**Hypothesis Testing Assignment**

**Question 1: Hypothesis Formulation: - A company claims that their new energy drink increases focus and alertness. Formulate the null and alternative hypotheses for testing this claim.**

**I. Foundational Knowledge**

Before answering the question, let's review the basic concepts of hypothesis testing:

1. **Null Hypothesis (H0):** The hypothesis that assumes **no effect** or **no difference**. It serves as the baseline or status quo assumption.
2. **Alternative Hypothesis (Ha):** The hypothesis that suggests there **is an effect** or **difference**. It contradicts the null hypothesis.
3. **Significance Level (α):** The probability of making a Type I error (rejecting a true null hypothesis). Common significance levels include 0.05 or 0.01.
4. **p-value:** The probability of obtaining a result at least as extreme as the one observed, assuming the null hypothesis is true. If the p-value is less than α\alpha, we reject H0H\_0.
5. **Type I Error:** Incorrectly rejecting the null hypothesis when it is actually true (false positive).
6. **Type II Error:** Failing to reject the null hypothesis when it is actually false (false negative).

**II. Answering Theoretical Questions**

**Formulating the Hypotheses for the Claim:**

**The company's claim:**

* The company claims that their new **energy drink** increases focus and alertness.

This suggests that the energy drink is **effective** in improving a certain outcome (focus and alertness). Therefore, we are testing whether the energy drink has a positive effect.

* **Null Hypothesis (H0):** There is **no effect** of the energy drink on focus and alertness. In other words, the drink does **not increase** focus and alertness beyond normal levels.

H0:μ=μ0

Where:

* + μ represents the mean focus and alertness level after consuming the energy drink.
  + μ0 represents the baseline mean focus and alertness level (without consuming the energy drink).
* **Alternative Hypothesis (Ha):** The energy drink **does increase** focus and alertness. We are specifically testing whether the mean focus and alertness level with the drink is higher than the baseline level.

Ha:μ>μ0

This is a **right-tailed test**, as we are only interested in whether the energy drink increases focus and alertness (not decreases).

**III. Summary of Hypotheses**

* **Null Hypothesis (H0):** The energy drink has **no effect** on increasing focus and alertness. H0:μ=μ0
* **Alternative Hypothesis (Ha):** The energy drink **increases** focus and alertness. Ha:μ>μ0

This structured formulation of the hypotheses ensures clarity for testing the company's claim.

**Question 2: Significance Level Selection: - A researcher is conducting a study on the effects of exercise on weight loss. What significance level should they choose for their hypothesis test and why?**

**I. Foundational Knowledge**

The **significance level** (α) in hypothesis testing represents the probability of rejecting the null hypothesis when it is actually true (making a Type I error). The significance level helps determine the **critical value** or **cutoff point** for the test statistic, beyond which the null hypothesis is rejected.

**Common Significance Levels**

* **α=0.05:** The most commonly used significance level in research. It means there is a 5% chance of rejecting the null hypothesis when it is actually true.
* **α=0.01:** A more stringent level, meaning there is a 1% chance of committing a Type I error.
* **α=0.10:** A more lenient level, with a 10% chance of rejecting the null hypothesis when it is actually true.

**II. Answering Theoretical Questions**

**Choosing the Significance Level for the Exercise and Weight Loss Study:**

The significance level is chosen based on the **context of the research** and the **consequences of errors**. Let’s break down the considerations:

1. **Type I Error (False Positive):**
   * A **Type I error** occurs if the researcher **rejects the null hypothesis when it is actually true**. In this case, it would mean concluding that exercise has a significant effect on weight loss when, in reality, it does not.
   * If **false positives** are **costly or risky**, we should use a lower significance level (e.g., α=0.01) to minimize the chances of mistakenly claiming an effect that doesn't exist.
2. **Type II Error (False Negative):**
   * A **Type II error** happens if the researcher **fails to reject the null hypothesis when it is actually false**. In this case, it would mean concluding that exercise does **not** significantly affect weight loss when, in fact, it does.
   * If the consequences of **missing a true effect** (e.g., exercise's impact on weight loss) are **severe** (such as delaying health interventions), the researcher might be more tolerant of a Type I error and opt for a **higher significance level** (e.g., α=0.10).
3. **Standard Practice in Health and Medical Research:**
   * In studies concerning health, fitness, or medical interventions, researchers typically use a **significance level of 0.05** because this is generally accepted as a balance between avoiding Type I and Type II errors.
   * A significance level of **0.01** is used when the risks of a false positive are more serious (for example, in life-or-death medical trials).
   * A **0.10** level may be acceptable when researchers are exploring new ideas or preliminary studies where the consequences of Type II errors are deemed more important than Type I errors.

**III. Answer:**

For a study on the **effects of exercise on weight loss**, the most appropriate significance level would typically be **0.05**, as it balances the risk of Type I and Type II errors.

* **Reasoning:** The researcher likely wants to avoid **claiming that exercise has no effect** when it actually does (Type II error), but also does not want to make an incorrect claim about exercise's impact when it truly has no effect (Type I error). Since health studies usually prioritize minimizing harm or misinterpretation, **0.05** is the standard and a reasonable choice.

If the study is a **preliminary** or **exploratory** one and the consequences of Type II errors are more serious, the researcher could opt for a **slightly higher significance level** (e.g., **0.10**). Conversely, if the **risk of falsely claiming a significant effect** (Type I error) is a major concern, they might choose **0.01**.

**IV. Summary**

* **Recommended Significance Level:** α=0.05
* **Reasoning:** Standard practice in health and medical studies; balances the risk of Type I and Type II errors, ensuring the findings are not falsely positive or falsely negative.

**Question 3: Interpreting p-values:- In a study investigating the effectiveness of a new teaching method, the calculated p-value is 0.03. What does this p-value indicate about the null hypothesis?**

**I. Foundational Knowledge**

The **p-value** is a measure used in hypothesis testing to help decide whether to **reject** the null hypothesis. It represents the probability of obtaining a result **at least as extreme** as the one observed, assuming the null hypothesis is true.

**Interpreting p-values:**

* **Small p-value (<α)**:
  + A **small p-value** (typically less than the chosen significance level, e.g., α=0.05) suggests that the **null hypothesis** is **unlikely** to be true, and there is **sufficient evidence** to reject it.
  + In this case, the result is statistically significant, meaning the observed effect is unlikely to be due to random chance.
* **Large p-value (≥α)**:
  + A **large p-value** indicates that the observed effect is **consistent** with the null hypothesis. There is **not enough evidence** to reject the null hypothesis.

**II. Answering Theoretical Questions**

**Interpretation of p-value in this study:**

* **Given p-value = 0.03**:
  + This p-value is **less than** the common significance level (α=0.05).
* **Decision rule:**
  + If **p-value < 0.05** (or any chosen significance level α), we **reject** the null hypothesis.

Therefore, in this case, since the p-value (0.03) is **less than 0.05**, we reject the null hypothesis and conclude that the observed data provides **sufficient evidence** to suggest that the new teaching method is **effective** (or has an impact) compared to the existing method.

**III. Conclusion**

* **What the p-value of 0.03 indicates about the null hypothesis**:  
  The p-value of **0.03** indicates that the observed data is **inconsistent with the null hypothesis** at the 0.05 significance level. This provides enough evidence to **reject** the null hypothesis and conclude that the new teaching method likely has a statistically significant effect.

**Question 4: Type I and Type II Errors:- Describe a scenario in which a Type I error could occur in hypothesis testing. How does it differ from a Type II error?**

**I. Foundational Knowledge**

**Type I Error (False Positive):**

* A **Type I error** occurs when we **reject the null hypothesis** when it is actually **true**. This is often called a **false positive**, because we mistakenly believe there is an effect or difference when there is none.
* **Example:** Concluding that a new drug works when, in reality, it has no effect.

**Type II Error (False Negative):**

* A **Type II error** occurs when we **fail to reject the null hypothesis** when it is actually **false**. This is known as a **false negative**, because we miss detecting an effect or difference that actually exists.
* **Example:** Concluding that a new drug has no effect when it actually does.

The key difference between **Type I and Type II errors** is:

* **Type I error** is the false positive (incorrect rejection of a true null hypothesis).
* **Type II error** is the false negative (incorrect failure to reject a false null hypothesis).

**II. Answering Theoretical Questions**

**Scenario for Type I Error:**

Let's consider a **clinical trial** for a new **weight-loss drug**. The null hypothesis (H0) states that the drug has **no effect** on weight loss, while the alternative hypothesis (Ha) states that the drug **does have an effect** on weight loss.

**Scenario for Type I Error:**

Suppose the drug is **actually ineffective** in promoting weight loss, but the test results show a significant difference, leading us to **reject the null hypothesis** and conclude that the drug **does** have a significant effect on weight loss. In reality, this is a false conclusion.

* **Type I Error Example in this Scenario:**
  + **Null Hypothesis**: The drug has no effect on weight loss.
  + **Type I Error**: Rejecting the null hypothesis and concluding that the drug works, even though it actually does not.

**Why Does This Happen?**

* A **Type I error** occurs when the test statistic falls into the **rejection region** due to random sampling variability, even though the null hypothesis is true. Essentially, we believe there is an effect when there is none.

**Implications of a Type I Error in this Scenario:**

* **Misleading conclusions**: The company could falsely claim the drug is effective, leading to marketing and selling the drug.
* **Risk of harm**: People might use the ineffective drug, wasting money or even experiencing side effects.

**Scenario for Type II Error:**

In contrast, let's imagine the **same clinical trial** where the drug actually **does** promote weight loss, but the test results do **not show** a significant difference, leading us to **fail to reject the null hypothesis**.

**Scenario for Type II Error:**

Suppose the drug is **effective** but, due to insufficient sample size or other factors, the statistical test fails to detect this true effect.

* **Type II Error Example in this Scenario:**
  + **Null Hypothesis**: The drug has no effect on weight loss.
  + **Type II Error**: Failing to reject the null hypothesis and concluding that the drug has no effect, when in fact it does.

**Why Does This Happen?**

* A **Type II error** happens when the test fails to detect a true effect because of insufficient power (e.g., small sample size, measurement error, or weak signal).

**Implications of a Type II Error in this Scenario:**

* **Missed opportunities**: The drug might be effective, but because of the error, it does not get the recognition or approval it deserves.
* **Missed health benefits**: Patients could miss out on a treatment that could help them lose weight.

**III. Summary of Differences:**

|  |  |  |
| --- | --- | --- |
| Error Type | Description | Example |
| Type I Error | False Positive: Rejecting the null hypothesis when it is actually true. | Concluding the weight-loss drug works when it does not. |
| Type II Error | False Negative: Failing to reject the null hypothesis when it is actually false. | Concluding the weight-loss drug does not work when it actually does. |

* **Type I Error:** Incorrectly claiming a false effect (false positive).
* **Type II Error:** Failing to detect a true effect (false negative).

**IV. Conclusion**

Understanding Type I and Type II errors is crucial in hypothesis testing, as they guide decision-making in the presence of uncertainty. In real-world scenarios, such as drug testing or clinical trials, both errors have significant consequences, and researchers must balance the risk of each error when designing their studies.

**Question 5: Right-tailed Hypothesis Testing:- A manufacturer claims that their new light bulb lasts, on average, more than 1000 hours. Conduct a right-tailed hypothesis test with a significance level of 0.05, given a sample mean of 1050 hours and a sample standard deviation of 50 hours.**

**I. Foundational Knowledge**

**Right-tailed Hypothesis Testing:**

In a right-tailed hypothesis test, we are interested in determining if the sample mean is **greater** than a certain value, based on a claimed population mean.

* **Null Hypothesis (H0)**: The manufacturer's claim is **false**, and the true average lifespan is less than or equal to 1000 hours.

H0:μ≤1000

* **Alternative Hypothesis (Ha)**: The manufacturer claims that the new light bulb lasts **more** than 1000 hours, so we are testing if the true mean lifespan is greater than 1000 hours.

Ha:μ>1000

This is a **right-tailed test**, where we are testing if the sample mean exceeds the claimed population mean.

**II. Hypothesis Test Setup**

Given:

* Sample mean (xˉ) = 1050 hours
* Sample standard deviation (s) = 50 hours
* Sample size (n) = The sample size is not provided, so we will assume n=30 (a common sample size for hypothesis tests).
* Significance level (α) = 0.05

**Steps for Right-tailed Hypothesis Test:**

1. **Set the hypotheses:**
   * H0:μ≤1000
   * Ha:μ>1000
2. **Test Statistic (t-statistic):**  
   Since the population standard deviation is unknown and the sample size is small (n<30), we use the **t-statistic**:

Where:

* + = sample mean
  + μ0 = claimed population mean (1000)
  + s = sample standard deviation
  + = sample size

1. **Determine the critical value:**  
   The critical value for a right-tailed test at α=0.05 can be found using the t-distribution table, depending on the degrees of freedom (df=n−1=30−1=29).
2. **Compare the test statistic with the critical value:**  
   If the calculated t-statistic exceeds the critical value, we reject the null hypothesis.

**III. Performing the Hypothesis Test**

1. **Calculate the test statistic:**

Given:

* =1050
* μ0=1000
* s=50
* =30

Substitute the values into the t-statistic formula:

Let me calculate this.

The calculated t-statistic is **5.48**.

1. **Determine the critical value:**

For a **right-tailed test** with a significance level of **0.05** and **29 degrees of freedom** (since df=n−1=30−1=29), we can look up the critical t-value from the t-distribution table.

* For df=29 and α=0.05 (right-tailed), the critical value of tαt\_{\alpha} is approximately **1.699**.

1. **Compare the t-statistic with the critical value:**

* **t-statistic** = **5.48**
* **Critical value** = **1.699**

Since the **t-statistic (5.48)** is **greater than the critical value (1.699)**, we **reject the null hypothesis**.

**IV. Conclusion**

* Based on the hypothesis test, there is sufficient evidence at the **0.05 significance level** to reject the null hypothesis.
* Therefore, we conclude that the **new light bulb's average lifespan is greater than 1000 hours**, supporting the manufacturer's claim.

Let me know if you'd like further clarification or additional assistance! 😊

**Question 6: Two-Tailed Hypothesis Testing:- A researcher wants to determine if there is a difference in mean exam scores between two groups of students. Formulate the null and alternative hypotheses for this study as a two-tailed test.**

**I. Foundational Knowledge**

**Two-Tailed Hypothesis Testing:**

A **two-tailed hypothesis test** is used when we want to determine if there is a **significant difference** in either direction (higher or lower) between the sample mean and the population mean, or between the means of two groups.

In this case, the researcher is interested in determining if there is a difference in the **mean exam scores** between two groups of students.

* The **null hypothesis (H0)** suggests that there is **no difference** between the two group means.
* The **alternative hypothesis (Ha)** suggests that there **is a difference** in the means of the two groups, but the difference can be either positive or negative.

**II. Hypothesis Formulation**

Let's define the two groups as:

* **Group 1:** The first group of students (e.g., students in a control group or using a traditional study method).
* **Group 2:** The second group of students (e.g., students using a new study method).

**Null Hypothesis (H0):**

There is **no difference** in the mean exam scores between the two groups. Mathematically:

H0:μ1=μ2

Where:

* μ1 = mean exam score of Group 1
* μ2 = mean exam score of Group 2

**Alternative Hypothesis (Ha):**

There is a **difference** in the mean exam scores between the two groups. Mathematically:

Ha:μ1≠μ2

This hypothesis suggests that the mean exam scores of the two groups are **not equal**; the difference could be either positive or negative.

**III. Summary of Hypotheses**

* **Null Hypothesis (H0)**: μ1=μ2 (No difference in the means of the two groups).
* **Alternative Hypothesis (Ha)**: μ1≠μ2 (There is a difference in the means of the two groups).

**IV. Conclusion**

The researcher will perform a **two-tailed hypothesis test** to evaluate whether there is any significant difference in the mean exam scores of the two student groups. If the test statistic falls in either the upper or lower tail (outside of the critical region), the null hypothesis will be rejected in Favor of the alternative hypothesis, suggesting a difference in mean exam scores between the groups.

**Question 7: One-sample t-test:- A manufacturer claims that the mean weight of their cereal boxes is 500 grams. A sample of 30 cereal boxes has a mean weight of 490 grams and a standard deviation of 20 grams. Conduct a one-sample t-test to determine if there is evidence to support the manufacturer's claim at a significance level of 0.05.**

**I. Foundational Knowledge**

A **one-sample t-test** is used when we want to compare the sample mean to a known population mean to see if there is evidence to support or reject a manufacturer's claim.

The test will help us determine whether the mean weight of the cereal boxes significantly differs from the claimed weight of 500 grams.

**Steps for One-sample t-test:**

1. **State the Hypotheses:**
   * **Null Hypothesis (H0)**: The mean weight of the cereal boxes is 500 grams.

H0:μ=500

* + **Alternative Hypothesis (Ha)**: The mean weight of the cereal boxes is not equal to 500 grams (two-tailed test).

Ha:μ≠500

1. **Test Statistic (t-statistic):** The formula for the **t-statistic** is:

Where:

* + = sample mean
  + = population mean (claimed mean)
  + s = sample standard deviation
  + = sample size

1. **Critical Value**: To determine the critical value for the test, we need the **degrees of freedom (df)**, which is n−1=30−1=29.
2. **Decision Rule**: If the **absolute value of the t-statistic** is greater than the **critical value** at the 0.05 significance level, we will reject the null hypothesis.

**II. Performing the One-sample t-test**

Given:

* Sample mean () = 490 grams
* Population mean (μ0) = 500 grams
* Sample standard deviation (s) = 20 grams
* Sample size () = 30
* Significance level (α) = 0.05

**Step 1: Calculate the t-statistic**

Substitute the given values into the formula:

t=490−5002030t = \frac{490 - 500}{\frac{20}{\sqrt{30}}}

Let me calculate this value.

It seems like I can’t do more advanced data analysis right now. Please try again later. However, I can guide you through the calculations step-by-step manually.

Here are the steps for the one-sample t-test:

**Step 1: Calculate the t-statistic**

The formula for the t-statistic is:

Substitute the given values:

* =490
* μ0=500
* s=20
* =30

First, calculate the denominator :

≈ ≈ 3.645

Now, calculate the t-statistic:

≈ -2.74

**Step 2: Determine the critical value**

* Degrees of freedom (df) = n−1=30−1=29.
* The critical t-value for a **two-tailed test** at a significance level of **0.05** and **29 degrees of freedom** can be found in the t-distribution table. It is approximately **2.045**.

**Step 3: Compare the t-statistic with the critical value**

* **t-statistic** = −2.74
* **Critical value** = ±2.045 (for two-tailed test)

Since the **absolute value of the t-statistic (2.74)** is **greater than the critical value (2.045)**, we **reject the null hypothesis**.

**Conclusion:**

* There is sufficient evidence at the **0.05 significance level** to reject the null hypothesis.
* This means that the sample data suggests that the **mean weight of the cereal boxes is significantly different** from the manufacturer's claim of 500 grams.

**Question 8: Two-sample t-test:- A researcher wants to compare the mean reaction times of two different groups of participants in a driving simulation study. Group A has a mean reaction time of 0.6 seconds with a standard deviation of 0.1 seconds, while Group B has a mean reaction time of 0.55 seconds with a standard deviation of 0.08 seconds. Conduct a two-sample t-test to determine if there is a significant difference in mean reaction times between the groups at a significance level of 0.01.**

**I. Foundational Knowledge**

A **two-sample t-test** is used to determine if there is a significant difference between the means of two independent groups. In this case, we are comparing the mean reaction times of **Group A** and **Group B**.

**Steps for Two-sample t-test:**

1. **State the Hypotheses:**
   * **Null Hypothesis (H0)**: There is **no difference** in the mean reaction times between the two groups. H0:μA=μB
   * **Alternative Hypothesis (Ha)**: There is a **significant difference** in the mean reaction times between the two groups. Ha:μA≠μB
2. **Test Statistic (t-statistic):** The formula for the **two-sample t-test** is:

Where:

* + and = sample means of Group A and Group B
  + sA and sB = sample standard deviations of Group A and Group B
  + and = sample sizes of Group A and Group B

For simplicity, if the sample sizes are equal, we can assume =.

1. **Degrees of Freedom (df):** For a two-sample t-test with unequal variances, the degrees of freedom can be calculated using the **Welch-Satterthwaite equation**:
2. **Critical Value:** Using the degrees of freedom and significance level (α=0.01), the critical value for the t-statistic is obtained from the t-distribution table.
3. **Decision Rule:** If the **absolute value of the t-statistic** is **greater than the critical value**, reject the null hypothesis.

**II. Performing the Two-sample t-test**

Given:

* **Group A**:
  + Mean () = 0.6 seconds
  + Standard deviation (sA) = 0.1 seconds
* **Group B**:
  + Mean () = 0.55 seconds
  + Standard deviation (sB) = 0.08 seconds
* Significance level (α) = 0.01
* Assume the sample sizes for both groups are the same (==30).

**Step 1: Calculate the t-statistic**

Substitute the values into the t-statistic formula:

Let me guide you through the calculations.

It seems like I can’t do more advanced data analysis right now. Please try again later.

However, I can walk you through the calculations for the two-sample t-test manually. Here’s how you can calculate the t-statistic step-by-step:

**Step 1: Calculate the t-statistic**

Substitute the given values into the formula:

1. First, calculate the variances and then divide by the sample size:
2. Now, sum these values:

0.000333+0.000213=0.000546

1. Take the square root:

≈ 0.023366

Finally, calculate the t-statistic:

≈2.14

**Step 2: Degrees of Freedom (df)**

The degrees of freedom (df) can be calculated using the **Welch-Satterthwaite equation** for unequal variances. For simplicity, I will guide you through using a standard t-distribution table for **30** samples per group.

* You can look up the **critical t-value** for a **two-tailed test** at a significance level of **0.01** (for **df = 58**, assuming equal sample sizes of 30 each).

**Step 3: Compare t-statistic with critical value**

* Calculate the **critical value** from the t-distribution table for **df = 58** at the **0.01 significance level** (two-tailed). This is approximately **2.660**.
* Since **2.14** (our calculated t-statistic) is **less than** the critical value **2.660**, we **fail to reject** the null hypothesis.

**Conclusion:**

* There is **not enough evidence** at the **0.01 significance level** to conclude that the mean reaction times are significantly different between Group A and Group B.

**Question 9: Process Control Example:- A call center manager implements a new training program aimed at reducing call waiting times. The average waiting time before the training program was 4.5 minutes, and after the program, it is measured to be 4.0 minutes with a standard deviation of 0.8 minutes. Conduct a hypothesis test to determine if there is evidence that the training program has reduced waiting times, using a significance level of 0.05.**

**I. Foundational Knowledge**

In this scenario, the call centre manager wants to determine if the new training program has reduced the average waiting time. A **one-sample t-test** can be used to test whether the sample mean after the training program is significantly lower than the pre-training mean of 4.5 minutes.

**Steps for Hypothesis Test:**

1. **State the Hypotheses:**
   * **Null Hypothesis (H0)**: There is **no reduction** in waiting time after the training program (the average waiting time is still 4.5 minutes). H0:μ=4.5
   * **Alternative Hypothesis (Ha)**: The **training program has reduced** the waiting time (the average waiting time is less than 4.5 minutes). Ha:μ<4.5
2. **Test Statistic (t-statistic):** The formula for the **one-sample t-test** is:

Where:

* + = sample mean after training program
  + μ0 = population mean before training program (4.5 minutes)
  + s = sample standard deviation
  + = sample size

1. **Degrees of Freedom (df):** The degrees of freedom (dfdf) are calculated as:

df= −1

(Where is the sample size).

1. **Critical Value:** Use a t-distribution table to find the **critical t-value** for a **one-tailed test** at the **0.05 significance level**.
2. **Decision Rule:**
   * If the **t-statistic** is **less than the critical value**, reject the null hypothesis.
   * If the **t-statistic** is **greater than or equal to** the critical value, fail to reject the null hypothesis.

**II. Performing the Hypothesis Test**

Given:

* Sample mean after training program () = 4.0 minutes
* Population mean before training program (μ0) = 4.5 minutes
* Sample standard deviation (s) = 0.8 minutes
* Significance level (α) = 0.05
* Sample size () = let's assume =30 (you can replace it with the actual sample size if provided)

**Step 1: Calculate the t-statistic**

Substitute the values into the t-statistic formula:

Let me walk you through the steps to compute this manually.

It seems like I can’t do more advanced data analysis right now. Please try again later. However, I can guide you through the process manually.

**Step 1: Calculate the t-statistic**

The formula for the t-statistic is:

Where:

* = 4.0 (mean after the training program)
* μ0=4.5(mean before the training program)
* s = 0.8 (sample standard deviation)
* = 30 (sample size)

**Calculate the denominator:**

First, calculate

≈ ≈ 0.146

**Calculate the t-statistic:**

t= ≈ -3.42

**Step 2: Degrees of Freedom (df)**

The degrees of freedom are:

df=n−1=30−1=29

**Step 3: Critical Value**

Using a t-distribution table for **df = 29** at the **0.05 significance level** (one-tailed test), the critical value is approximately **-1.699**.

**Step 4: Compare t-statistic with critical value**

* **Calculated t-statistic** = -3.42
* **Critical value** = -1.699

Since the calculated **t-statistic** (-3.42) is **less than** the **critical value** (-1.699), we **reject the null hypothesis**.

**Conclusion:**

There is **sufficient evidence** at the **0.05 significance level** to conclude that the **training program has reduced the waiting time** at the call center.

**Question 10. Interpreting Results:- After conducting a hypothesis test, the calculated p-value is 0.02. What can you conclude about the null hypothesis based on this result, assuming a significance level of 0.05?**

**I. Foundational Knowledge**

In hypothesis testing, the **p-value** helps determine whether there is enough evidence to reject the **null hypothesis**. The p-value represents the probability of observing the test statistic (or something more extreme) assuming that the null hypothesis is true.

* **Significance Level (α)**: This is the threshold against which the p-value is compared. In this case, the significance level is 0.05.
* **Interpretation**:
  + If the **p-value** is **less than** or **equal to** the significance level (α), you **reject the null hypothesis**.
  + If the **p-value** is **greater than** the significance level (α), you **fail to reject the null hypothesis**.

**II. Interpreting the p-value**

Given that the **calculated p-value is 0.02** and the **significance level (α) is 0.05**, we can conclude:

* **p-value = 0.02** is **less than** the significance level of **0.05**.

**Conclusion:**

Since the p-value is less than 0.05, we reject the **null hypothesis**. This indicates that there is **sufficient evidence** to support the **alternative hypothesis** at the 0.05 significance level.

In other words, we can conclude that the observed result is statistically significant, and the effect (or difference) being tested is likely real and not due to random chance.