

Standard Normal Table Review

by Sophia



WHAT'S COVERED

This tutorial will review the standard normal table. Our discussion breaks down as follows:

1. Standard Normal Table

1a. Percent Below a Z-Score

1b. Percent Above a Z-Score

1c. Percent Between Two Z-Scores

1d. Percent Outside Two Z-Scores

1. Standard Normal Table

The **standard normal table** is the table that is used when you have a normal distribution, and you want to find probabilities or percent. The table can be used actually to do four things.

1. The table value itself gives you the percent of observations below a particular z-score.
2. You can find the percent above a particular z-score by subtracting the table value from 100% because the table value always gives the area to the left.
3. You can find the percent of observations between two z-scores by subtracting the table values.
4. You can find the percent of values outside of two z-scores by finding both the percent above the higher number and the percent below the lower number, which is sort of a combination of these other options.



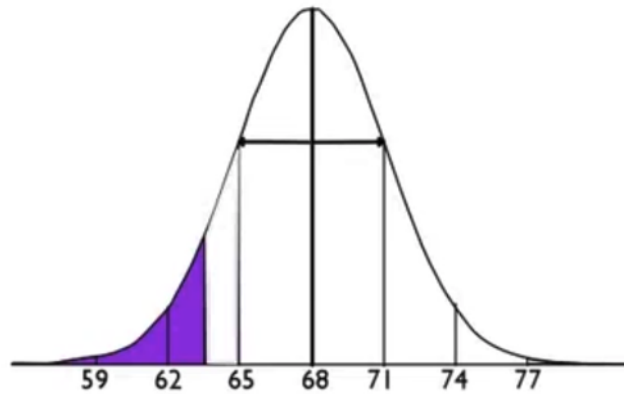
TERM TO KNOW

Standard Normal Table

A table showing the values of the cumulative distribution function of the standard normal distribution.

1a. Percent Below a Z-Score

Suppose you want to know the percent of men who are shorter than 63.5 inches. Men's heights are normally distributed with a mean of 68 inches and a standard deviation of 3 inches. Using this distribution, 63.5 falls right between 62 and 65.



First we need to find the z-score by using the following formula:

$$z = \frac{x - \mu}{\sigma}$$

x = given value = 63.5 inches

μ = mean = 68 inches

σ = standard deviation = 3 inches

$$z = \frac{63.5 - 68}{3} = \frac{-4.5}{3} = -1.5$$

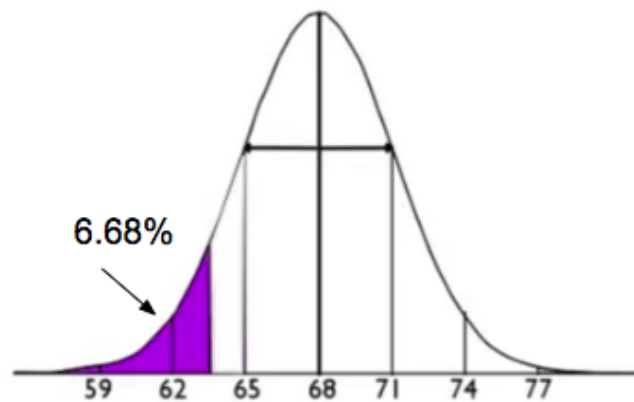
The z-score ends up being negative 1.5; it's 1.5 standard deviations below the mean of 68.

You can use the negative z-score table, and go to the negative 1.5 row and the zero hundredths column, and find that the probability is 0.0668.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
-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	0.0017	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

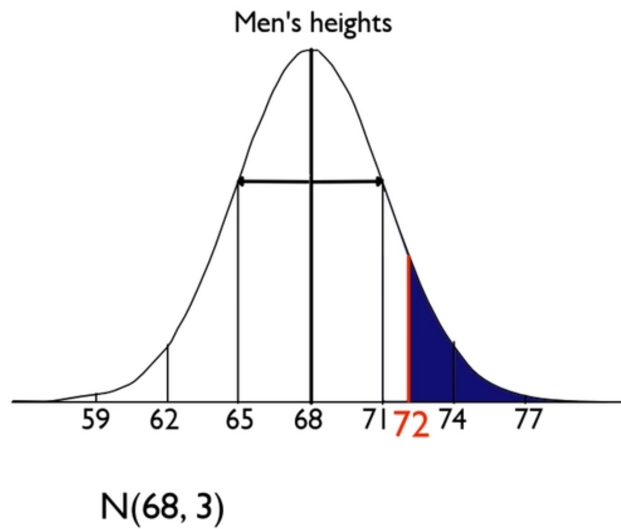
This means that about 7% of men are shorter than 63.5 inches.



1b. Percent Above a Z-Score

This example focuses on men taller than 72 inches. Again, we will use the same information that says men's heights are normally distributed with a mean of 68 inches and a standard deviation of 3 inches. What percent of men are over six feet tall?

Here's the normal distribution. 72 inches is the cutoff value, and you want the percent of men that are taller than that.



To find this z-score, use the following formula:

$$z = \frac{x - \mu}{\sigma}$$

$x = \text{given value} = 72 \text{ inches}$

$\mu = \text{mean} = 68 \text{ inches}$

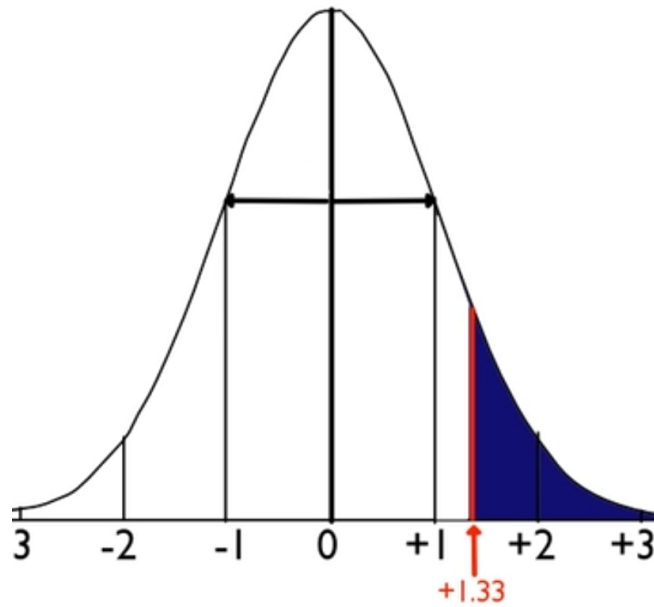
$\sigma = \text{standard deviation} = 3 \text{ inches}$

$$z = \frac{72 - 68}{3} = \frac{4}{3} = 1.33$$

The 72 inches standardizes to positive 1.33 for a z-score.

We can also take the normal distribution, centered at 68 with a standard deviation of 3, and convert it into the standard deviation of 1 and mean of zero. The image below is called the standard normal curve.

Men's heights (standardized)



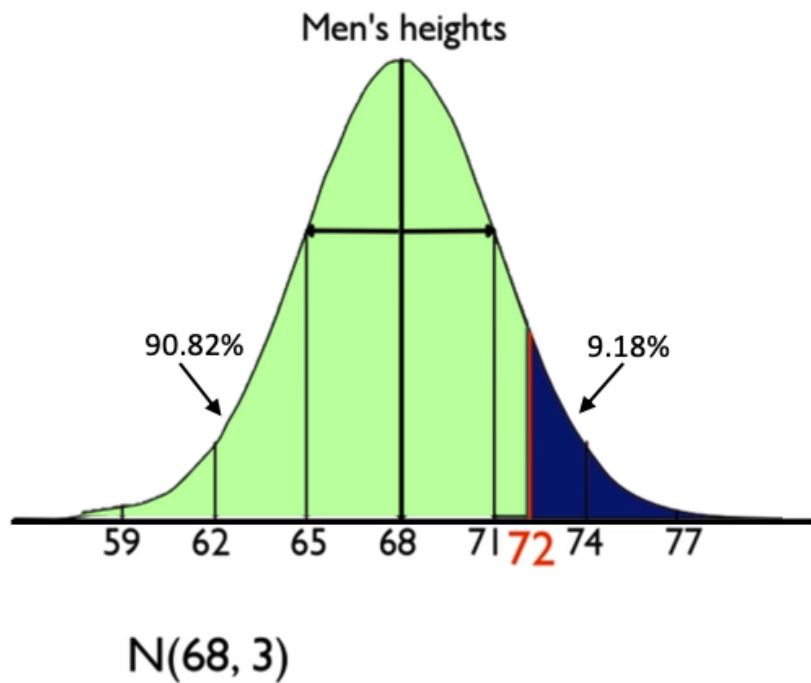
$$N(68, 3) \longrightarrow N(0, 1)$$

Our z-score was positive 1.33, so you will look in the positive z-score table. Positive z-scores deal with the tenths place and the hundredths place. Because your z-score was positive 1.33, you will go to the 1.3 row (tenths) and the 0.03 column (hundredths).

z	0.00	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
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At that intersection, you will find 0.9082, which is the area to the *left* of 1.33. But, the question was asking the area above so now you simply subtract from 100%.

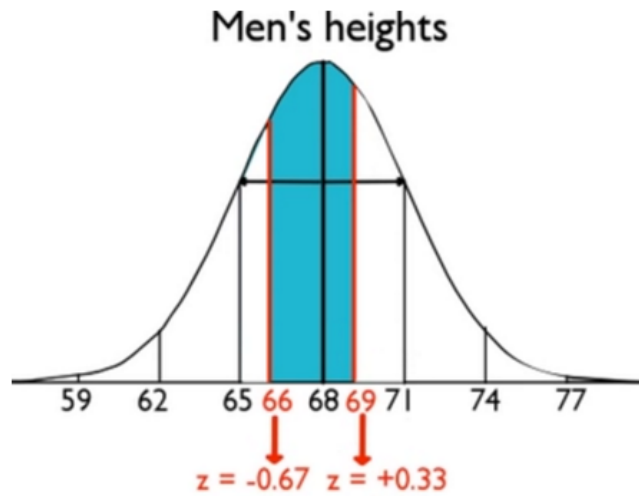


$$\begin{aligned}
 &P(\text{Height} > 72 \text{ inches}) \\
 &= 100\% - P(\text{Height} < 72 \text{ inches}) \\
 &= 100\% - P(z < 1.33) \\
 &= 1 - 0.9082 \\
 &= 0.0918
 \end{aligned}$$

This tells us that 9.18% of adult men have heights over 72 inches.

1c. Percent Between Two Z-Scores

You can do another type of problem, which is finding the area between two values, such as 5'6" and 5'9", or 66 inches and 69 inches.



Something like this is a little trickier. When you standardize the values of 66 and 69, you end up with these two z-scores.

$$z = \frac{x - \mu}{\sigma}$$

$x = \text{given value} = 66 \text{ inches}$

$\mu = \text{mean} = 68 \text{ inches}$

$\sigma = \text{standard deviation} = 3 \text{ inches}$

$$z = \frac{66 - 68}{3} = \frac{-2}{3} = -0.67$$

$x = \text{given value} = 69 \text{ inches}$

$\mu = \text{mean} = 68 \text{ inches}$

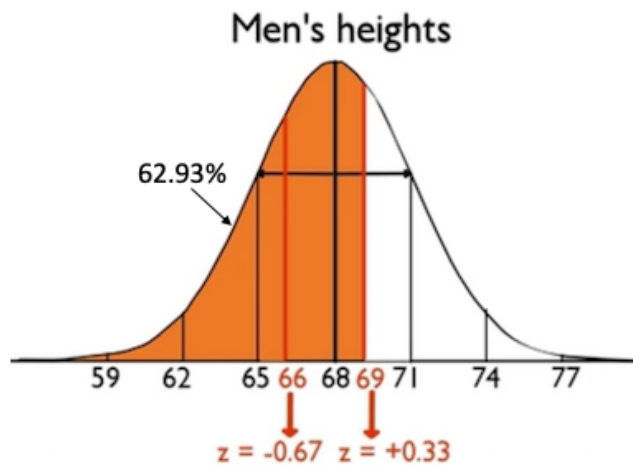
$\sigma = \text{standard deviation} = 3 \text{ inches}$

$$z = \frac{69 - 68}{3} = \frac{1}{3} = 0.33$$

To find the probability of the area between these two numbers, you actually need to find the probabilities of both z-scores.

First, for the area corresponding to the z-score of positive 0.33, look in the positive z-score table at 0.3 row and 0.03 column to find that the orange area shown below is 0.6293.

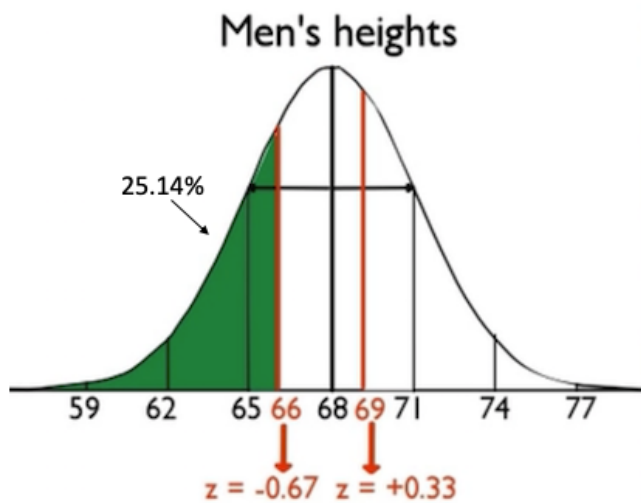
<i>z</i>	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	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



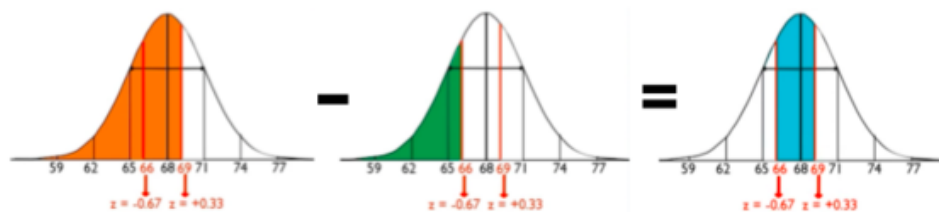
Now, we need to consider our second z-score, negative 0.67. When you look at the negative z-score table for the negative 0.67 z-score, you find that its probability in the negative 0.6 row and the 0.07 column is 0.2514, shown in the green area below.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
-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	0.0017	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



The area between 66 inches and 69 inches is the area below the 0.33 z-score but not below the -0.67 z-score. Therefore, we need to subtract the orange area by the green area to obtain the area between the two values, shown in blue below.

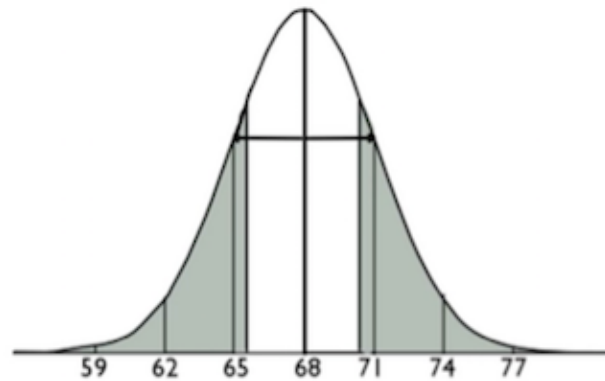


$$\begin{aligned}
 &P(\text{Height} < 69 \text{ inches}) - P(\text{Height} < 66 \text{ inches}) \\
 &= P(z < 0.33) - P(z < -0.67) \\
 &= 0.6293 - 0.2514 \\
 &= 0.3779
 \end{aligned}$$

The orange area is equal to 0.6293, the green area is equal to 0.2514, so 0.6293 minus 0.2514 is 0.3779, which tells us that about 38% of men are between those two heights.

1d. Percent Outside Two Z-Scores

Lastly, you can find the area outside of a particular region. What percent of men are not within 2.5 inches of the mean of 68; in other words, what percent of men are not within 65.5 inches and 70.5 inches? What does this one look like? It looks like this, where this grey area is the particular area that we want.



All you do is add the two probabilities of the area below 65.5 and the area above 70.5. First, convert both of these to z-scores.

$$z = \frac{x - \mu}{\sigma}$$

$$\begin{aligned} x &= \text{given value} = 65.5 \text{ inches} \\ \mu &= \text{mean} = 68 \text{ inches} \\ \sigma &= \text{standard deviation} = 3 \text{ inches} \\ z &= \frac{65.5 - 68}{3} = \frac{-2.5}{3} = -0.83 \end{aligned}$$

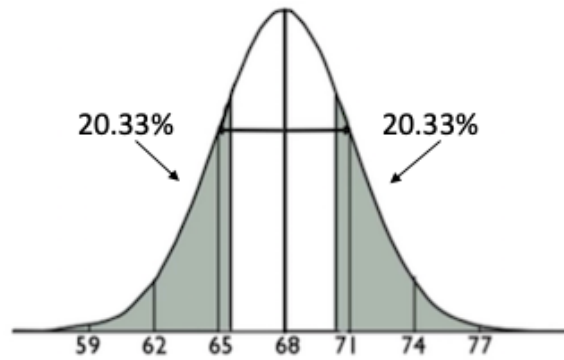
$$\begin{aligned} x &= \text{given value} = 70.5 \text{ inches} \\ \mu &= \text{mean} = 68 \text{ inches} \\ \sigma &= \text{standard deviation} = 3 \text{ inches} \\ z &= \frac{70.5 - 68}{3} = \frac{2.5}{3} = 0.83 \end{aligned}$$

We get z-scores of negative 0.83 and positive 0.83. Now, since these two values are the same distance away from the mean and because of the symmetry of the normal curve, you can actually just find one of these two areas and double it. In general, you wouldn't be able to do that if they were different differences from the mean. Let's find the probability of negative 0.83 in the table.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
-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	0.0017	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

You would find the area below the negative 0.83 z-score, which is 0.2033. Normally you would find the area above the positive 0.83 z-score, but you don't have to do that, because it's the same as the area below the negative 0.83 z-score. Just use the symmetry and double it to obtain about 41% of men being outside that range.



$$\begin{aligned} &P(\text{Height} < 65.5) + P(\text{Height} > 70.5) \\ &= P(z < -0.83) + P(z > 0.83) \\ &= 0.2033 + 0.2033 \\ &= 0.4066 \end{aligned}$$



SUMMARY

It's possible to use the standard normal table to find the percent of values above or below a particular value, or between two values, or even outside two values, using z-scores on the normal distribution. The normal probability table, also called the z-table or the standard normal table, can find these percents by finding the percent of values below a certain z- score, and subtract as necessary.

Good luck!

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TERMS TO KNOW

Standard Normal Table

The table that allows us to find the percent of observations below a particular z-score in the normal distribution.