How to Use the Z Table (With Examples)

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The Z table, formally recognized as the Standard Normal Table, is an indispensable statistical tool. This table systematically maps the cumulative probability associated with a specific z-score within a standard normal distribution. Essentially, it quantifies the percentage of data values that fall below a given z-score. Understanding and utilizing the Z table is fundamental for professionals across various fields, including finance, engineering, and the social sciences, as it provides the foundation for determining probabilities in datasets that follow a normal distribution.

In applied statistics, the Z table serves several critical functions. It is frequently employed when calculating probabilities for normally distributed variables, which is a prerequisite for more complex statistical procedures. Primary applications include conducting hypothesis testing, constructing confidence intervals, and performing various other parametric statistical tests. The process always begins by transforming a raw data point (X) into its corresponding z-score. This transformation standardizes the data, allowing the universal table to be used regardless of the original mean or standard deviation of the population.

Defining the Z Table and the Standard Normal Distribution

The core function of the Z table is to link a specific z-score--which represents a distance in terms of standard deviations--to the cumulative area under the probability density function of the standard normal distribution. This area represents the probability that a randomly selected observation will fall below that particular score. Since the total area under the curve is always equal to 1 (or 100%), the values listed in the table are direct probabilities or percentages.

The standard normal distribution itself is a special case of the normal distribution where the **population mean (μ)** is set to zero (0) and the **population standard deviation (σ)** is set to one (1). This standardization is why the Z table is so powerful; any normally distributed variable can be converted into a standard normal variable (a z-score), allowing us to use a single, pre-calculated table for probability determination. This transformation simplifies complex calculations and enables consistent comparison across different datasets.

It is essential to recognize that the Z table, in its most common form, is a **cumulative probability table**. This means it always reports the area from the far left tail of the distribution up to the specified Z value. When tackling problems that require finding probabilities above a score, or probabilities between two scores, simple subtraction or addition techniques must be applied, leveraging this cumulative property.

Understanding the Z-Score Formula

Before referencing the Z table, the initial and most crucial step is calculating the z-score associated with the raw data value of interest. The z-score, also known as the standard score, provides a standardized measure of how far a specific data point lies from the **population mean**. It achieves this by expressing the distance in units of **standard deviation**.

If the calculated z-score is positive, the data point lies above the mean; if it is negative, the data point lies below the mean. A z-score of zero indicates that the data point is exactly equal to the mean. The magnitude of the score represents the statistical rarity of that observation. The formula for calculating this essential metric is straightforward:

z-score = (x - μ) / σ

The symbols in this formula carry specific statistical meanings:

x: This variable represents the **individual data value** or the raw score for which the probability is being sought.
μ **(mu):** This symbol denotes the **population mean**, which is the average value of all observations within the entire population.
σ **(sigma):** This symbol signifies the **population standard deviation**, measuring the typical amount of variation or dispersion from the mean within the population.

Mastering this transformation is non-negotiable for accurate statistical analysis using the Z table. Once the z-score is derived, we can proceed to the lookup stage, where the probability is determined. The remainder of this tutorial will walk through practical examples demonstrating this entire process, from data transformation to probability interpretation.

Interpreting the Z Table Structure

The structure of the Z table is specifically designed to facilitate the rapid determination of cumulative probabilities. Typically, the left column of the table lists the **z-score** up to the first decimal place (e.g., 1.5, -0.3, 2.1). The top row of the table then displays the second decimal place of the **z-score** (e.g., .00, .01, .02, ..., .09).

To find the probability associated with a calculated **z-score**, say 1.57, one must locate 1.5 in the left column of the Z table and then move across that row until reaching the column labeled .07. The intersection of this row and column provides the cumulative probability, expressed as a decimal (e.g., 0.9418), which corresponds to 94.18%. This value signifies that 94.18% of observations in the standard normal distribution fall below a z-score of 1.57.

It is crucial to be aware that Z tables often come in two forms: those that show the area to the left of Z (cumulative probability, the most common form) and those that show the area between the mean (Z=0) and the calculated Z. Our examples will focus on the **cumulative probability (Area to the Left)** table, as this is the standard required for precise hypothesis testing and the construction of confidence intervals. Always verify the specific convention used by your reference table to ensure correct interpretation.

Example 1: Calculating the Area to the Left

This first example illustrates the most direct application of the Z table: finding the probability that a random variable falls below a specific raw score. Consider a scenario involving a **college entrance exam** where scores are **normally distributed**. The **population mean (μ)** is 82, and the **population standard deviation (σ)** is 8. The objective is to determine the approximate percentage of students who score less than 84 on this rigorous exam.

Step 1: Calculate the Z-score. We must first convert the raw score (x = 84) into a z-score using the standardization formula. This tells us exactly how many standard deviations 84 is away from the mean of 82.

z-score = (x - μ) / σ = (84 - 82) / 8 = 2 / 8 = **0.25**

A **z-score** of 0.25 indicates that the score of 84 is 0.25 standard deviations above the mean score. Because we are looking for scores **less than** 84, we are seeking the cumulative probability associated with Z = 0.25.

Step 2: Use the Z Table to find the corresponding probability. We locate the value 0.2 in the left column of the Z table and follow that row to the column corresponding to 0.05. The intersection provides the cumulative area.

z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545

The table value for Z = 0.25 is 0.5987. Converting this decimal probability to a percentage, we conclude that approximately **59.87%** of students score less than 84 on this particular entrance exam. This demonstrates a direct lookup, where the z-score calculation yields the exact value needed for table reference.

Example 2: Determining the Area to the Right (Greater Than)

This example introduces a variation where we must calculate the probability of a value falling **above** a certain point, requiring an extra step in interpretation. Suppose the height of plants in a garden follows a normal distribution with a **mean (μ)** of 26.5 inches and a **standard deviation (σ)** of 2.5 inches. We aim to find the percentage of plants that are greater than 26 inches tall.

Step 1: Calculate the Z-score. We standardize the raw score (x = 26 inches) to determine its position relative to the mean.

z-score = (x - μ) / σ = (26 - 26.5) / 2.5 = -0.5 / 2.5 = **-0.2**

The resulting **negative z-score** (-0.2) confirms that 26 inches is slightly below the population mean of 26.5 inches.

Step 2: Use the Z Table to find the cumulative percentage. We look up the z-score of -0.20 in the Z table.

z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
-2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
-2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
-2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
-2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
-2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
-2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
-2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
-2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
-2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
-2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
-1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
-1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
-1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
-1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
-1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
-1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
-1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
-1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
-1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
-1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
-0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
-0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
-0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
-0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
-0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
-0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
-0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

The table lookup reveals a cumulative probability of 0.4207, meaning **42.07%** of values fall **below** a z-score of -0.2. Since the question asks for the percentage of plants **greater than** 26 inches, we must utilize the complement rule. The total probability under the curve is 1 (or 100%). We subtract the area found from 100%: 100% - 42.07% = **57.93%**.

Therefore, approximately **57.93%** of the plants in this garden are greater than 26 inches tall. This methodology is crucial when calculating probabilities related to the upper tail of the standard normal distribution.

Example 3: Calculating Probability Between Two Specific Values

This final, more complex example demonstrates how the Z table is used to determine the probability or percentage of observations falling within a specified range. Suppose the weight of a particular species of dolphin is **normally distributed**, featuring a **mean (μ)** of 400 pounds and a **standard deviation (σ)** of 25 pounds. We want to find the percentage of dolphins whose weight falls between 410 pounds and 425 pounds.

Step 1: Calculate two Z-scores. Since we are dealing with an interval, we must calculate a separate z-score for both the lower limit (x1 = 410) and the upper limit (x2 = 425).

For 410 pounds: z-score = (410 - 400) / 25 = 10 / 25 = **0.4**

For 425 pounds: z-score = (425 - 400) / 25 = 25 / 25 = **1.0**

These two **z-scores** define the boundaries of the area we seek under the standard normal curve.

Step 2: Look up the cumulative percentages in the Z Table. We must find the cumulative area corresponding to both Z=1.0 and Z=0.4.

First, we will look up the value **0.4**:

z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706

Then, we will look up the value **1**:

z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706

Step 3: Determine the intermediate area through subtraction. To isolate the area between these two scores, we subtract the smaller cumulative area (Area below Z=0.4, which is 0.6554) from the larger cumulative area (Area below Z=1.0, which is 0.8413): **0.8413 - 0.6554 = 0.1859**.

Thus, approximately **18.59%** of dolphins in this population weigh between 410 and 425 pounds. This method of subtraction is standard practice when solving interval probability problems in the context of the normal distribution.

Advanced Applications in Statistical Inference

While calculating raw probabilities is the most direct use of the Z table, its true importance lies in statistical inference. The Z distribution is critically utilized in situations where the sample size is large (typically n > 30) or when the population **standard deviation** is known, particularly when conducting two powerful types of analyses: hypothesis testing and the creation of confidence intervals.

In hypothesis testing, we use the Z table to find the critical Z values or to determine the p-value associated with a calculated test statistic. For example, if a researcher sets an alpha level (significance level) of 0.05 for a two-tailed test, they would use the Z table to find the critical Z values (e.g., ±1.96) that define the rejection regions. The Z table provides the probability needed to make decisions regarding the null hypothesis, helping researchers determine if observed data is statistically significant.

Similarly, in constructing confidence intervals, the Z table is instrumental in identifying the margin of error. A confidence interval provides a range of values within which the true population parameter is expected to lie with a certain degree of probability (e.g., 95% or 99%). The specific Z-score taken from the table--known as the **Z-critical value**--corresponds directly to the desired level of confidence. For a 95% confidence level, the Z-critical value is 1.96, extracted directly from the area lookup process in the Z table.

Summary and Key Takeaways

The Z table is an indispensable resource for anyone working with normally distributed data, providing a unified approach to calculating probabilities across diverse datasets. The central concept relies on the principle of **standardization**, converting any raw score into a z-score that reflects its distance from the mean in standard deviation units.

To efficiently utilize this statistical tool, remember the following critical steps and principles:

Standardization is Required: Always convert the raw score (x) into a Z-score using the formula $Z = (x - \mu) / \sigma$ before consulting the table.
The Table is Cumulative: Unless otherwise specified, the Z table reports the area to the left of the Z-score.
Area to the Right: If calculating the probability of a score being greater than Z, use the complement rule: 1 - P(Area to the Left).
Area Between Two Values: If calculating the probability between Z1 and Z2, find P(Area to the Left of Z2) and subtract P(Area to the Left of Z1).

By following these steps, you can accurately derive probabilities for real-world scenarios, transforming complex statistical problems into manageable table lookups and simple arithmetic operations.