Introduction

Welcome to the module on 'Hypothesis Testing'.

In the previous modules, you learnt exploratory data analysis and inferential statistics.

In this session

The statistical analyses learnt in Inferential Statistics enable you try to make inferences about population mean from the sample data when you have no idea of population mean. However, sometimes you have some starting assumption about the population mean and you want to confirm those assumptions using the sample data. It is here that **hypothesis testing** comes into the picture. We will cover the basic concepts of hypothesis testing in this session, which are as follows:

- Types of hypotheses
- Types of tests
- Decision criteria
- Critical value method of hypothesis testing

This session covers the **concepts of Hypothesis Testing from the theory perspective**, since that is very important while performing Hypothesis Testing in industry using tools like Python, Excel etc. The demonstration of Hypothesis Testing on Excel has been done in the last session of this module.

The in-video and in-content questions for this module are not graded. Note that graded questions are given on a separate page labelled 'Graded Questions' at the end of this session. The questions in this session will adhere to the following guidelines:

	First Attempt Marks	Second Attempt Marks
Question with 2 Attempts	10	5
Question with 1 Attempt	10	0

People you will hear from in this session

Subject Matter Expert

Tricha Anjali

Associate Professor, IIIT- B

The International Institute of Information Technology, Bangalore, commonly known as IIIT Bangalore, is a premier national graduate school in India. Founded in 1999, it offers Integrated M.Tech., M.Tech., M.S. (Research) and Ph.D. programs in the field of Information Technology.

Industry Expert

Ankit Jain

Head of Data Science & Analytics, Roadrunnr

Roadrunnr is a B2B platform with the aim of building India's largest fleet of on-demand

Rohit Sharma

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NEXT
Understanding Hypothesis Testing

Understanding Hypothesis Testing

In the last two modules, you learned about the following topics:

- Exploratory data analysis: Exploring data for insights and patterns
- Inferential statistics: Making inferences about the population using the sample data

Now, these methods help you formulate a basic idea or conclusion about the population. Such assumptions are called “hypotheses”. But how do you really confirm these conclusions or hypotheses? Let’s see.

Let's understand the **basic difference between inferential statistics and hypothesis testing**.

Inferential statistics is used to find some population parameter (mostly population mean) when you have no initial number to start with. So, you start with the sampling activity and find out the sample mean. Then, you estimate the population mean from the sample mean using the confidence interval.

Hypothesis testing is used to confirm your conclusion (or hypothesis) about the population parameter (which you know from EDA or your intuition). Through hypothesis testing, you can determine whether there is enough evidence to conclude if the hypothesis about the population parameter is true or not.

Both these modules have a few similar concepts, so don't confuse terminology used in hypothesis testing with inferential statistics.

Let's get started by understanding the basics of hypothesis testing.

Hypothesis Testing starts with the formulation of these two hypotheses:

- **Null hypothesis** (H_0): The status quo
- **Alternate hypothesis** (H_1): The challenge to the status quo

Question 1/2

Mandatory

Null and Alternate Hypotheses

In the Maggi Noodles example, if you **fail to reject the null hypothesis**, what can you conclude from this statement?

Maggi Noodles contain excess lead — Incorrect

Feedback:
The null hypothesis in this example is that the average lead content is less than or equal to 2.5 ppm.

Maggi Noodles do not contain excess lead — Correct

Feedback:
The null hypothesis is that the average lead content is less than or equal to 2.5 ppm. Since you fail to reject the null hypothesis, you can conclude that Maggi

Now, having got a brief idea about what hypothesis testing is, in the next page, we will look at its different aspects in detail, starting with the formulation of the null and alternate hypotheses.

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PREVIOUS
Introduction

NEXT
Null and Alternate Hypotheses

Hypothesis Testing starts with the formulation of these two hypotheses:

- **Null hypothesis** (H_0): The status quo
- **Alternate hypothesis** (H_1): The challenge to the status quo

Question 2/2 Mandatory

Types of Hypotheses

The null and alternative hypotheses divide all possibilities into:

- 2 sets that overlap
- 2 non-overlapping sets ✓ Correct

  Feedback:

  Both the null and alternate hypotheses can't be true at the same time. Only one of them will be true.

- 2 sets that may or may not overlap

Null and Alternate Hypotheses

The first step of hypothesis testing is the formulation of the null and alternate hypotheses for a given situation. Let’s learn how to do this through different examples.

But in some instances, if your claim statement has words like “at least”, “at most”, “less than”, or “greater than”, **you cannot formulate the null hypothesis just from the claim statement** (because it’s not necessary that the **claim is always about the status quo**).

You can use the following rule to formulate the null and alternate hypotheses:

The null hypothesis always has the following signs: $=$ OR $\leq$ OR $\geq$

The alternate hypothesis always has the following signs: $\neq$ OR $>$ OR $<$

For example:

Situation 1: Flipkart claimed that its total valuation in December 2016 was at least $14 billion. Here, the claim contains ≥ sign (i.e. the at least sign), so **the null hypothesis is the original claim**.

The hypothesis in this case can be formulated as:

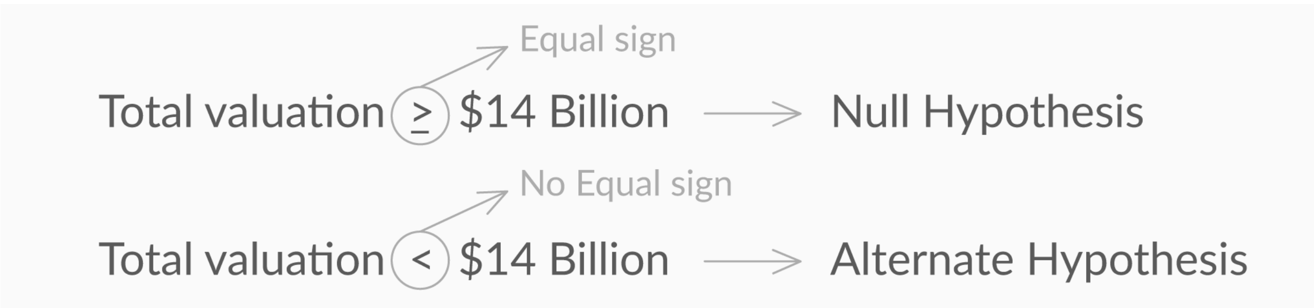

Figure 1 - Hypotheses for Situation 1

formulated as:

The hypothesis in this case can be formulated as:

Figure 2 - Hypotheses for Situation 2

Now, answer the following questions to consolidate your learning about the formulation of null and alternate hypotheses.

Question 1/2 Mandatory

Null and Alternate Hypotheses

The average commute time for an UpGrad employee to and from office is at least 35 minutes.

What will be the null and alternate hypotheses in this case if the average time is represented by μ?

- H_0: μ ≤ 35 minutes and H_1: μ > 35 minutes

Feedback:

The null hypothesis is always formulated by either = or ≤ or ≥ whereas the alternate hypothesis is formulated by ≠ or > or <. In this case, the average time taken was greater than or equal to 35 minutes. So, that becomes the null hypothesis. Less than 35 minutes becomes the alternate hypothesis.

H_0: μ < 35 minutes and H_1: μ ≥ 35 minutes

Your answer is Correct. Attempt 1 of 2 Continue

To summarize this, you cannot decide the status quo or formulate the null hypotheses from the claim statement, you need to take care of signs in writing the null hypothesis. Null Hypothesis never contains ≠ or > or < signs. It always has to be formulated using = or ≤ or ≥ signs.

Before you go ahead and look at some more examples of formulating null and alternate hypothesis, let us hear from Ankit Jain about how he used hypothesis testing during his time at Facebook.

FREQUENTLY ASKED QUESTIONS (FAQ)

My answer does not match with the given solution

My video doesn't play properly

My progress is stuck/ Unable to proceed to the next section

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PREVIOUS
Understanding Hypothesis Testing

NEXT
Making a Decision

formulated as:

The hypothesis in this case can be formulated as:

Figure 2 - Hypotheses for Situation 2

Now, answer the following questions to consolidate your learning about the formulation of null and alternate hypotheses.

Question 2/2 Mandatory

Null and Alternate Hypotheses

Goodyear claims that each of its tyres can travel more than 7500 miles on average before they need any replacement.

Assuming that the average travel distance is given by μ, what would be the null and the alternate hypothesis in this case?

- [ ] H_0: μ>7500 miles and H_1: μ ≤ 7500 miles

H_0: $\mu \leq 7500$ miles and H_1: $\mu > 7500$ miles ✓ Correct

- Feedback:
  The null hypothesis is always formulated by either = or ≤ or ≥ whereas the alternate hypothesis is formulated by ≠ or > or <. If you check the claim statement, it has the > sign (i.e. μ> 7500 miles). Hence the null hypothesis would be the complement of the claim statement i.e. μ ≤ 7500 miles, and the alternate hypothesis would be the claim statement itself or μ > 7500 miles.

Your answer is Correct. | Attempt 2 of 2 | Continue

To summarize this, you cannot decide the status quo or formulate the null hypotheses from the claim statement, you need to take care of signs in writing the null hypothesis. Null Hypothesis never contains ≠ or > or < signs. It always has to be formulated using = or ≤ or ≥ signs.

Before you go ahead and look at some more examples of formulating null and alternate hypothesis, let us hear from Ankit Jain about how he used hypothesis testing during his time at Facebook.

Making a Decision

Once you have formulated the null and alternate hypotheses, let's turn our attention to the most important step of hypothesis testing — **making the decision to either reject or fail to reject the null hypothesis** — through an interesting example of a friend playing archery.

Question 1/1 Mandatory

Making a decision

If your sample mean lies in the acceptance region, then:

You reject the null hypothesis ✕ Incorrect

Feedback:

You reject the null hypothesis only if your sample mean lies in the critical region.

You fail to reject the null hypothesis ✓ Correct

Feedback:

If your sample mean lies in the acceptance region, you fail to reject the null hypothesis because it is not beyond the critical point and you can consider that sample mean is equal to the population mean statistically.

Your answer is Wrong. Attempt 1 of 1 Continue

Let's learn more about the critical region and understand how the position of the critical region changes with the different types of null and alternate hypotheses.

The formulation of the null and alternate hypotheses determines the type of the test and the position of the critical regions in the normal distribution.

You can tell the type of the test and the position of the critical region on the basis of the **'sign' in the alternate hypothesis.**

$\neq$ in H_1 → Two-tailed test → Rejection region on **both sides** of distribution

$<$ in H_1 → Lower-tailed test → Rejection region on **left side** of distribution

$>$ in H_1 → Upper-tailed test → Rejection region on **right side** of distribution

Question 3/3 Mandatory

Question 1	Correct	
Question 2	Correct	

FREQUENTLY ASKED QUESTIONS (FAQ)

Does the claim statement directly give the null hypothesis?

Report an error

PREVIOUS
Null and Alternate Hypotheses

NEXT
Critical Value Method

The formulation of the null and alternate hypotheses determines the type of the test and the position of the critical regions in the normal distribution.

You can tell the type of the test and the position of the critical region on the basis of the **'sign' in the alternate hypothesis.**

$\neq$ in H_1 $\rightarrow$ Two-tailed test $\rightarrow$ Rejection region on **both sides** of distribution

$<$ in H_1 $\rightarrow$ Lower-tailed test $\rightarrow$ Rejection region on **left side** of distribution

$>$ in H_1 $\rightarrow$ Upper-tailed test $\rightarrow$ Rejection region on **right side** of distribution

Question 1/3 Mandatory

Null and Alternate Hypotheses

Lower-tailed test, with the rejection region on the right side

Upper-tailed test, with the rejection region on the right side

Lower-tailed test, with the rejection region on the left side ✓ Correct

Feedback:

For this situation, the hypotheses would be formulated as H_0: $\mu \geq 35$ minutes and H_1: $\mu < 35$ minutes. As < sign is used in alternate hypothesis, it would be a lower-tailed test and the rejection region would be on the left side of the distribution.

Upper-tailed test, with the rejection region on the left side

Your answer is Correct. Attempt 1 of 2 Continue

FREQUENTLY ASKED QUESTIONS (FAQ)

Does the claim statement directly give the null hypothesis?

The formulation of the null and alternate hypotheses determines the type of the test and the position of the critical regions in the normal distribution.

You can tell the type of the test and the position of the critical region on the basis of the **'sign' in the alternate hypothesis.**

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$>$ in H_1 → Upper-tailed test → Rejection region on **right side** of distribution

Question 2/3 Mandatory

Null and Alternate Hypotheses

$H_0 : \mu \neq 3; H_1 : \mu = 3;\ \ Test : Two - tailed\ \ test$

$H_0 : \mu = 3; H_1 : \mu \neq 3;\ \ Test : Lower - tailed\ \ test$

$H_0 : \mu = 3; H_1 : \mu \neq 3;\ \ Test : Upper - tailed\ \ test$

$H_0 : \mu = 3; H_1 : \mu \neq 3;\ \ Test : Two - tailed\ \ test$ ✓ Correct

Feedback:
H0 always has an equal sign. And since H1 has an unequal sign, we need to test both the sides.

Your answer is Correct. Attempt 1 of 2 Continue

FREQUENTLY ASKED QUESTIONS (FAQ)

Does the claim statement directly give the null hypothesis?

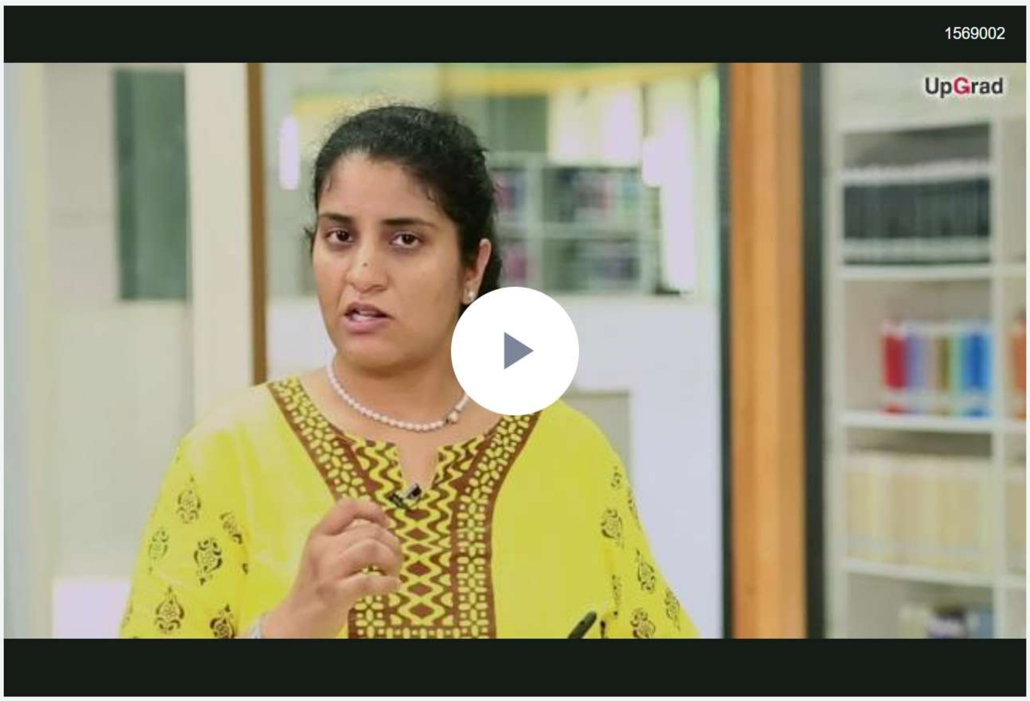
You fail to reject the null hypothesis ✓ Correct

Feedback:

If your sample mean lies in the acceptance region, you fail to reject the null hypothesis because it is not beyond the critical point and you can consider that sample mean is equal to the population mean statistically.

Your answer is Wrong. Attempt 1 of 1 Continue >

Let's learn more about the critical region and understand how the position of the critical region changes with the different types of null and alternate hypotheses.



The formulation of the null and alternate hypotheses determines the type of the test and the position of the critical regions in the normal distribution.

You can tell the type of the test and the position of the critical region on the basis of the 'sign' **in the alternate hypothesis.**

$\neq$ in H_1 → Two-tailed test → Rejection region on **both sides** of distribution

$<$ in H_1 → Lower-tailed test → Rejection region on **left side** of distribution

$>$ in H_1 → Upper-tailed test → Rejection region on **right side** of distribution

Question 3/3 Mandatory

Null and Alternate Hypotheses

A researcher claims that the weight of an average male Bengal tiger is less than 220 KG.

$H_0 : \mu >= 220kg, H_1 : \mu < 220kg, \ \ Test : Upper - tailed \ \ test$ ✗ Incorrect

Feedback:
Recall when to use an upper tailed and lower tailed test.

$H_0 : \mu < 220kg, H_1 : \mu \geq 220kg, \ \ Test : Upper - tailed \ \ test$

$H_0 : \mu > 220kg, H_1 : \mu \leq 220kg, \ \ Test : Lower - tailed \ \ test$

None of the above ✓ Correct

Feedback:
The correct formulation is as follows:

$H_0 : \mu >= 220kg, H_1 : \mu < 220kg, \ \ Test : Lower - tailed \ \ test$

Your answer is Wrong. | Attempt 2 of 2 | Continue >

FREQUENTLY ASKED QUESTIONS (FAQ)

Does the claim statement directly give the null hypothesis?

Report an error

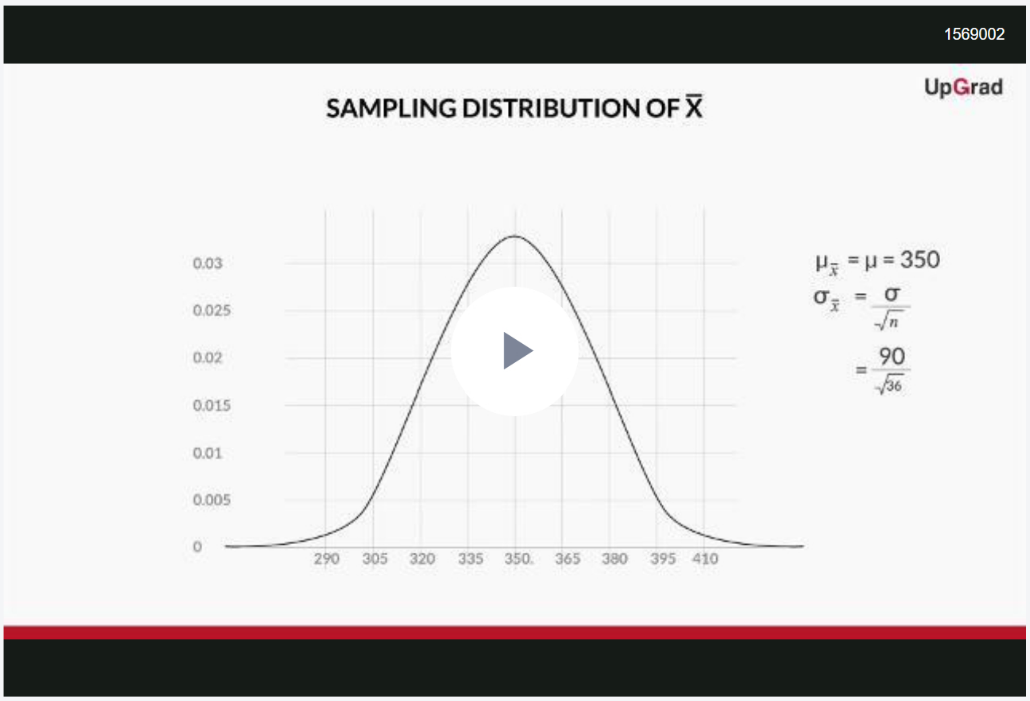
PREVIOUS
Null and Alternate Hypotheses

NEXT
Critical Value Method

Critical Value Method

Now, let's learn how to find the critical values for the critical region in the distribution and make the final decision of rejecting or failing to reject the null hypothesis.

(***Note***: *In the video below, the graph showing the distribution of average sales data at 1:06 incorrectly displays 370.6 as the sample mean instead of 370.16. Also, it would be* $\sigma_{\bar{x}} = 15$ *instead of* $\sigma = 15$*at 3:41*)



Before you proceed with finding the Zc and finally the critical values, let's revise the steps performed in this method till now.

1. First, you define a new quantity called α, which is also known as the significance level for the test. It refers to the proportion of the sample mean lying in the critical region. For this test, α is taken as 0.05 (or 5%).
2. Then, you calculate the cumulative probability of UCV from the value of α, which is further used to find the z-critical value (Zc) for UCV.

Attempt the following questions before you go ahead and learn the remaining steps in this method.

Question 1/3

Mandatory

Area of rejection region

What will be the area of the critical region on the right-hand side of the distribution if the significance level (α) for a two-tailed test is 3%?

- 0.03
- 0.97
- 0.015 ✓ Correct

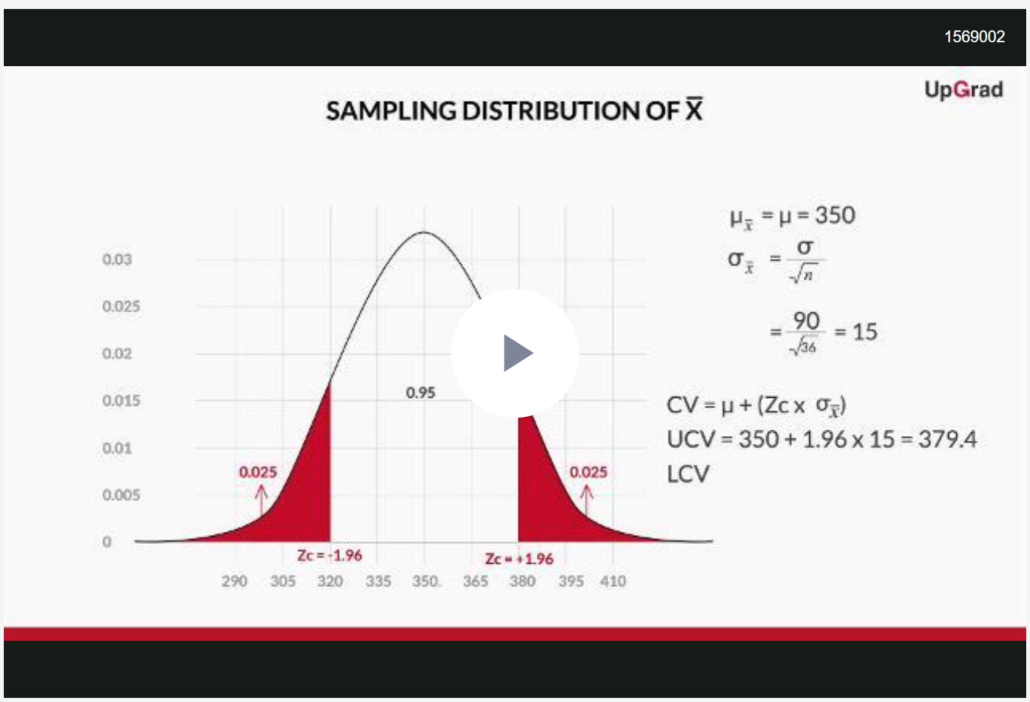
  Feedback:

  Here, value of α is 0.03 (of 3%), so the area of the rejection region would be 0.03 and the area of the acceptance region would be 0.97. In addition, since this is a two-tailed test, the area of the critical region on the right-hand side would be half of 0.03, i.e. 0.015.
- 0.985

Your answer is Correct.

Attempt 1 of 2

Continue >



After formulating the hypothesis, the steps you have to follow to **make a decision** using **the critical value method** are as follows:

1. Calculate the value of Zċ from the given value of α (significance level). Take it a 5% if not specified in the problem.
2. Calculate the critical values (UCV and LCV) from the value of Zċ.

3. Make the decision on the basis of the value of the sample mean x with respect to the critical values (UCV AND LCV).

You can download the z-table from the attachment below. It will be useful in the subsequent questions.

Z-table Download

Let's solve the following problem stepwise to consolidate your learning on how to make a decision about any hypothesis.

A manufacturer claims that the average life of its product is 36 months. An auditor selects a sample of 49 units of the product, and calculates the average life to be 34.5 months. The population standard deviation is 4 months. Test the manufacturer's claim at 3% significance level using the critical value method.

First, you need to **formulate the hypotheses** for this two-tailed test, which would be:

$$H_0: \mu = 36 \text{ months and } H_1: \mu \neq 36 \text{ months}$$

Now, you need to follow the three steps to **find the critical values and make a decision.**

Try out the three-step process by answering the following questions.

Question 3/3 Mandatory

Question 1	Incorrect	
Question 2	Correct	
Question 3	Correct	

Report an error

1. First, you define a new quantity called α, which is also known as the significance level for the test. It refers to the proportion of the sample mean lying in the critical region. For this test, α is taken as 0.05 (or 5%).
2. Then, you calculate the cumulative probability of UCV from the value of α, which is further used to find the z-critical value (Zc) for UCV.

Attempt the following questions before you go ahead and learn the remaining steps in this method.

Question 2/3 Mandatory

Area of rejection region

What would be the area of the critical region on the right-hand side of the distribution if the significance level (α) for an upper-tailed test is 3%?

- 0.03 ✓ Correct

  Feedback:

  Here, the value of α is 0.03 (of 3%), so the area of the critical region would be 0.03 and the area of the acceptance region would be 0.97. Since this is an upper-tailed test, the critical region is only on the right-hand side of the distribution, and the area of the critical region would be 0.03.

- 0.97
- 0.015

0.03 and the area of the acceptance region would be 0.97. In this case, what would be the area of the critical region on the right-hand side if this is an upper-tailed test?

Your answer is Wrong. Attempt 2 of 2 Continue

After formulating the hypothesis, the steps you have to follow to **make a decision** using **the critical value method** are as follows:

1. Calculate the value of Zċ from the given value of α (significance level). Take it a 5% if not specified in the problem.
2. Calculate the critical values (UCV and LCV) from the value of Zċ.

1. First, you define a new quantity called α, which is also known as the significance level for the test. It refers to the proportion of the sample mean lying in the critical region. For this test, α is taken as 0.05 (or 5%).
2. Then, you calculate the cumulative probability of UCV from the value of α, which is further used to find the z-critical value (Zc) for UCV.

Attempt the following questions before you go ahead and learn the remaining steps in this method.

Question 3/3 Mandatory

Area of rejection region

What would be the value of the cumulative probability of UCV if the significance level (α) for an upper-tailed test is 3%?

- 0.03
- 0.97 ✓ Correct
  - Feedback:
    The area of the critical region in this case would be 0.03 (as calculated in the last question), which would be the area beyond the UCV point in the distribution. So, the area till the UCV point would be 1 - 0.03, i.e. 0.97. This would be the cumulative probability of that point, going by the definition of cumulative probability.

Standard Normal Probabilities

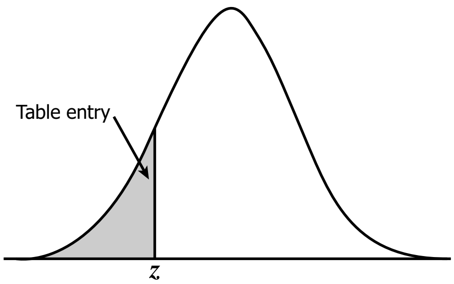


Table entry for z is the area under the standard normal curve to the left of z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
−3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
−3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
−3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
−3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
−2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
−1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
−0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
−0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
−0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
−0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
−0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
−0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
−0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
−0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
−0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
−0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

Standard Normal Probabilities

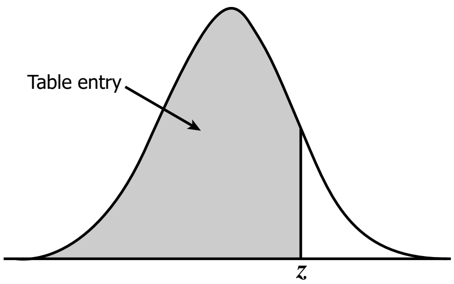


Table entry for z is the area under the standard normal curve to the left of z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

Let's solve the following problem stepwise to consolidate your learning on how to make a decision about any hypothesis.

A manufacturer claims that the average life of its product is 36 months. An auditor selects a sample of 49 units of the product, and calculates the average life to be 34.5 months. The population standard deviation is 4 months. Test the manufacturer's claim at 3% significance level using the critical value method.

First, you need to **formulate the hypotheses** for this two-tailed test, which would be:

$H_0: \mu = 36$ months and $H_1: \mu \neq 36$ months

Now, you need to follow the three steps to **find the critical values and make a decision**.

Try out the three-step process by answering the following questions.

Question 1/3

Mandatory

Critical Value Method

1st step: Calculate the value of Zc from the given value of α (significance level).

Calculate the z-critical score for the two-tailed test at 3% significance level.

- 1.88
- 1.04 ✕ Incorrect
  - Feedback:
    For 3% significance level, you would have two critical regions on both sides with a total area of 0.03. So, the area of the critical region on the right side would be 0.015, which means that the area till UCV (cumulative probability of that point) would be 1 - 0.015 = 0.985. So, you need to find the z-score of 0.985.
- 2.965
- 2.17 ✓ Correct
  - Feedback:
    For 3% significance level, you would have two critical regions on both sides with a total area of 0.03. So, the area of the critical region on the right side would be 0.015, which means that the area till UCV (cumulative probability of that point) would be 1 - 0.015 = 0.985. So, you need to find the z-value of 0.985. The z-score for 0.9850 in the z-table is 2.17 (2.1 on the horizontal axis and 0.07 on the vertical axis).

Your answer is Wrong.

Attempt 2 of 2

Continue

Let's solve the following problem stepwise to consolidate your learning on how to make a decision about any hypothesis.

A manufacturer claims that the average life of its product is 36 months. An auditor selects a sample of 49 units of the product, and calculates the average life to be 34.5 months. The population standard deviation is 4 months. Test the manufacturer's claim at 3% significance level using the critical value method.

First, you need to **formulate the hypotheses** for this two-tailed test, which would be:

$H_0: \mu = 36$ months and $H_1: \mu \neq 36$ months

Now, you need to follow the three steps to **find the critical values and make a decision**.

Try out the three-step process by answering the following questions.

Question 2/3

Mandatory

Critical Value Method

2nd step: Calculate the critical values (UCV and LCV) from the value of Zc.

Find out the UCV and LCV values for Zc = 2.17.

μ = 36 months σ = 4 months   n (Sample size) = 49

- UCV = 37.24 and LCV = 34.76   ✓ Correct

  Feedback:

  The critical values can be calculated from $\mu \pm Zc \times (\sigma/\sqrt{N})$ as $36 \pm 2.17(4/\sqrt{49}) = 36 \pm 1.24$ which comes out to be 37.24 and 34.76.

- UCV = 36.18 and LCV = 35.82
- UCV = 44.68 and LCV = 27.32
- UCV = 36.31 and LCV = 35.69

Your answer is Correct.   Attempt 2 of 2   Continue

Report an error

Let's solve the following problem stepwise to consolidate your learning on how to make a decision about any hypothesis.

A manufacturer claims that the average life of its product is 36 months. An auditor selects a sample of 49 units of the product, and calculates the average life to be 34.5 months. The population standard deviation is 4 months. Test the manufacturer's claim at 3% significance level using the critical value method.

First, you need to **formulate the hypotheses** for this two-tailed test, which would be:

$$H_0: \mu = 36 \text{ months and } H_1: \mu \neq 36 \text{ months}$$

Now, you need to follow the three steps to **find the critical values and make a decision**.

Try out the three-step process by answering the following questions.

Question 3/3 Mandatory

Critical Value Method

3rd step: Make the decision on the basis of the value of the sample mean $\bar{x}$ with respect to the critical values (UCV AND LCV).

What would be the result of this hypothesis test?

UCV = 37.24 months LCV = 34.76 months Sample mean ($\bar{x}$) = 34.5 months

- Fail to reject the null hypothesis
- Reject the null hypothesis ✓ Correct

  Feedback:

  The UCV and LCV values for this test are 37.24 and 34.76. The sample mean in this case is 34.5 months, which is less than LCV. So, this implies that the sample mean lies in the critical region and you can reject the null hypothesis.
- Can't say

Your answer is Correct. Attempt 2 of 2 Continue

Report an error

Critical Value Method - Examples

You have learnt how to perform the three steps of the critical value method with the help of the AC sales problem as well as the above product lifecycle comprehension problem, which was a two-tailed test. But what would happen if it were a one-tailed test? Let’s watch the video below to understand.

subsequent questions.

Z-table Download

Question 1/3 Mandatory

Critical Value Method

Consider this problem — H_0: $\mu \leq 350$ and H_1: $\mu > 350$

In case of a two-tailed test, you find the z-score of 0.975 in the z-table, since 0.975 was cumulative probability of UCV in that case. In this problem, what would be the cumulative probability of critical point in this example for the same significance level of 5%?

- 0.975
- 0.025
- 0.950 ✓ Correct

  Feedback:
  In this problem, the area of the critical region beyond the only critical point, which is on the right side, is 0.05 (in the last problem, it was 0.025). So, the cumulative probability of the critical point (the total area till that point) would be 0.950.
- 0.050

Comprehension

Government regulatory bodies have specified that the maximum permissible amount of lead in any food product is 2.5 parts per million or 2.5 ppm. Let's say you are an analyst working at the food regulatory body of India FSSAI. Suppose you take 100 random samples of Sunshine from the market and have them tested for the amount of lead. The mean lead content turns out to be 2.6 ppm with a standard deviation of 0.6.

One thing you can notice here is that the standard deviation of the sample is given as 0.6, instead of the population's standard deviation. In such a case, you can approximate the against Sunshine or not, at 3% significance level.

Question 4/4

Mandatory

Question 1	Correct
Question 2	Correct
Question 3	Correct
Question 4	Incorrect

You can look at the solution of this comprehension from this video .

(**Note**: At 2:06, the sample size would be n instead of m while calculating critical value)

FREQUENTLY ASKED QUESTIONS (FAQ)

What exactly is the value of $\sigma/\sqrt{n}$?

Report an error

PREVIOUS
Critical Value Method

NEXT
Summary

Standard Normal Probabilities

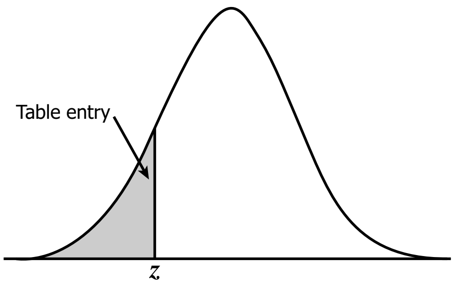


Table entry for z is the area under the standard normal curve to the left of z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
–3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
–3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
–3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
–3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
–3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
–2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
–2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
–2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
–2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
–2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
–2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
–2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
–2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
–2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
–2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
–1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
–1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
–1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
–1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
–1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
–1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
–1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
–1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
–1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
–1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
–0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
–0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
–0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
–0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
–0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
–0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
–0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
–0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
–0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
–0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

Standard Normal Probabilities

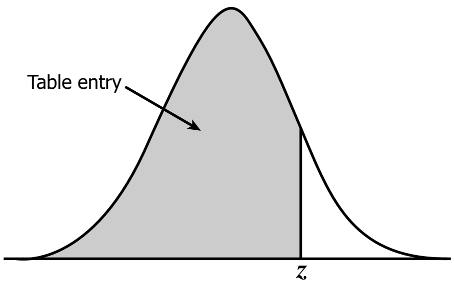


Table entry for z is the area under the standard normal curve to the left of z.

z	**.00**	**.01**	**.02**	**.03**	**.04**	**.05**	**.06**	**.07**	**.08**	**.09**
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

subsequent questions.

Z-table Download

Question 2/3 Mandatory

Critical Value Method

Consider this problem — H_0: $\mu \leq 350$ and H_1: $\mu > 350$

The next step would be to find the Zc, which would basically be the z-score for the value of 0.950. Look at the z-table and find the value of Zc.

- 1.64
- 1.645 ✓ Correct

  Feedback:

  0.950 is not there in the z-table. So, look for the numbers nearest to 0.950. You can see that the z-score for 0.9495 is 1.64 (1.6 on the horizontal bar and 0.04 on the vertical bar), and the z-score for 0.9505 is 1.65. So, taking the average of these two, the z-score for 0.9500 is 1.645.
- 1.65
- 1.96

Continue

subsequent questions.

Z-table Download

Question 3/3 Mandatory

Critical Value Method

Consider this problem, H_0: μ ≤ 350 and H_1: μ > 350

So, the Zc comes out to be 1.645. Now, find the critical value for the given Zc and make the decision to accept or reject the null hypothesis.

μ = 350 σ = 90 N (Sample size) = 36 $\bar{x}$= 370.16

- Critical value = 374.67 and Decision = Reject the null hypothesis
- Critical value = 326.25 and Decision = Reject the null hypothesis
- Critical value = 374.67 and Decision = Fail to reject the null hypothesis ✓ Correct

  Feedback:

  The critical value can be calculated from μ + Zc x (σ/$\sqrt{N}$). 350 + 1.645(90/$\sqrt{36}$) = 374.67. Since 370.16 ($\bar{x}$) is less than 374.67, $\bar{x}$ lies in the acceptance region and you fail to reject the null hypothesis.
- Critical value = 326.25 and Decision = Fail to reject the null hypothesis

against Sunshine or not, at 3% significance level.

Question 1/4 Mandatory

Critical Value Method

Select the correct null and alternate hypotheses in this case.

- H_0: Average lead content ≤ 2.6 ppm and H_1: Average lead content > 2.6 ppm
- H_0: Average lead content ≤ 2.5 ppm and H_1: Average lead content > 2.5 ppm ✓ Correct
  - Feedback:
    The null hypothesis is your assumption about the population — it is based on the status quo. It always makes an argument about the population using the equality sign. The null hypothesis in this case would be that the average lead content in the food material is less than or equal to 2.5 ppm. And the alternate hypothesis is that the average lead content is greater than 2.5 ppm.
- H_0: Average lead content ≥ 2.6 ppm and H_1: Average lead content < 2.6 ppm
- H_0: Average lead content ≥ 2.5 ppm and H_1: Average lead content < 2.5 ppm

Continue