

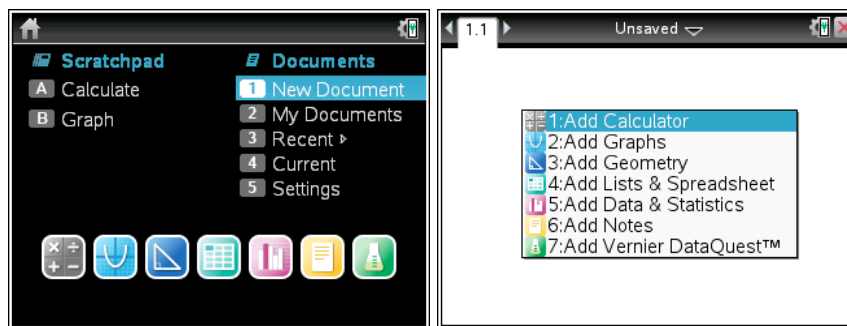
## Using Your TI-NSpire Calculator: Normal Distributions

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Statistics I

Always start by drawing a sketch of the normal distribution that you are working with. Shade in the relevant area (probability), and label the mean, standard deviation, lower bound, and upper bound that you are given or trying to find. Don't worry about making your drawing to scale; the purpose of the sketch is to get you thinking clearly about the problem you are trying to solve. For illustration purposes, let's consider the distribution of adult scores on the Weschler IQ test. These IQ scores are normally distributed with  $\mu = 100$  and  $\sigma = 15$ .

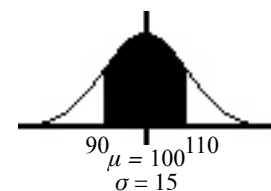
### Using the normCdf command

The `normCdf` command is used for finding a specified area under a normal density curve. The syntax used is `normCdf(lowerbound, upperbound,  $\mu$ ,  $\sigma$ )`. The resulting area corresponds to the probability of randomly selecting a value between the specified lower and upper bounds. You can also interpret this area as the percentage of all values that fall between the two specified boundaries. This command can be typed directly or accessed via menus on the TI-NSpire.



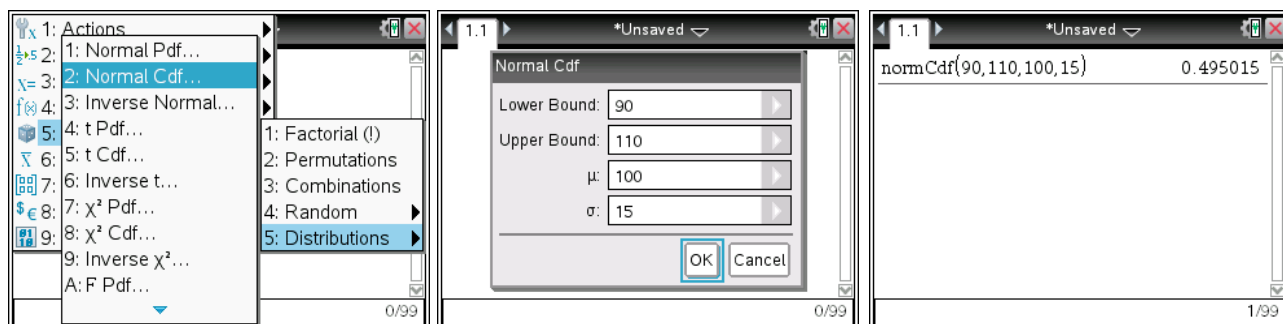
1. Create a new document from the home screen of your TI-NSpire and choose option **1: Add Calculator**.

2. Let's find the percentage of adults who score between 90 and 110 on the Weschler IQ test. Begin by sketching the distribution and labeling the relevant information. We are ultimately trying to find the area under the normal density curve that is bounded by 90 and 110, so shade in that area on your sketch.

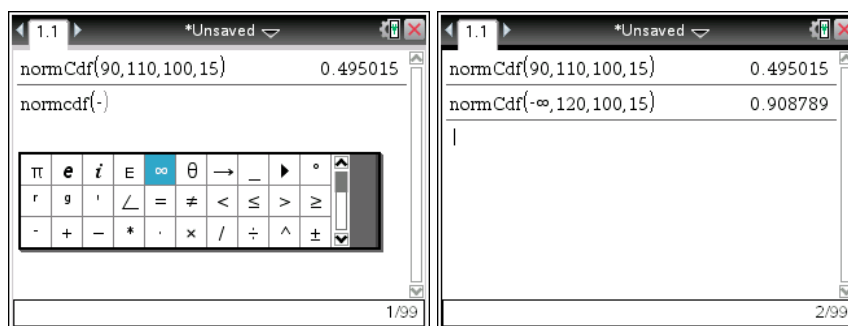


3. Press the `menu` key and select **5: Probability** followed by **5: Distributions**.

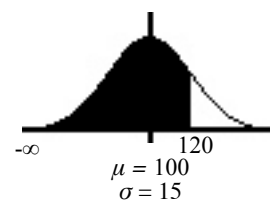
Highlight **2: Normal Cdf** and press `enter`. You will be prompted for the two  $x$  values that form the lower and upper boundaries of the area that you are trying to find, the population mean, and the population standard deviation. Alternatively, you can type `normcdf(90, 110, 100, 15)` directly on the command line instead of using menus.



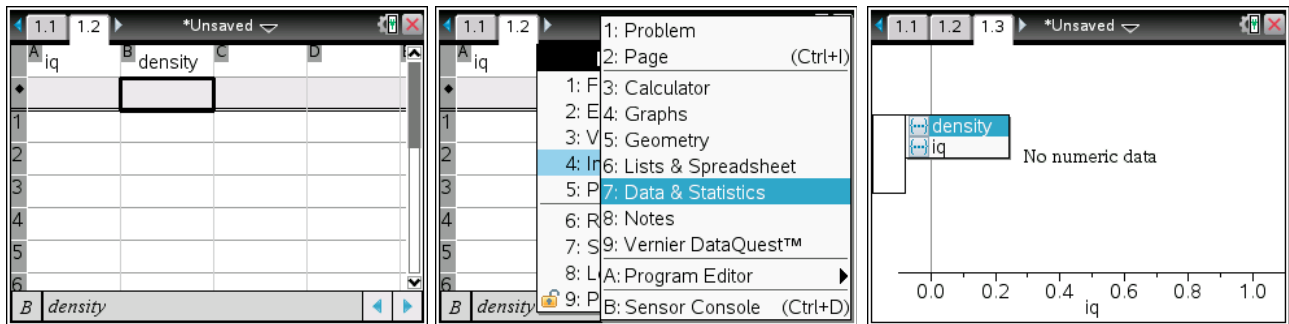
4. Your calculator will return the area under the normal curve bounded by 90 and 110. Thus, we find that 49.5% of adults score between 90 and 110 on the Weschler IQ test. *Remember to round percentages to three significant figures.*
5. What is the probability that a randomly selected adult scores less than 120 on the Weschler IQ test? Problems like this are a bit trickier because your calculator requires both a lower bound and an upper bound. What is the lower bound in this case? (You may have noticed that your calculator uses  $-\infty$  as the default lower bound when you use menus to access the `normCdf` command, which is helpful for problems like this one.)



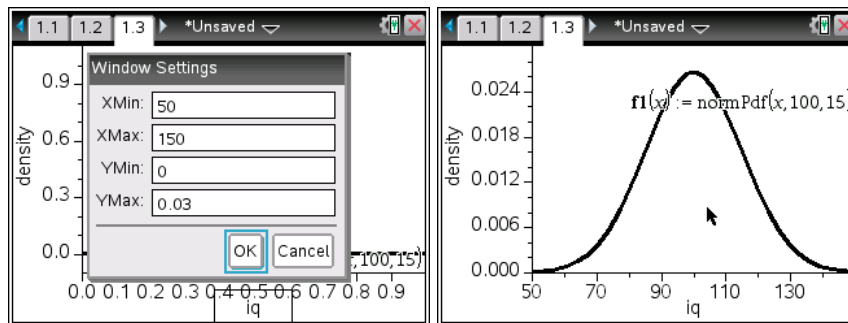
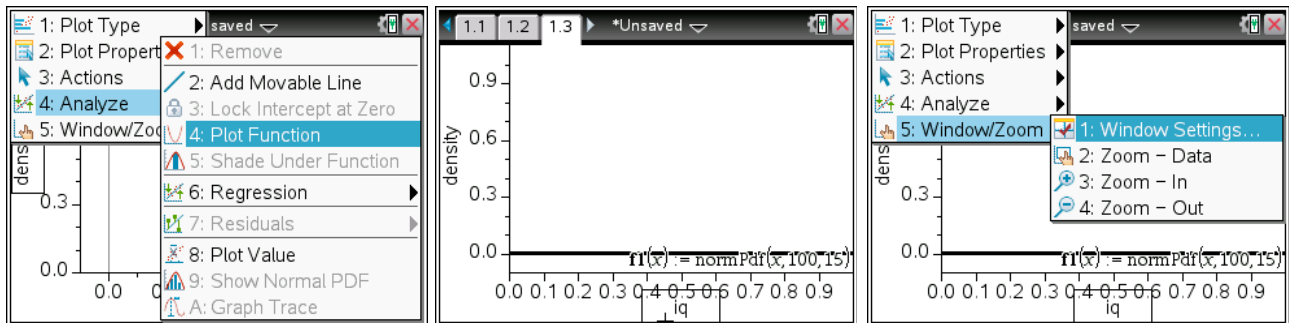
6. Start by drawing a sketch. This time, try typing in the command `normcdf(-∞,120,100,15)` directly into the calculator rather than using the menus. You can type the infinity symbol by pressing `ctrl` `□` to access a menu of special symbols. (Be sure to use the `(-)` key to specify a negative sign rather than the subtraction key.) We find that the probability of randomly selecting an adult whose IQ is below 120 is 0.909. In symbols,  $P(x < 120) = 0.909$ . *Remember to round probability values to 3 significant figures.*



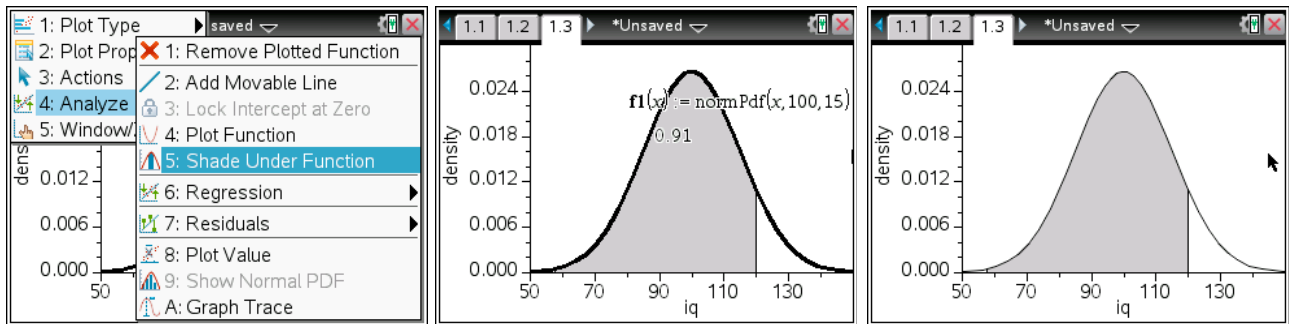
7. It is a bit tedious to graph a normal distribution on a TI-Nspire, but it can be done. Let's try plotting the adult Weschler IQ distribution and shading in the area for the previous example. Press `docv` and then select **4: Insert** followed by **6: Lists & Spreadsheets**. Name list A *iq* and list B *density*. Then, press the `docv` key again and select **4: Insert** followed by **7: Data & Statistics**. Click at the bottom the graph window that appears, and identify the *x*-axis variable as *iq*. Identify the *y*-axis variable as *density*.



8. Press the **menu** key and select **4: Analyze** followed by **4: Plot Function**. Type in  $\text{normPdf}(x, 100, 15)$  and press **enter**. You will need to change the window settings so that the graph is actually readable. To do this, press **menu** and select **5: Window/Zoom** followed by **1: Window Settings**. Experiment until you find the settings that result in the best graph. As a rule of thumb, pick Xmin and Xmax values that are a bit more than three standard deviations below and above the mean, respectively. You can get an idea of what to use for YMax by looking at the initial graph; Ymin should always be 0.

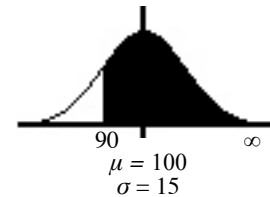


9. We can now shade in the area corresponding to  $P(x < 120)$  or any other desired probability. Press the **menu** key and select **4: Analyze** followed by **5: Shade Under Function**. Use the touch pad to select your desired lower limit and click **▢**. Then, move to your desired upper limit and click on **▢** again. You'll notice that you can only click on the approximate limits; hence, the numerical value that is returned along with the shaded graph is only an approximation of the actual area you were trying to find. In this case, 0.91 is a pretty good approximation of  $P(x < 120)$ . However, you should not rely on using a graph to find areas under the normal curve; the results obtained using the  $\text{normCdf}$  command are much more accurate. Click anywhere on the screen to hide the function.

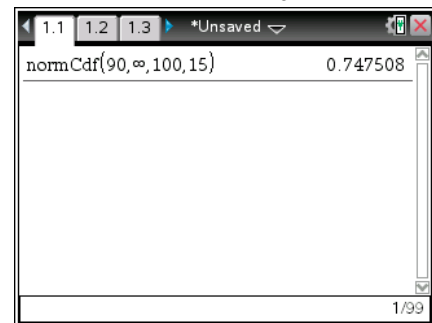


10. What percentage of adults score at least 90 on the Weschler IQ test?

Because your calculator requires both a lower bound and an upper bound, you will need to use  $\infty$  for your upper bound. Hence, the syntax for problems of this sort is `normCdf(lowerbound,  $\infty$ ,  $\mu$ ,  $\sigma$ )`.



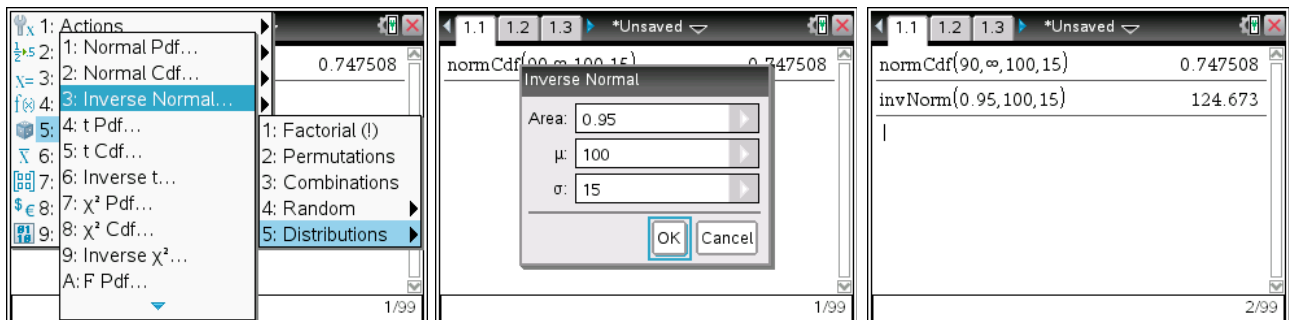
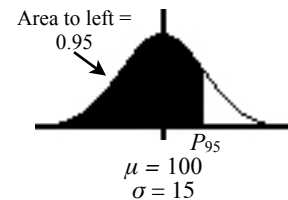
11. Start by drawing a sketch. Go back to the calculator screen (1.1) and enter the command `normcdf(90,  $\infty$ , 100, 15)` either directly or by navigating through the relevant menus on your TI-Nspire.
12. We find that 74.8% of adults score at least 90 on the Weschler IQ test. Remember to round to 3 significant figures.



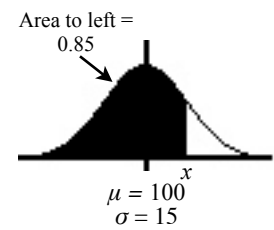
### Using the `invNorm` command

Use the `invNorm` command when you are given a probability or percentage and asked to find an  $x$  value. This command is often used to find values corresponding to percentiles or quartiles. Your calculator requires that you enter the cumulative area to the left of the desired value; drawing a sketch is very useful for making sure you enter the correct area. Sometimes you will need to work with an area other than the one specified by the problem.

- Let's start by finding the IQ score corresponding to the 95<sup>th</sup> percentile ( $P_{95}$ ). Begin by drawing a sketch and labeling it.
- Press `menu` and select **5: Probability** followed by **5: Distributions**. We'll be using **3: Inverse Normal**. You will be prompted to enter the total area to the left of the desired  $x$  value,  $\mu$ , and  $\sigma$ . Note that instead of using the menus, you can type in this command directly using the syntax `invNorm(area to left,  $\mu$ ,  $\sigma$ )`.



- Your calculator will return the desired  $x$  value. For this example, we find that the Weschler IQ score corresponding to the 95th percentile is 124.7. *Round your answer to one more decimal place than what was provided for  $\mu$ .*
- Let's try a trickier example. This time, find the IQ score separating the top 15% of all Weschler IQ scores from the rest. Start by drawing a sketch. Given that the total area under the normal density curve is always 1, the area to the left of the IQ score that we are seeking can be found by subtracting the given area from 1. In this case,  $1 - 0.15 = 0.85$ . *Don't forget to convert percentages to their equivalent decimal values.*
- The area to the left of the IQ score we are seeking is 0.85, so type `invNorm(0.85, 100, 15)` and then press `enter`. We find that an IQ score of 115.5 separates the top 15% of all adult Weschler IQ scores from the rest.



Function	Result
<code>normCdf(90,∞,100,15)</code>	0.747508
<code>invNorm(0.95,100,15)</code>	124.673
<code>invNorm(0.85,100,15)</code>	115.547

## Applying the Central Limit Theorem

### Working with sample means

- The Central Limit Theorem applies whenever you are working with a distribution of sample means ( $\bar{x}$ ), and the sample comes from a normally distributed population, and/or the sample size is at least 30 ( $n \geq 30$ ).
- Recall that the mean for a distribution of sample means is  $\mu_{\bar{x}} = \mu$ , and the standard deviation for a distribution of sample means is  $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$ .
- Thus, the modified calculator commands to use when you are applying the Central Limit Theorem to work with a distribution of sample means ( $\bar{x}$ ) are as follows:

$$\text{normalcdf}(\text{lowerbound}, \text{upperbound}, \mu, \frac{\sigma}{\sqrt{n}})$$

$$\text{normalcdf}(-\infty, \text{upperbound}, \mu, \frac{\sigma}{\sqrt{n}})$$

$$\text{normalcdf}(\text{lowerbound}, \infty, \mu, \frac{\sigma}{\sqrt{n}})$$

$$\text{invNorm}(\text{area to left}, \mu, \frac{\sigma}{\sqrt{n}})$$

### ***Working with sample proportions***

- The mean for a distribution of sample proportions is  $\mu_{\hat{p}} = p$ , and the standard deviation for a distribution of sample proportions is  $\sigma_{\hat{p}} = \sqrt{\frac{pq}{n}}$ .
- Whenever  $np \geq 10$  and  $nq \geq 10$ , the sampling distribution of a sample proportion can be approximated by a normal distribution. (Note that  $q = 1 - p$ .)
- The modified calculator commands to use when you are working with a distribution of sample proportions ( $\hat{p}$ ) that can be approximated by a normal distribution are as follows:

$$\text{normalcdf}(\text{lowerbound}, \text{upperbound}, p, \sqrt{\frac{pq}{n}})$$

$$\text{normalcdf}(\emptyset, \text{upperbound}, p, \sqrt{\frac{pq}{n}})$$

$$\text{normalcdf}(\text{lowerbound}, 1, p, \sqrt{\frac{pq}{n}})$$

$$\text{invNorm}(\text{area to left}, p, \sqrt{\frac{pq}{n}})$$