**HYPOTHESIS TESTING**

Hypothesis Testing in statistics is a method to test whether the results of an experiment are meaningful or not. Using Hypothesis Testing we are basically testing if the results are valid by figuring out the odds that your results have occurred by chance.

**What is a Hypothesis?**

Hypothesis is a statement about something in the world around you. It should be testable, either by observation or experiment. For example:

* A new book which you might think is interesting
* A better way of experimenting which you might think is more effective.
* The possibility of an error in an experiment.

**What is a Hypothesis Statement ?**

Before you propose a Hypothesis, it is very important to write a Hypothesis statement. A Hypothesis statement is of this format:

“If I do this (to an independent variable) then this will happen (to the dependent variable)”

Example:

* If you get at least 7 hours of sleep, you will do better on exams than if you get less sleep.
* If you get a good rest, then you will feel fresh later.
* If you play football regularly, then your stamina will increase.

**Major concern regarding Hypothesis testing**

Hypothesis Testing is difficult as well as very important. Many students find this method difficult because they are unable to get the right hypothesis statement for that particular problem statement.

**Method to get the right Hypothesis**

* Reading the problem statement thoroughly.
* Identifying the independent and dependent variables.
* Performing background research.
* Creating a hypothesis.
* Check whether the created hypothesis is testable.

**MCQ -1**

1. Hypothesis should be :
2. Testable
3. Untestable
4. Complex
5. Unclear
6. Characteristics of a good hypothesis:
7. Simple
8. Clear
9. Specific
10. Relevant
11. All the above
12. Which of the following is not a method to get right hypothesis:
13. Identifying the independent and dependent parameters.
14. Not performing background research
15. Creating hypothesis
16. Reading problem statement correctly

**Let’s Start with Hypothesis Testing**

To begin with this method, first you need to know what Null Hypothesis and Alternative Hypothesis is.

**What is Null Hypothesis (H0)?**

A null hypothesis may be a kind of hypothesis employed in statistics that proposes that there's no distinction between bound characteristics of a population.

In other words, the null hypothesis states that there is no relationship between two population parameters, I.e., an independent variable and a dependent variable.

Example:

* Question: Empire restaurant, selling Chicken biryani, claims that each parcel packet has 400 grams of biryani. You are skeptical of their claims and believe that on average each packet does not contain 400 grams of biryani. Null Hypothesis is that the average grams in a Biryani packet is 400 grams.

Hypothesis Testing becomes easy once Null hypothesis is determined. all you need to do is:

“Figure out your **H0** , state your **H0**, choose what kind of test you need to perform, either support or reject **H0.**”

**Example:**

A college headmaster claims that students in his college score an average of 8 out of 10 in exams. The null hypothesis is that the population mean is 8.0. To test this null hypothesis, we record marks of say 50 students (sample) from the entire student population of the school (say 500) and calculate the mean of that sample. We can then compare the (calculated) sample mean to the (hypothesized) population mean of 8.0 and attempt to reject the null hypothesis. (Here the Null hypothesis—that the population mean is 8.0—cannot be proven considering the sample data; it will solely be rejected.)

**What is Alternative Hypothesis (H1)?**

The alternate/ alternative hypothesis is just an alternative to Null Hypothesis.

For example, in this Question: Empire restaurant, selling Chicken biryani, claims that each parcel packet has 400 grams of biryani. You are skeptical of their claims and believe that on average each packet does not contain 400 grams of biryani. Alternative Hypothesis is that the average grams in a Biryani packet is not equal to 400 grams.

**The idea of Hypothesis Testing:**

* Identify the Null Hypothesis
* State your Null hypothesis
* Decide the type of test to be performed
* Either support or reject the Null Hypothesis

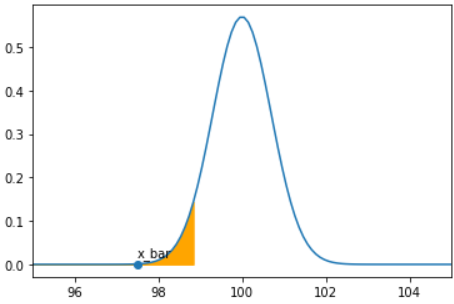
**Types of tests under Hypothesis testing :**

* One Tailed test
* Two Tailed test

**One Tailed Test**

Here the test can be either **Lower tailed** or **Upper tailed** Test.

**Lower tailed test:**



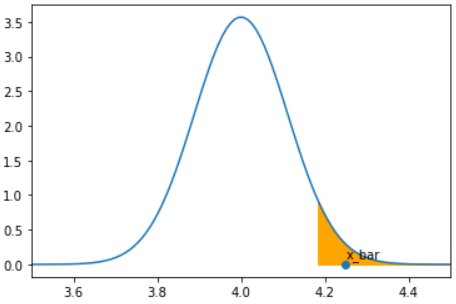
Rejection region for this test with α as significance level

**H1: μ < μ 0**, where μ0 is the comparator or null value and an increase is proposed - this type of test is called a **Lower-tailed test**

**Example:**

You have developed a new Active Learning Application and claim that on average it takes **less than** 100 milliseconds to predict for any future datapoint. Here you perform a Lower **tailed test.**

**Upper tailed test:**



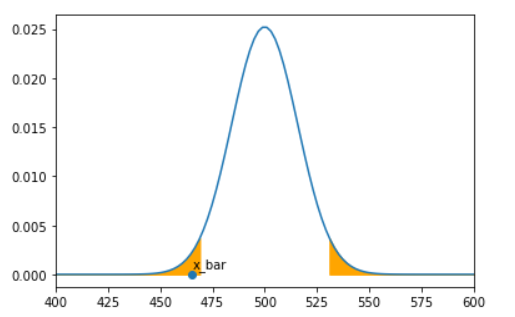
Rejection region for this test with α as significance level

**H1: μ > μ 0**, where μ0 is the comparator or null value and a decrease is proposed- this type of test is called an **Upper-tailed test**

**Example:**

You have developed a brand new Active Learning Application and claim that on the average it takes over one hundred milliseconds to predict for any future datapoint. Here you perform **Upper tailed test**

Two Tailed Test



Rejection region for this test with α/2 as significance level

**H1: μ ≠ μ 0**, where a difference is proposed and this is called a **two-tailed test.**

**Example:**

Let’s consider one of our previous examples:

Empire Restaurant, selling Chicken biryani claims that each parcel packet has 400 grams of biryani. You are skeptical of their claims and believe that on average each packet does not contain 400 grams of biryani. Here we consider that the **average is not** 400 grams (**μ ≠ 400**). Here you perform **Two tailed test**.

**Note**:

**Concentrate on the bold statements.**

**Steps to implement Hypothesis Testing:**

* Identify Null (Status Quo) and Alternative Hypothesis (Bold claim). For H1 we use **>, <** and ≠. For H0 we use **>=, <=** and =.
* Collect a sample of size n. Collect the mean from the sample x̄.
* Compute Test statistics:

1) If population variance is known.



2) If population variance is unknown.



* Decide the significance level α. **The significance level α, gives a measurement of the strength of the information that must be present in the considered sample before the Null hypothesis is rejected or accepted** . Lower α means you need stronger information/evidence to reject the Null hypothesis. **α= 1 – Confidence Interval. A confidence interval shows the probability that a variable will fall between a pair of values around the mean (μ)**. α is considered for one tailed tests and α/2 is considered for two tailed tests.
* Apply Decision rule:

If test statistics is z-score:

1) Two tailed z-test:

|z| > zα/2 , then Accept H1 or reject H0

2) Upper tailed z-test:

z > zα , then Accept H1 or reject H0

3) Lower tailed z-test:

z < -zα , then Accept H1 or reject H0

If test statistics is t-score:

1) Two tailed t-test:

|t| > tn-1,α/2 then Accept H1 or reject H0

2) Upper tailed t-test:

t > tn-1,α then Accept H1 or reject H0

3) Lower tailed t-test:

t < -tn-1,α , then Accept H1 or reject H0

**MCQ -2**

1. “KFC brings out a new chicken dish and claims that each parcel packet has 5 chicken drumsticks. The customers are sceptical of their claims and believe that on average each packet does not contain 5 chicken drumstick” . which of the following is the Null hypothesis:
2. On an average each packet contains 5 chicken drumstick
3. On an average each packet does not contain 5 chicken drumstick
4. On an average each packet contains less than 5 chicken drumstick
5. On an average each packet contains more than 5 chicken drumstick
6. “A Car company has developed a better fuel management system for the Off road model type. They claim that with this system, on average the model’s mileage is at least 20 km/litre”.which of the following is the Null hypothesis:

a) The average mileage is less than 20 km/litre

b) The average mileage is not equal to 20 km/litre

c) The average mileage is equal to 20 km/litre

d) The average mileage is less than or equal to 20 km/litre

1. “You developed a new Deep Learning model and claim that on average it takes less than 50 ms to predict the result. How do you convince your client about this claim”.which of the following is the Null hypothesis: ms- millisecond.

a) The average time is more than 50 ms

b) The average mileage is not equal to 50 ms

c) The average mileage is equal to 50 ms

d) The average mileage is more than or equal to 50 ms

1. “You developed a new Deep Learning model and claim that on average it takes less than 50 ms to predict the result. How do you convince your client about this claim”.which of the following is the Alternative hypothesis

a) The average time is less than 50 ms

b) The average mileage is not equal to 50 ms

c) The average mileage is more than 50 ms

d) The average mileage is more than or equal to 50 ms

1. “A Car company has developed a better fuel management system for the Off road model type. They claim that with this system, on average the model’s mileage is at least 20 km/litre”.which of the following is the Alternative hypothesis:

a) The average mileage is more than 20 km/litre

b) The average mileage is not equal to 20 km/litre

c) The average mileage is less than 20 km/litre

d) The average mileage is less than or equal to 20 km/litre

1. Types of one tailed test

a) Two tailed test

b) upper tailed test

c) lower tailed test

d) Both b and c

1. Significance level is α is equal to
2. 1 + Confidence Interval
3. 1 – Confidence Interval

c) 2 – Confidence Interval

d) Both a and b

1. Null Hypothesis is also called as
2. Bold claim

b) status quo

c) statement

d) Both a and b

1. Which test is performed when population variance is unknown

a) Z test

b) T test

c) XY test

d) L test

1. Which test is performed when population variance is known

a) Z test

b) T test

c) XY test

d) L test

1. Alternative hypothesis is also called

a) statement

b) status quo

c) bold claim

d) both a and b

1. For which test do we consider significance level as α/2:

a) upper tailed test

b) lower tailed test

c) two tailed test

d) None of the above

1. Upper tailed and lower tailed tests are also called

a) left tailed and right tailed test

b) right tailed and left tailed test

c) right back and left back test

d) left back and right back test

1. “You developed a new Deep Learning model and claim that on average it takes less than 50 ms to predict the result. How do you convince your client about this claim”.which of the following test is to be performed

a) Upper tailed test

b) Lower tailed test

c) Two tailed test

d) both a and b

1. “A Car company has developed a better fuel management system for the Off road model type. They claim that with this system, on average the model’s mileage is at least 20 km/litre”.which of the following test is to be performed

a) Upper tailed test

b) Lower tailed test

c) Two tailed test

d) both a and b

**QUESTIONS:**

1. The Empire Restaurant, selling Chicken biryani claims that each parcel packet has 500 grams of biryani. You are skeptical of their claims and believe that on average each packet does not contain 500 grams of biryani. How do you prove your claim? (Given that the population std is 50)

**SOLUTION**

**Step 1:**

Alternative Hypothesis (Bold claim) : µ ≠ 500

Null Hypothesis (status quo) : µ = 500

**Step 2:**

* **Collect a sample of size n =10 (sample size)**
* **Consider sample [490,220,470,500,495,496,496,498,508,480]**
* **Computing sample mean x̄ = [490+220+470+500+495+496+496+498+508+480]/10 = 465.3**
* **Population mean = 500 (µ = 500)**
* **Population standard deviation 50 (σ)**

**Step 3:**

Computing Test Statistics: z-score



**Step 4:**

Let the confidence level be 0.95.

Therefore, Significance level or α = 1- Confidence level = 1 - 0.95 = 0.05

**Step 5:**

To calculate z-score we have to identify the type of test to be used.

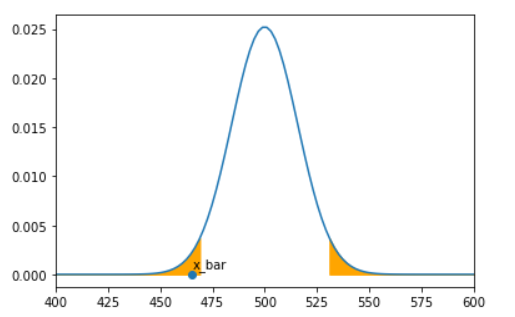
Here, since Null Hypothesis: µ = 500

Therefore, it is a two tailed test. Here, we consider α/2 as significance level.

Calculating z-score using formula,

**Z = -2.1946**

Calculating z-critical value from table.

We get **z-critical = 1.9599**

Finally, we get

**|z|> z-critical**

Therefore, we can reject Null Hypothesis.

1. The Empire Restaurant, selling Chicken biryani claims that each parcel packet has 500 grams of biryani. You are skeptical of their claims and believe that on average each packet does not contain 500 grams of biryani. How do you prove your claim? Here standard deviation of population is not given .

**SOLUTION**

**Step 1:**

Alternative Hypothesis (Bold claim) : µ ≠ 500

Null Hypothesis (status quo) : µ = 500

**Step 2:**

* **Collect a sample of size n =10 (sample size)**
* **Consider sample [490,220,470,500,495,496,496,498,508,480]**
* **Computing sample mean x̄ = [490+220+470+500+495+496+496+498+508+480]/10 = 465.3**
* **Population mean = 500 (µ = 500)**
* **Sample standard deviation S = StdDeviation(sample)**

**Step 3:**

Computing Test Statistics: t-score



**Step 4:**

Let the confidence level be 0.95.

Therefore, Significance level or α = 1- Confidence level = 1 - 0.95 = 0.05

**Step 5:**

To calculate t-score we have to identify the type of test to be used.

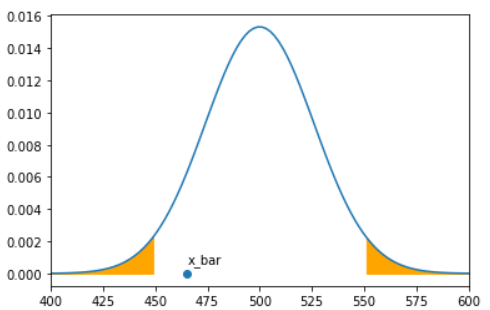
Here, since Null Hypothesis: µ = 500

Therefore, it is a two tailed test. Here, we consider α/2 as a significance level.

Calculating t-score using formula,

**t = -1.3318**

Calculating t-critical value from table.

We get **t-critical = 1.9604**

Finally, we get

**|t|< t-critical**

Therefore, we fail to reject Null Hypothesis.

1. You have developed a new Algorithm and done a user study. You claim that the average rating given by the users **is greater than** 4 on a scale of 1 to 5. How do you prove this to your client? (Given that the population std is 0.5)

**Solution**

**Step 1:**

Alternative Hypothesis (Bold claim) : µ >4

Null Hypothesis (status quo) : µ <= 4

**Step 2:**

* **Collect a sample of size n =20 (sample size)**
* **Consider sample [4,3,5,4,5,3,5,5,4,2,4,5,5,4,4,5,4,5,4,5]**
* **Computing sample mean x̄ = [4+3+5+4+5+3+5+5+4+2+4+5+5+4+4+5+4+5+4+5]/10 = 4.25**
* **Population mean = 4 (µ = 4)**
* **Population standard deviation = 0.5 (σ)**

**Step 3:**

Computing Test Statistics: z-score



**Step 4:**

Let the confidence level be 0.95.

Therefore, Significance level or α = 1- Confidence level = 1 - 0.95 = 0.05

**Step 5:**

To calculate z-score we have to identify the type of test to be used.

Here, in this question it it given that user’s rating is **greater than 4** on a scale of 1 to 5)

Therefore, it is an Upper one-tailed test. Here, we consider α as significance level.

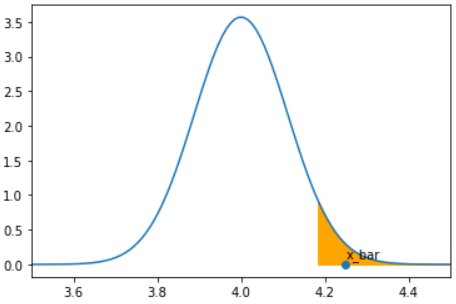
**NOTE:**

If the question states that the user’s rating is **lower than 4** on a scale of 1 to 5, then we would consider Lower one tailed test.

Calculating z-score using formula,

**Z = 2.2360**

Calculating z-critical value from table.

We get **z-critical = 1.6448**

Finally, we get

**|z|> z-critical**

Therefore, we can reject Null Hypothesis.

**Exercise questions:**

1. The Empire Restaurant, selling Chicken biryani claims that each parcel packet has more than 300 grams of biryani. You are skeptical of their claims and believe that on average each packet does not contain more than 300 grams of biryani. How do you prove your claim? Here standard deviation of population is not given .
2. Meghana biryani Restaurant, selling biryani claims that each parcel packet has more than 300 grams of biryani. You are skeptical of their claims and believe that on average each packet does not contain more than 300 grams of biryani. How do you prove your claim?(Given that the population std is 30)
3. You have created a game and finished a user study. You claim that the average rating given by the users **is more than** 8 on a scale of 1 to 10. How do you prove this to your client? (Given that the population std is 0.6)

**MCQ - Answers**

**MCQ -1**

1. a) testable
2. e) All the above
3. b) Not performing background research

**MCQ -2**

1. a) On an average each packet contains 5 chicken drumstick
2. d) The average mileage is less than or equal to 20 km/litre
3. d) The average mileage is more than or equal to 50 ms
4. a) The average time is less than 50 ms
5. a) The average mileage is more than 20 km/litre
6. d) both b and c
7. b) 1 – Confidence Interval
8. b) status quo
9. b) T test
10. a) Z test
11. c) bold claim
12. c) Two tailed test
13. b) right tailed and left tailed test
14. b) Lower tailed test
15. a) Upper tailed test