

# How to Calculate Critical Values Easily in Google Sheets

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In the realm of statistical analysis, calculating the appropriate critical value is essential for conducting accurate hypothesis tests. When using powerful spreadsheet tools like **Google Sheets**, specific built-in functions simplify this process significantly. While older methods sometimes relied on functions like `T.DIST` to calculate percentiles, modern Google Sheets implementations provide more direct inverse functions, such as `T.INV` and `NORM.S.INV`, which are designed to return the precise critical value based on the specified probability and degrees of freedom (where applicable).

The critical value represents a threshold--a point of demarcation on the distribution curve--that determines whether we reject or fail to reject the null hypothesis. Understanding how to correctly input parameters such as the desired **confidence level** and the nature of the test (one-tailed versus two-tailed) is paramount for obtaining the correct result in your statistical calculations using Google Sheets.

This comprehensive guide will detail the appropriate functions and syntax required to calculate both **T-critical values** (derived from the Student's T-distribution) and **Z-critical values** (derived from the standard normal distribution) within the Google Sheets environment, accompanied by practical examples.

When conducting any form of hypothesis test, the output always includes a **test statistic**. The primary objective is to evaluate whether the evidence provided by this statistic is sufficient to declare the results as statistically significant. This determination is made by comparing the calculated **test statistic** to a predetermined **critical value**, which serves as the decision boundary.

The fundamental rule of hypothesis testing based on the critical value approach is straightforward: If the absolute magnitude of the calculated **test statistic** exceeds the calculated critical value, the observed difference is considered unlikely to have occurred by random chance alone, leading to the conclusion that the results are statistically significant.

## Choosing the Right Function for Critical Value Calculation

The choice between calculating a T-critical value or a Z-critical value depends primarily on the sample size and whether the population standard deviation is known. For situations involving small samples (typically  $n < 30$ ) or when the population standard deviation is unknown, the **T-distribution** is necessary. To find a **T-critical value** in Google Sheets, you will use inverse T-distribution functions which require both the probability (often the significance level, alpha, or 1-alpha) and the degrees of freedom (df).

The required syntax for calculating T-critical values in Google Sheets is as follows:

**T.INV**(probability, deg\_freedom) - This function returns the inverse of the Student's T-distribution for a specified probability and degrees of freedom. It is primarily used to find the T-critical value for

a **one-tailed t-test** (left-tailed or right-tailed).

**T.INV.2T**(probability, deg\_freedom) - This function is specifically designed to handle **two-tailed t-tests**. It calculates the inverse T-distribution based on the probability (alpha) distributed evenly across both tails.

Conversely, when dealing with large sample sizes ( $n \geq 30$ ) or when the population standard deviation is known, the **Z-distribution** (standard normal distribution) is the appropriate model. Finding a **Z-critical value** in Google Sheets uses functions that relate to the standard normal distribution, requiring only the probability parameter.

The required syntax for calculating Z-critical values in Google Sheets is as follows:

**NORM.S.INV**(probability) - This function returns the inverse of the standard normal cumulative distribution (Z-score) for a specified probability. It is used to find the critical value for a **one-tailed z-test**.

**NORM.S.INV**(probability/2) - For a **two-tailed z-test**, the input probability (alpha) must be halved before being input into the function, as the significance level is split equally between the upper and lower tails of the distribution.

The following examples provide detailed, step-by-step demonstrations showing how to utilize each of these critical statistical functions in practical scenarios within Google Sheets.

### Example 1: One-Tailed T-Test Critical Value Calculation

A common statistical requirement is determining the threshold for a directional test, such as a one-tailed test. For instance, imagine a scenario where we are conducting a left-tailed test with a strict significance level (alpha) set at 0.05, and our sample size yields degrees of freedom equal to 11 ( $df = n - 1$ ). The **T.INV** function is perfectly suited for this calculation.

Since **T.INV** calculates the inverse cumulative probability from the left tail, we can directly input our significance level (0.05) as the probability argument for a left-tailed test. The formula entered into Google Sheets would be: `=T.INV(0.05, 11)`. This formula asks Google Sheets to find the T-score below which 5% of the distribution area lies, given 11 degrees of freedom.

To find the t-critical value for a left-tailed test with a significance level of 0.05 and degrees of freedom = 11, we can type the following formula into Google Sheets:

	A	B	C	D
A1	$\text{=T.INV}(0.05, 11)$			
1	-1.795884819			
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				

Upon execution, the calculation reveals the **t-critical value** is **-1.79588**. Any calculated **test statistic** less than this value (i.e., further into the negative rejection region) would lead to the rejection of the null hypothesis.

### Example 2: Two-Tailed T-Test Critical Value Calculation

For scenarios where we are testing for differences in either direction (greater or less than the null hypothesis value), a **two-tailed test** is required. This means the total significance level (alpha) must be split evenly between the two tails of the T-distribution.

Let us use the same parameters as before: a significance level of 0.05 and degrees of freedom (df) equal to 11. Since we are using a two-tailed test, the **T.INV.2T** function simplifies the process by automatically distributing the probability across both tails. We input the full alpha value (0.05) directly into the function.

To find the t-critical value for a two-tailed test with a significance level of 0.05 and degrees of freedom = 11, we can type the following formula into Google Sheets:

A1	$\text{fx}$	<code>=T.INV.2T(0.05, 11)</code>			
	A	B	C	D	E
1	2.20098516				
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					

The output of the function provides the positive critical value (the boundary of the upper rejection region). The resulting **critical value** is **2.200985**. Due to the symmetry of the T-distribution, the lower critical value will be the negative counterpart, -2.200985. We reject the null hypothesis if the absolute value of the **test statistic** is greater than 2.200985.

### Example 3: One-Tailed Z-Test Critical Value Calculation

Z-tests are utilized when the population parameters are well-established or when dealing with sufficiently large samples, allowing us to approximate the distribution using the standard normal distribution. In this case, the concept of degrees of freedom is not applicable, simplifying the function input. We use the **NORM.S.INV** function, which finds the inverse of the standard normal cumulative distribution (the Z-score associated with a specific cumulative probability).

Consider finding the Z-critical value for a left-tailed test at a significance level (alpha) of 0.05. Since **NORM.S.INV** calculates the Z-score corresponding to the cumulative area from the far left, we input the alpha value directly. The formula is straightforward: `=NORM.S.INV(0.05)`. This calculation identifies the Z-score cutoff where 5% of the data falls below it.

To find the z-critical value for a left-tailed test with a significance level of 0.05, we can type the following formula into Google Sheets:

	A	B	C	D
A1	$\text{=NORM.S.INV}(0.05)$			
1	-1.644853625			
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
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18				
19				

The resulting **Z-critical value** is **-1.64485**. This is a very commonly cited value in statistics, often rounded to -1.645, and it delineates the critical boundary for a 5% one-tailed test on the Z-distribution.

### Example 4: Two-Tailed Z-Test Critical Value Calculation

When conducting a two-tailed Z-test, the total significance level (alpha) must be divided equally between the two tails. If our alpha is 0.05, then 0.025 (2.5%) belongs in the far left tail and 0.025 (2.5%) belongs in the far right tail.

To correctly use the **NORM.S.INV** function, which is inherently left-cumulative, we must find the Z-score corresponding to the cumulative probability of the lower tail (0.025) or the upper boundary (0.975). The simplest approach is to calculate the Z-score for the lower tail by inputting  $\text{alpha}/2$ . The formula becomes:  $\text{=NORM.S.INV}(0.05/2)$ .

To find the z-critical value for a two-tailed test with a significance level of 0.05, we can type the following formula into Google Sheets:

	A	B	C	D
A1	$\text{=NORM.S.INV}(0.05/2)$			
1	-1.959963986			
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
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The resulting **Z-critical value** for the lower tail is **-1.96**. Due to the symmetry of the Z-distribution, the upper critical value is +1.96. These boundaries (-1.96 and +1.96) are the classic cutoffs for a 95% confidence interval or a 5% two-tailed test.

## Differentiating Between T-Critical and Z-Critical Values

It is vital for accurate statistical work to understand when to apply the T-distribution versus the Z-distribution. The T-distribution, characterized by its heavier tails, is used when we must estimate the population standard deviation from the sample standard deviation, introducing greater uncertainty. This uncertainty is reflected in the requirement for the degrees of freedom parameter. For a given significance level, the T-critical value will always be slightly further from zero than the Z-critical value, especially for small sample sizes.

As the degrees of freedom increase (i.e., as the sample size grows larger), the shape of the T-distribution gradually approaches the shape of the Z-distribution (standard normal distribution). Once the sample size is large enough (often cited as  $n > 30$ ), the difference between the T-critical and Z-critical values becomes negligible, and the Z-test is often used as a simplification. Google Sheets correctly handles the nuanced calculations for both using the functions discussed above.

## Cautions on Finding Critical Values in Google Sheets: Error Handling

While the Google Sheets functions **T.INV()**, **T.INV.2T()**, and **NORM.S.INV()** are highly reliable, they are strict about the format and range of their input arguments. Failing to adhere to these constraints will result in a **#NUM!** or **#VALUE!** error, halting your hypothesis test calculation.

Note that the **T.INV()**, **T.INV.2T()**, and **NORM.S.INV()** functions will throw an error if any of the following critical conditions occur:

If any argument supplied to the function (whether it is the probability or the degrees of freedom) is non-numeric, such as text or symbols.

If the value provided for the probability argument is invalid, meaning it is less than zero (probability must be non-negative) or greater than 1 (as probability cannot exceed 100%).

If the value specified for the *deg\_freedom* argument (applicable only to T-functions) is less than 1, as the concept of degrees of freedom fundamentally requires at least one independent observation.

Always ensure that your inputs are valid decimal numbers between 0 and 1 for probability, and positive integers greater than zero for the degrees of freedom, to achieve accurate and clean calculation of the critical value.

By mastering these specific inverse distribution functions--**T.INV**, **T.INV.2T**, and **NORM.S.INV**--you can efficiently determine the statistical thresholds necessary for sound decision-making in any quantitative analysis project within Google Sheets.