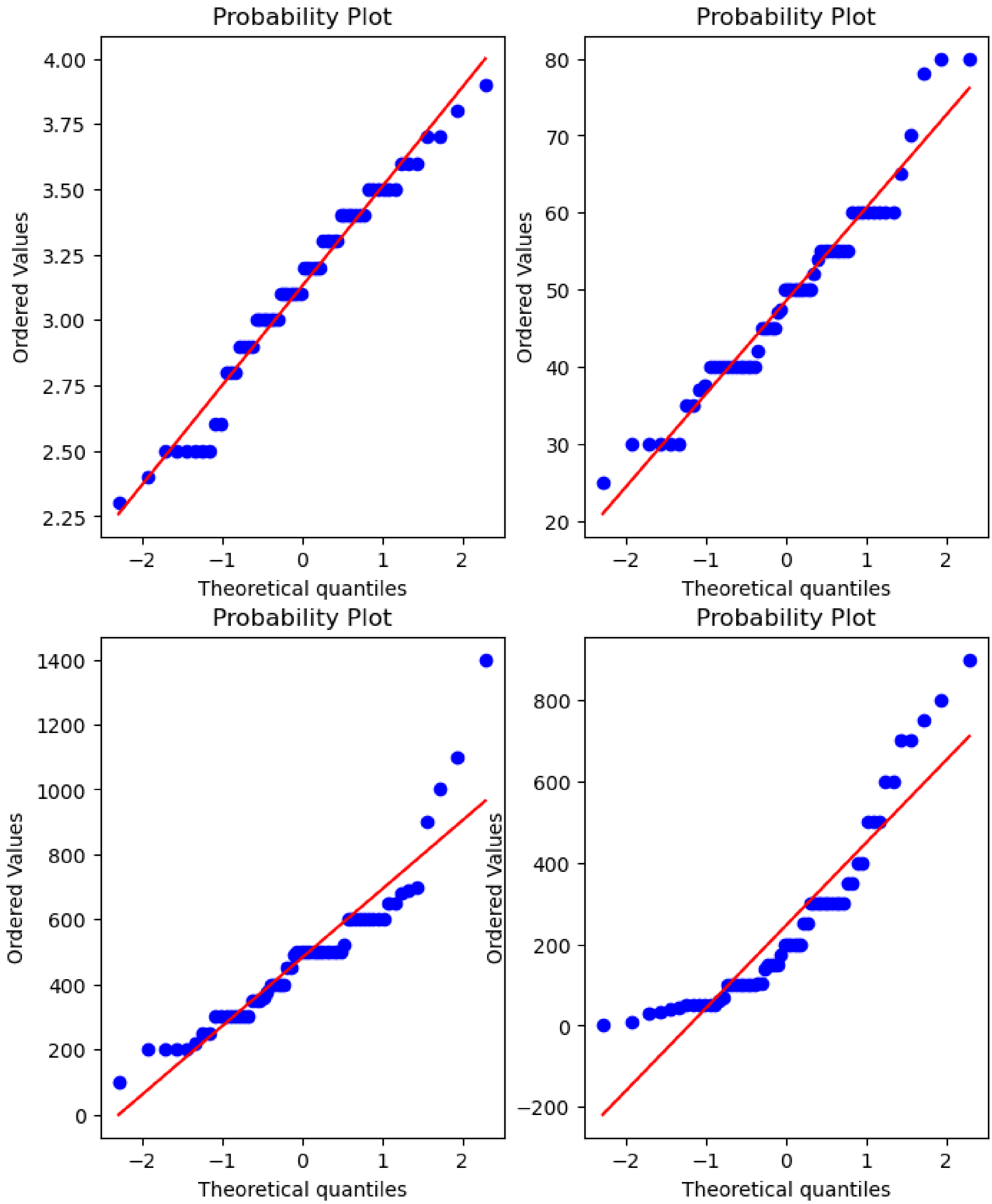
To assess whether they follow a normal distribution, we'll do the following:

1. **Visually examine the data distribution and check the skew values**
2. **Examine the probability plots**

1. The data distribution and check the skew values.



2. Examine the probability plots



Conclusion-

Based on the normal probability plots, we can make some conclusions about the normality of the continuous variables in the data.

GPA: The normal probability plot for GPA shows a linear pattern, indicating that the GPA variable is approximately normally distributed. This is consistent with the assumption that GPA is a continuous variable that follows a normal distribution.

Salary: The normal probability plot for Salary shows a slight deviation from linearity, indicating that the Salary variable may not be perfectly normally distributed. However, the deviation is relatively small, and the Central Limit Theorem may still apply due to the large sample size. Therefore, we can assume that the Salary variable is approximately normally distributed for the purposes of the business problem.

Spending: The normal probability plot for Spending shows a clear deviation from linearity, indicating that the Spending variable is not normally distributed. This is consistent with the business problem, as Spending is a continuous variable that is often skewed due to the presence of outliers or extreme values.

Text Messages: The normal probability plot for Text Messages shows a slight deviation from linearity, indicating that the Text Messages variable may not be perfectly normally distributed. However, the deviation is relatively small, and the Central Limit Theorem may still apply due to the large sample size. Therefore, we can assume that the Text Messages variable is approximately normally distributed for the purposes of the business problem.

In summary, based on the normal probability plots, we can assume that the GPA and Salary variables are approximately normally distributed, while the Spending variable is not normally distributed. The Text Messages variable may not be perfectly normally distributed, but it is close enough for the purposes of the business problem.

Problem 2

Context

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 coloring 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 is calculated. The company would like to show that the mean moisture content is less than 0.35 pounds per 100 square feet.

Objective

Based on the above context, the manufacturer wants to understand the following:

1. Is there any evidence that the mean moisture content in both types of shingles is within the permissible limits?
2. Is the population mean for shingles A and B are equal?

Use the relevant statistical tests to answer the above questions and state your conclusions along with all necessary steps.

Hint: Use the test for equality of means for the second question

Overview of the Dataset

View the first and last 5 rows of the dataset

	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

	A	B
31	0.40	NaN
32	0.29	NaN
33	0.43	NaN
34	0.34	NaN
35	0.37	NaN

The shape of the dataset

```
(36, 2)
```

The data types of the columns for the dataset¶

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

Check the missing values in the dataset

```
A    0
B    5
dtype: int64
```

Check the statistical summary of the data

	A	B
count	36.000000	31.000000
mean	0.316667	0.273548
std	0.135731	0.137296
min	0.130000	0.100000
25%	0.207500	0.160000
50%	0.290000	0.230000
75%	0.392500	0.400000
max	0.720000	0.580000

1. **Is there any evidence that the mean moisture content in both types of shingles is within the permissible limits?**

Sample A

Define Null and alternate hypothesis

The null hypothesis (H0) for sample B would be:

H0: $\mu B \geq 0.35$

This means that the population mean moisture content for sample B is greater than or equal to the permissible limit of 0.35 pounds per 100 square feet.

The alternate hypothesis (Ha) for sample B would be:

Ha: $\mu B < 0.35$

This means that the population mean moisture content for sample B is less than the permissible limit of 0.35 pounds per 100 square feet.

Step 2: Decide the significance level

Here we select α = 0.05 as given in the question.

Step 3: Identify the test statistic

We have two samples (A and B) and we do not know the population standard deviation. Sample sizes for both samples are not the same. The sample size is , n > 30. So we use the t distribution and the $tSTAT$ test statistic for one sample test for A sample. One tail test for sample A

Step 4: Calculate the p - value and test statistic

```
tstat -1.4735046253382782
P Value 0.07477633144907513
```

Step 5: Decide to reject or accept null hypothesis

```
one-sample t-test p-value= 0.07477633144907513
We do not have enough evidence to reject the null hypothesis in favour of alternative hypothesis
We conclude that the moisture content is greater than permissible limit in sample A.
```

Define Null and alternate hypothesis for sample B

Sample B

Step 1:

Testing whether the moisture content is less the permissible limit

The null hypothesis states that the moisture content of sample B is greater or than equal to the permissible limit of 0.35

$$H0:\mu\geq 0.35H0:�\geq 0.35$$

The alternative hypothesis states that the moisture content of sample B is less than permissible limit.

$$HA:\mu<0.35HA:�<0.35$$

Step 2: Decide the significance level

Here we select α = 0.05 as given in the question.

Step 3: Identify the test statistic

We have two samples (A and B) and we do not know the population standard deviation. Sample sizes for both samples are not the same. The sample size is , n > 30. So we use the t distribution and the $tSTAT$ test statistic for one sample test for B sample. one tail test for Sample B

Step 4: Calculate the p - value and test statistic

```
tstat -3.1003313069986995
P Value 0.0020904774003191813
```

Step 5: Decide to reject or accept null hypothesis

```
one-sample t-test p-value= 0.0020904774003191813
We have enough evidence to reject the null hypothesis in favour of alternative hypothesis
We conclude that the moisture content is less than permissible limit in sample B.
```

2. Is the population mean for shingles A and B are equal?

Step 1:

Define Null and alternate hypothesis

The null hypothesis (H0) for sample B would be:

H0: μB ≥ 0.35

This means that the population mean moisture content for sample B is greater than or equal to the permissible limit of 0.35 pounds per 100 square feet.

The alternate hypothesis (Ha) for sample B would be:

Ha: μB < 0.35

This means that the population mean moisture content for sample B is less than the permissible limit of 0.35 pounds per 100 square feet.

Step 2: Decide the significance level

Here we select α = 0.05 as the population standard deviation is not known.

Step 3: Identify the test statistic

We have two samples and we do not know the population standard deviation. Sample sizes for both samples are not the same. The sample size is , n > 30. So we use the t distribution and the $tSTAT$ test statistic for two sample test.

Step 4: Calculate the p - value and test statistic

```
tstat 1.2896282719661123
P Value 0.20174965718353277
```

Step 5: Decide to reject or accept null hypothesis

```
two-sample t-test p-value= 0.20174965718353277
We do not have enough evidence to reject the null hypothesis in favour of alternative hypothesis
We conclude that mean for shingles A and singles B are not the same
```

Problem 3

Context

Salary is hypothesized to depend on educational qualification and occupation. To understand the dependency, the salaries of 40 individuals are collected and each person's educational qualification and occupation are noted. Educational qualification is at three levels, High school graduate, Bachelor's, and Doctorate. Occupation is at four levels, Administrative and clerical, Sales, Professional or specialty, and Executive or managerial. A different number of observations are in each level of education–occupation combination.

Objective

Based on the above context, we want to understand the following:

1. Is there any significant difference in salaries among different levels of education?
2. Is there any significant difference in salaries among different levels of different occupations?
3. Is there a significant interaction between Education and Occupation on Salary?

Use the relevant statistical tests to answer the above questions and state your conclusions along with all necessary steps.

Note: Assume that the data follows a normal distribution. In reality, the normality assumption may not always hold if the sample size is small.

Overview of the Dataset

View the first and last 5 rows of the dataset

	Education	Occupation	Salary
0	Doctorate	Adm-clerical	153197
1	Doctorate	Adm-clerical	115945
2	Doctorate	Adm-clerical	175935
3	Doctorate	Adm-clerical	220754
4	Doctorate	Sales	170769

	Education	Occupation	Salary
35	Bachelors	Exec-managerial	173935
36	Bachelors	Exec-managerial	212448
37	Bachelors	Exec-managerial	173664
38	Bachelors	Exec-managerial	212760
39	Doctorate	Exec-managerial	212781

Understand the shape of the dataset

```
(40, 3)
```

Check the data types of the columns for the dataset

```
Education     object
Occupation    object
Salary         int64
dtype: object
```

Check the missing values in the dataset

```
Education     0
Occupation    0
Salary        0
dtype: int64
```

Check the statistical summary of the data

	Salary
count	40.000000
mean	162186.875000
std	64860.407506
min	50103.000000
25%	99897.500000
50%	169100.000000
75%	214440.750000
max	260151.000000

1. Is there any significant difference in salaries among different levels of education?

State the null and the alternate hypothesis for conducting one-way ANOVA for both Education and Occupation individually.

Null hypothesis (H0): There is no significant difference in salaries among different levels of education or different occupations. Alternate hypothesis (H1): There is a significant difference in salaries among different levels of education or different occupations.

One-Way ANOVA: Salary with respect to Education

Reject the null hypothesis. There is a significant difference in salaries based on education.

2. Is there any significant difference in salaries among different levels of different occupations?

One-Way ANOVA: Salary with respect to Occupation

Fail to reject the null hypothesis. There is no significant difference in salaries based on occupation.

3. Is there a significant interaction between Education and Occupation on Salary?

Reject the null hypothesis. There is a significant interaction between Education and Occupation on Salary.

Business implications of performing ANOVA for this particular case study.
Performing ANOVA in this case study helps understand the relationship between Salary and the factors Education and Occupation. The results provide insights into how salaries vary across different levels of education and occupation categories. If significant differences are found, it can aid in making informed decisions related to salary structures, career paths, and educational requirements. For example, if there are significant differences in salaries based on education levels, organizations may consider adjusting compensation or designing targeted professional development programs to enhance employee qualifications. Similarly, if significant differences are observed based on occupation, businesses can strategize recruitment, promotion, or compensation strategies to align with the demands and competencies associated with different job roles.

Additionally, the two-way ANOVA examines the interaction effect between Education and Occupation. If a significant interaction is present, it indicates that the effect of one factor (e.g., Education) on Salary may depend on the levels of the other factor (e.g., Occupation). This finding can guide organizations in understanding the complex interplay between education and occupation and how it influences salary outcomes, providing insights for talent management, job design, and performance evaluation.