

Statistics with the TI-89

The TI-89 Manual, besides coming with your calculator, can be downloaded or read in a browser in Adobe Acrobat Reader form from [http://education.ti.com/product/pdf/gb/eng/8992p/\\$8992book-eng.pdf](http://education.ti.com/product/pdf/gb/eng/8992p/$8992book-eng.pdf).

Using Graphlink to Transfer Variables, Files, and Flash Applications

You can link two TI-89's to transfer variables, files, and flash applications. To do this, you connect the calculators by the linking cable that comes with each calculator. Make sure that it is inserted securely in each calculator. How to do this is found in Chapter 22 of the Manual. You can also purchase a graphlink cable and software that allows transfer of data from the calculator to and from a computer and the internet.

Receiving Files. If you have the receiving calculator, hit $\boxed{2\text{nd}}$ $\boxed{[\text{VAR-LINK}]}$ $\boxed{[\text{F3}]}$ (Link)→2:Receive to receive files, folders and/or flash applications and $\boxed{2\text{nd}}$ $\boxed{[\text{VAR-LINK}]}$ $\boxed{[\text{F3}]}$ (Link)→5:Receive Product SW to receive operating system updates, which may be necessary to get new flash applications. You then get the WAITING TO RECEIVE and BUSY indicators on the status line. This means the calculator is ready to receive a transmission. To cancel this receive mode or to stop any transmission from either the receiving or sending unit, press $\boxed{[\text{ON}]}$ followed by $\boxed{[\text{ESC}]}$ in the error window that opens. Once transmission begins, messages requiring response may be received on the screen. If these are not self-explanatory, refer to the Manual.

Sending files. To transmit files to another calculator, hit $\boxed{2\text{nd}}$ $\boxed{[\text{VAR-LINK}]}$. You then select (and/or deselect) the variables or folders to send using the $\boxed{[\text{F4}]}$ ($\sqrt{}$) key. To transmit Flash Applications, first hit $\boxed{[\text{F2}]}$ (View) \blacktriangleright 2:FlashApps $\boxed{[\text{ENTER}]}$. Once the items to transmit have been chosen and the receiving calculator is in receiving mode, hit $\boxed{[\text{F3}]}$ (Link)→1:Send to TI-89/92 Plus.

To transmit an updated operating system to the other calculator, hit $\boxed{2\text{nd}}$ $\boxed{[\text{VAR-LINK}]}$ $\boxed{[\text{F3}]}$ (Link)→4:Send Product SW.

Installing the Inferential Statistics and Distribution Features

In all that follows, except possibly for random numbers, use the Stats/List Editor Flash Application. You will need to acquire this either from the internet using graphlink or from another TI-89 that has it using the linking method described above. A manual for the Stats/List Editor is on my web site and is available at <http://education.ti.com/product/pdf/gb/statsle.pdf>.

To use the Stats/List Editor application, hit $\boxed{[\text{APPS}]}$ →1:FlashApps, then navigate to the Stats/List Editor using the direction arrows and hit $\boxed{[\text{ENTER}]}$. In the folder selection window that opens, unless you wish to create a new folder for your Statistics Applications, just hit $\boxed{[\text{ENTER}]}$. To switch back and forth between the Stats/List Editor application and the home page, just hit $\boxed{2\text{nd}}$ $\boxed{[\text{=}]}$. Of course, pressing $\boxed{[\text{HOME}]}$ also returns you to the home page at any time.

Working with Lists

Editing lists with the TI-89. When opening the Stats/List Editor, there are six lists that are usually opened by default, named list1 through list6. Lists are saved to list variables. Any legal variable name

can be used. To enter a list called **protein**, whose elements are listed below, use the up arrow key to move the cursor to the top row, and then the right arrow key to move horizontally until you reach a blank column. See Figure 1. Then type **protein** and hit **[ENTER]**.

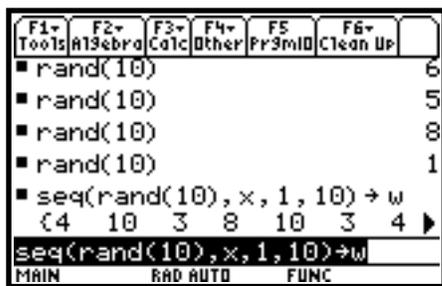


Figure 1

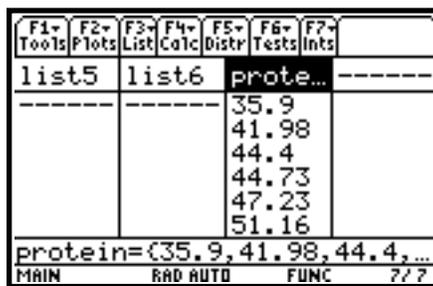


Figure 2

Now successively punch in each of the 61 elements in the list, each followed by **[↓]** or **[ENTER]**.

35.90	41.98	44.40	44.73	47.23	51.16	51.70	53.07	54.07	54.38	54.41	55.05	55.47
57.68	57.73	57.90	58.50	59.20	59.36	59.76	61.10	61.70	61.90	62.20	62.32	62.80
63.96	66.60	67.10	67.20	69.91	70.17	71.50	72.10	72.20	72.30	73.50	73.53	74.78
76.33	77.40	77.63	78.15	79.55	82.60	83.82	84.70	85.40	86.24	88.17	88.78	91.47
95.06	95.33	100.36	106.00	109.30	114.79	128.40	149.49	153.56				

When editing an already entered list, use the arrow keys to move horizontally to the list you want to work with. Then edit the list, adding or changing items as necessary. You can delete any element of a list by hitting the **[←]** key when the cursor is on that element. To choose a different list to work with, use the arrow keys to move horizontally onto the list you want. If the list you want to work with is not displayed in the list editor, move to a blank spot in the top line, hit **[F3](List)→1:Names**, and, using the up and down arrow keys, scroll to the list you wish and then hit **[ENTER]**. Of course, you could also just type in the list name, as you do if creating a new list. In either case, now hit **[↓]** or **[ENTER]**. You can remove a list and all its elements from the editor by hitting the **[←]** key when the cursor is on the list's name. To sort the list **protein** into ascending order, make sure the cursor is on the list's name and then hit **[F3](List)→2:Ops→1:Sort List [ENTER]**. The list should now be sorted in ascending order. See Figure 2.

Entering lists on the home page. Lists can be entered manually on the home page by beginning with a left brace "{" (hit **[2nd]** **[{]**), typing in the numbers separated by commas, and ending with a right brace "]" (hit **[2nd]** **[}]**). Suppose you have two lists as follows:

x 10 8 13 9 11 14 6 4 12 7 5

y 7.46 6.77 12.74 7.11 7.81 8.84 6.08 5.39 8.15 6.42 5.73

Also, suppose you want to save the x list as **listx** and the y list as **listy** since these lists will be used later. Start with the x list. After hitting **[CLEAR]** to clear the entry line, type in the first list. To save the list as **listx**, hit the **[STO]** key. Then hit **[2nd][alpha]listx[alpha][ENTER]**. See Figure 3. **(2nd)[alpha]** puts one in alpha lock and the last **[alpha]** releases that mode.)

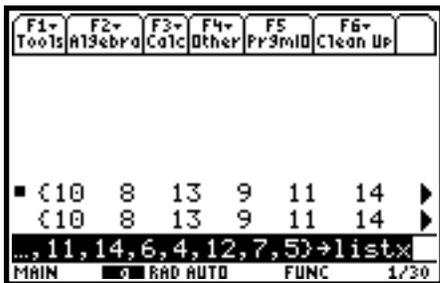


Figure 3

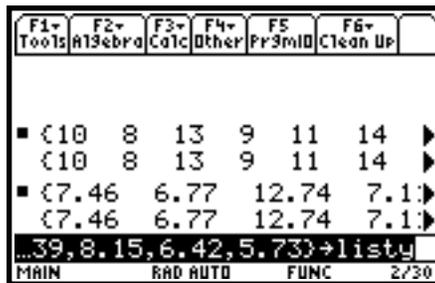


Figure 4

The y list can similarly be entered as listy. See Figure 4.

Random Numbers on the TI-89

Random number commands native to the operating system of the TI-89 are:

[2nd] [MATH]→7:Probability→4:rand(. The command `rand()` returns a random number > 0 and < 1 after ENTER is punched. Continuing to punch ENTER generates more random numbers. The command `rand(20)`, for instance, will generate a random integer between 1 and 20. Similarly, `rand(-20)` will generate a random integer between -1 and -20.

[2nd] [MATH]→7:Probability→5:randNorm(. The command `randNorm(MEAN, SD)` returns a random real number from a normal distribution specified by MEAN and SD.

[2nd] [MATH]→7:Probability→6:randSeed. The command `randSeed n` where n is an integer resets the seed to the system default if n is 0 and generates two seeds saved to the system variable `seed1` and `seed2` if n is not 0.

You can find more about this on page 463 of the TI-89 Manual.

Random Numbers with the Stats/List Editor

From within the List Editor, the random number commands are found at **[F4](Calc)→4:Probability**. Typically, you would be interested in generating a list of random numbers. To do this, put the cursor on the name of an empty list and then put one of the following commands on the entry line:

[F4](Calc)→4:Probability→1:Rand83([NUMTRIALS]). NUMTRIALS random numbers > 0 and < 1 are generated. If NUMTRIALS is left blank, a single random number is generated.

[F4](Calc)→4:Probability→5:RandInt(LOW,UP,[NUMTRIALS]). Returns NUMTRIALS random integers bounded by the specified integers, $LOW \leq \text{integer} \leq UP$.

[F4](Calc)→4:Probability→6:RandNorm([μ],[σ],[NUMTRIALS]). Returns NUMTRIALS random real numbers from a normal distribution specified by mean μ and standard deviation σ .

[F4](Calc)→4:Probability→7:RandBin(N, P , [NUMTRIALS]). Returns NUMTRIALS random real numbers from a binomial distribution, where the number of trials $N \geq 1$ and $0 \leq P \leq 1$.

[F4](Calc)→4:Probability→8:RandSamp(LIST1,CHOOSE[,NOREP=1]) Returns a LIST containing a random sample of the size you CHOOSE from LIST1 with an option for sample replacement or no sample replacement (NOREP=1 or 0). The default is with sample replacement (1).

You can find more about these commands on pages 101-112 of the Stats/List Editor Manual.

Descriptive Statistics

One variable statistics with the TI-89. Suppose you wish to find the descriptive statistics for the list `protein`. Assuming the list is properly prepared and that you are in the List Editor, hit `[F4](Calc)→1:1-Var Stats`. In the window that opens, with the cursor in the box for list, type the list name (`protein` here) or find it by hitting `[2nd][VAR-LINK]` and then using the arrow keys to navigate to the variable `protein`, where you will then hit `[ENTER]` to put it in the box (see Figure 5), hit `[ENTER]` again to accept it, and then hit `[ENTER]` one last time to get the statistics. See Figure 6. You can get any hidden results by hitting `⊖` or `⊕`. From top to bottom you have the mean, the sum of the data entries, the sum of the data entries squared, the sample standard deviation, the population standard deviation, the number of data points, the minimum value, the first quartile value, the median, the third quartile value, the maximum value, and the sum of the squares of the deviations from the mean. When you are finished viewing the statistics, hit `[ENTER]`.



Figure 5

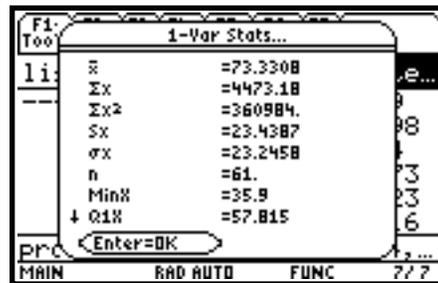


Figure 6

Two variable statistics with the TI-89. This is similar to one variable statistics with the exception that two lists need to be entered in the provided boxes. Where data is paired, such as with `listx` and `listy`, a scatter plot of the data may be prepared. From the List Editor, hit `[F2](Plots)→1:Plot Setup`, and with the cursor on `Plot1` (or any other plot you prefer), hit `[F1](Define)`. If `Scatter` is not showing as `Plot Type`, hit `⊙1:Scatter`. This is followed by `⊖`, where, unless the `Mark` you want is chosen, press, for instance, `⊙1:Box` to choose boxes to mark the points. Hit `⊖` again, and in the box for `x`, either type in `listx` or choose it from the list under `[2nd][VAR-LINK]` as illustrated above under one variable statistics. Then hit `⊖` once more and, as above, enter `listy` for `y`. After another `⊖`, making sure `Use Freq and Categories?` is set to `NO`, press `[ENTER]`. See Figure 7. You now notice a $\sqrt{}$ in front of `Plot1` and an abbreviated description of the plot following it. Defined plots may be selected and deselected by moving the cursor to the plot and choosing `[F4]($\sqrt{}$)` from the menu. With `Plot1` selected, hit `[F5](ZoomData)` to get the scatter plot in a window selected to show all of the data points. See Figure 8. To return to the List Editor, hit `[2nd][←]`.



Figure 7

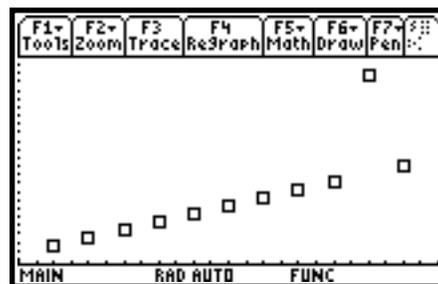


Figure 8

Regression with the TI-89. The Stats/List Editor on the TI-89 supports several types of regression, among which are linear, quadratic, cubic, quartic, logarithmic, exponential, power, and multiple linear. All of them work pretty much the same, so linear regression will be used as an example.

Use the lists *listx* (the *x*'s) and *listy* (the *y*'s) entered earlier. You have seen the scatter plot in the previous section. To find the linear regression equation, hit [F4](Calc)→3:Regressions→1:LinReg(a+bx). In the window that opens, as above, enter *listx* for X List and *listy* for Y List. Moving the cursor to the line Store RegEqn to: (See Figure 9), if you wish to graph the regression line, press \blacktriangleright , then hit \blacktriangleleft until you get to the equation you want, such as $y_1(x)$, and press [ENTER]. Then press [ENTER] again to get the results. See Figure 10. The regression equation is $y=3.00245+.499727x$, the coefficient of determination $r^2=.666324$ and the correlation coefficient is $r=.816287$. When you are finished looking at the results, hit [ENTER] to return to the List Editor. There you will notice a new list named *Resid*, the residuals of the regression.



Figure 9



Figure 10

At this point, if you hit [F2](Plots)→1:Plot Setup and then make sure the cursor is on the appropriate plot, Plot1 in this example, and that the plot is selected pressing [F5](ZoomData), you now get the scatter plot with the regression line. See Figure 11.

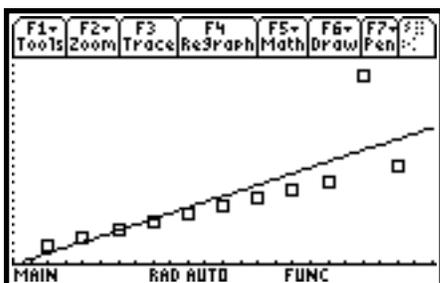


Figure 11

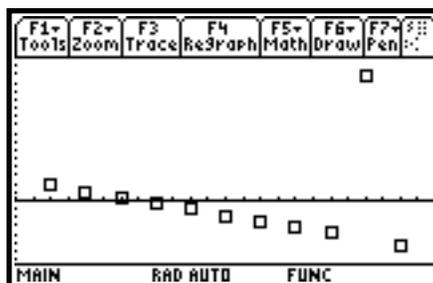


Figure 12

We will next plot the residuals. Hit [2nd] [⇄] to return to the List Editor. Use the instructions above under two variable statistics to define Plot2 (or any other plot number you choose) with the lists *listx* and *vars\resid* (the list *resid* found in the *STATVARS* folder – you may need to place the cursor on *STATVARS* and press \blacktriangleright to open it. After hitting the final [ENTER] that returns you to the Plots screen, move the cursor to Plot1 and hit [F4]($\sqrt{}$) to deselect it. Then pressing [F5](ZoomData) gives you the residual plot. See Figure 12.

You can estimate and predict based on the regression equation. Suppose you wish to do this for *x* values of 9 and 15. Go to your home page by hitting [HOME]. Hit [2nd][VAR-LINK]. Navigate by arrows to y_1 . See Figure 13. Pressing [ENTER] places y_1 (on the entry line, which you should complete to $y_1(9)$). Then press [ENTER] to get the result of 7.5. See Figure 14. Since the last entry is still highlighted, press \blacktriangleright \blacktriangleleft \leftarrow 15 [ENTER] to get $y_1(15)=10.4984$.



Figure 13

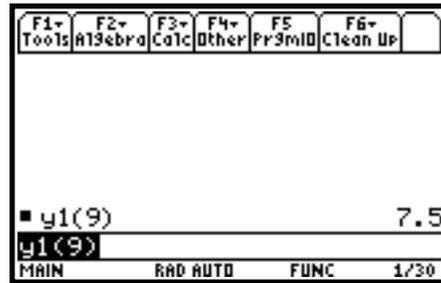


Figure 14

Probability Distribution Functions on the TI-89

Binomial Distribution. Assume that for a sample of $n=15$ you have that $p = .75$. You want to find first $P(X=6 | 15, .75)$. We can compute this probability by using the **binomial probability density function**

$$f(x) = \binom{n}{x} p^x (1-p)^{n-x}, x = 0 \dots n.$$

After putting yourself in the List Editor, hit [F5](Distr)→B:Binomial Pdf. In the window that opens, enter 15 for Num trials, n , .75 for Prob Success, p , and 6 for X Value. See Figure 15.



Figure 15

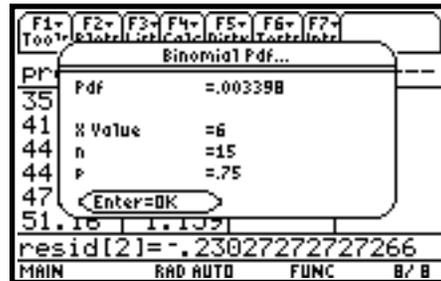


Figure 16

Then hit [ENTER] to get the results screen in Figure 16. You see that $P(X=6 | 15, .75)=.003398$. If Value is left blank, the result screen shows a list of Pdf values, and hitting [ENTER] adds the list Pdf to the List Editor where the values for $x=0$ through $x=15$ can be found. Keep in mind, however, that in the entry line Pdf[n] corresponds to $x=n-1$. See Figure 17.

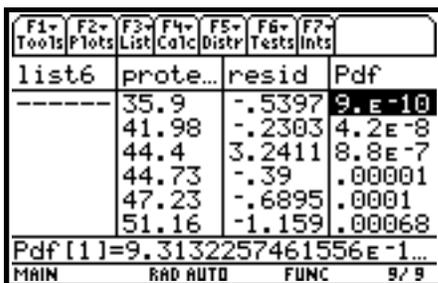


Figure 17



Figure 18

To find $P(X \leq 5 | 15, .75)$, use the **binomial cumulative density function**. Similar to what you did above hit [F5](Distr)→C:Binomial Cdf. In the window that opens, enter 15 for Num trials, n , .75 for Prob Success, p , 0 for Lower Value, and 5 for Upper Value. See Figure 18. Then hit [ENTER] to get the results screen in Figure 19. You see that $P(X \leq 5 | 15, .75)=.000795$. Leaving both Lower Value and Upper Value blank results in a list Cdf similar to the list Pdf above. See Figure 20.

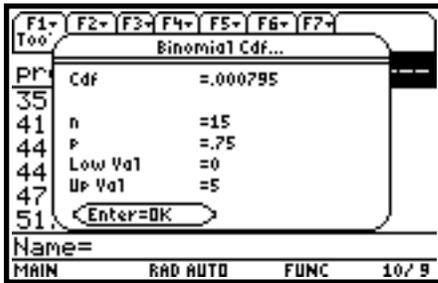


Figure 19

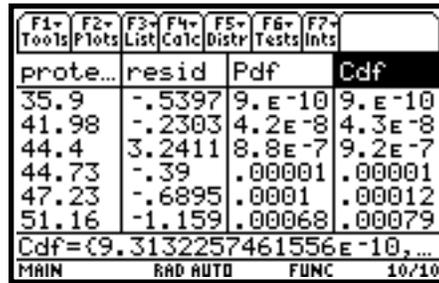


Figure 20

To find $P(6 \leq X \leq 9 \mid 15, .75)$, just use 6 for Lower Value and 9 for Upper Value.

Poisson Distribution. Assume that $p = .5$. You want to find $P(X=1 \mid .5)$, $P(X \leq 7 \mid 2.2)$, and $P(4 \leq X \leq 9 \mid 2.2)$. You can compute these probabilities by using the **Poisson probability density function**

$$f(x) = \frac{e^{-\lambda} \lambda^x}{x!}, x = 0, 1, 2, \dots$$

or the **Poisson cumulative density function**. These are implemented similar to the binomial probability and cumulative density functions above by the commands [F5](Distr)→D:Poisson Pdf and [F5](Distr)→E:Poisson Cdf with the difference that there is now a box for λ and the various value boxes cannot be left blank. You will find that $P(X=1 \mid .5) = .303265$, $P(X \leq 7 \mid 2.2) = .998022$, and $P(4 \leq X \leq 9 \mid 2.2) = .180547$.

Normal Distribution. The **normal probability density function** is given by

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, \mu > 0.$$

Assume $\mu = 100$ and $\sigma = 20$. Find $f(110)$, for instance, hit [F5](Distr)→3:Normal Pdf. In the window that opens, put in 110 for X Value, 100 for μ , and 20 for σ . Hitting [ENTER] then gives you the results screen in Figure 21, where you see that $f(110) = .017603$. Suppose you wish to plot the normal curve for these parameters. Go back to your home screen and hit [2nd][WINDOW], and set the window parameters, to $xmin=40$, $xmax=160$, $xsc1=20$, $ymin=0$, $ymax=.05$, $ySc1=1$, and $xRes=1$. This will

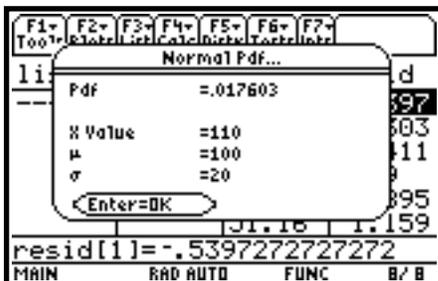


Figure 21



Figure 22

allow you to see the curve a distance of three standard deviations from the mean in both directions and cause tick marks to be placed along the x-axis at intervals of one standard deviation. Now hit [2nd][Y=] and by using [left], [right], and [F4](√) as necessary, deselect all plots and functions other than y_1 , and move the cursor onto y_1 . Then hit [CLEAR] [CATALOG] [F3](flash Apps), and then use the arrow keys to navigate to normPdf(. At the bottom of the screen, you will now see $X[, [,]]$. This indicates that three parameters are needed to complete the function, X , μ , and σ , just as were entered in the box above. The brackets are around μ and σ to indicate that they are optional, the defaults being the 0 and 1 of the standard normal distribution. Now hit [ENTER] and complete the command to $T1Stat.normPdf(x, 100, 20)$. See Figure 22. Then hit [2nd][GRAPH] to see the curve. See Figure 23.

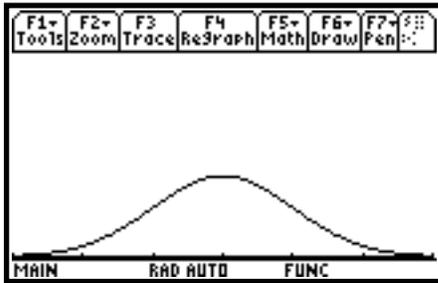


Figure 23

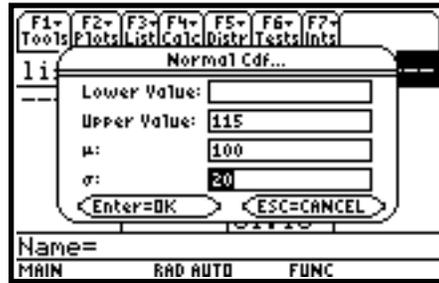


Figure 24

To find $P(X \leq 115)$ using the same distribution, you need the **normal cumulative distribution function**. Go to the List Editor and hit [F5](Distr)→4:Normal Cdf. In the window that opens, leave Lower Value blank. This then uses the default of $-\infty$ for Lower Value. Enter 115 for Upper Value (leaving this box blank is the same as $-\infty$), 100 for μ , and 20 for σ . See Figure 24. Then hit [ENTER] to get the results screen in Figure 25. You get that $P(X \leq 115) = .773373$. Again, not including the mean and standard deviation will result in the assumption of the standard normal distribution. To find $P(X \geq 95)$, you would use 95 for Lower Value and leave Upper Value blank. To find $P(90 \leq X \leq 135)$, you would use 90 for Lower Value and 135 for Upper Value.

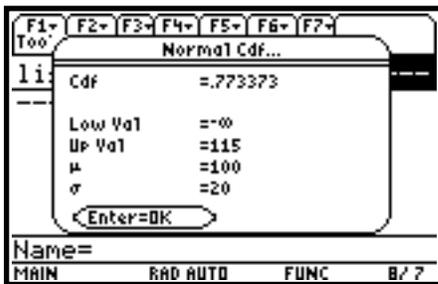


Figure 25



Figure 26

To find x_1 such that $P(X \leq x_1) = .975$, which is useful for finding critical values for hypotheses tests, go first to the List Editor. You will use the **inverse normal distribution function**. This is the inverse of the normal cumulative distribution function. Hit [F5](Distr)→2:Inverse→1:Inverse Normal. In the screen that opens, enter .975 for Area, 100 for μ , and 20 for σ . See Figure 26. Then press [ENTER] to get the screen in Figure 27. You see that $x_1 = 139.199$.

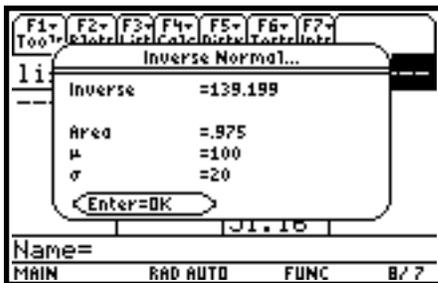


Figure 27

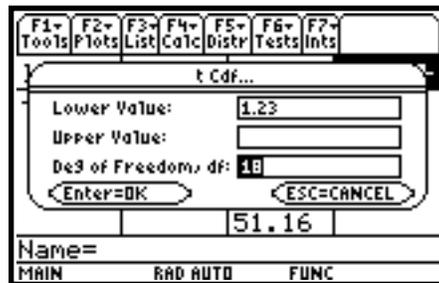


Figure 28

Student's t Distribution. The **cumulative t distribution** can be used to compute probabilities such as $P(t \geq 1.23 | df = 18)$ or $P(t < 1.42 | df = 9)$. This procedure is similar to that of the normal cumulative distribution function, except that there is a box for degrees of freedom and none for mean and standard deviation. To find the former, hit [F5](Distr)→6:t Cdf and complete the screen that appears as in Figure 28. After hitting [ENTER], you find from the results screen that $P(t \geq 1.23 | df = 18) = .117266$. The **t probability distribution function** is applied similar to that of the normal probability distribution function beginning with [F5](Distr)→5:t Pdf.

To find t_1 such that $P(t \geq t_1 | df=15) = .025$, which is useful for finding critical values for hypotheses tests, go first to the List Editor. You will use the **inverse t distribution function**. This is the inverse of the t cumulative distribution function. Hit [F5](Distr)→2:Inverse→2:Inverse t. In the screen that opens, enter .025 for Area and 15 for Deg of Freedom, df. See Figure 29. Then press [ENTER] to get the screen in Figure 30. You see that $t_1 = -2.13145$.



Figure 29

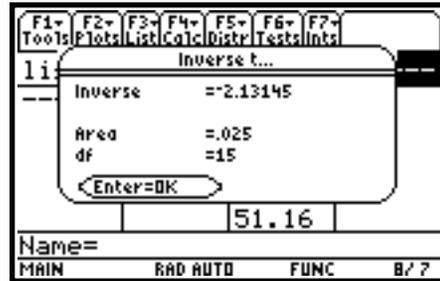


Figure 30

χ^2 Distribution. The **cumulative χ^2 distribution** can be used to compute probabilities such as $P(\chi^2 \geq 24 | df=16)$. This procedure is similar to that of the normal cumulative distribution function, except that there is a box for degrees of freedom and none for mean and standard deviation. . To find this value, hit [F5](Distr)→8:Chi-square Cdf and complete the screen that appears as in Figure 31. After hitting [ENTER], you find from the results screen that $P(\chi^2 \geq 24 | df=16) = .089504$. The **χ^2 probability distribution function** is applied similar to that of the normal probability distribution function beginning with [F5](Distr)→7:Chi-square Pdf.

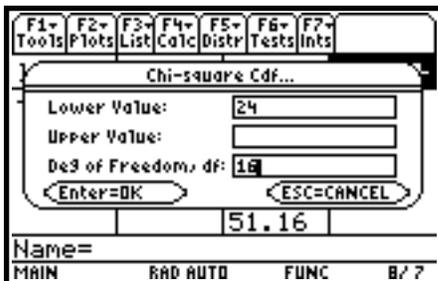


Figure 31

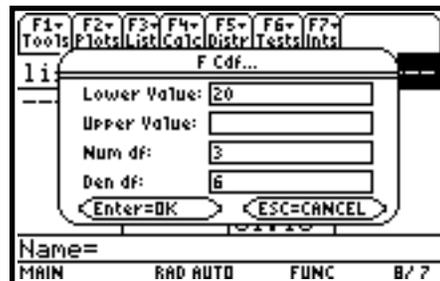


Figure 32

To find $(\chi^2)_1$ such that $P(\chi^2 \geq (\chi^2)_1 | df=28) = .95$, which is useful for finding critical values for hypotheses tests, go first to the List Editor. You will use the **inverse χ^2 distribution function**. This is the inverse of the χ^2 cumulative distribution function. Hit [F5](Distr)→2:Inverse→3:Inverse Chi-square. In the screen that opens, enter .95 for Area and 28 for Deg of Freedom, df. Then press [ENTER]. You see that $(\chi^2)_1 = 41.3371$.

F Distribution. The **cumulative F distribution** can be used to compute probabilities such as $P(F \geq 20 | num\ df=3, den\ df=6)$. This procedure is similar to that of the normal cumulative distribution function, except that there are two boxes for degrees of freedom and none for mean and standard deviation. To find this value, hit [F5](Distr)→A:F Cdf and complete the screen that appears as in Figure 32. After hitting [ENTER], you find from the results screen that $P(F \geq 20 | num\ df=3, den\ df=6) = .001586$. The **F probability distribution function** is applied similar to that of the normal probability distribution function beginning with [F5](Distr)→9:t Fdf.

To find F_1 such that $P(F \geq F_1 | num\ df=5, den\ df=8) = .99$, which is useful for finding critical values for hypotheses tests, go first to the List Editor. You will use the **inverse F distribution function**. This is the inverse of the F cumulative distribution function. Hit [F5](Distr)→2:Inverse→4:Inverse F. In the screen that opens, enter .99 for Area, 5 for Num df, and 8 for Den df. Then press [ENTER]. You see that $F_1 = 63183$.

Inferential Statistics on the TI-89

Begin by entering two lists of data from two independent samples. As an example, cadmium level determinations were made on the placentas of two groups of mothers in nanograms per gram. The first group of 18 mothers were nonsmokers (ns), while the second group of 14 mothers were smokers (sm).

ns: 10.0 8.4 12.8 25.0 11.8 9.8 12.5 15.4 23.5 9.4 25.1 19.5 25.5 9.8 7.5 11.8 12.2 15.0

sm: 30.0 30.1 15.0 24.1 30.5 17.8 16.8 14.8 13.4 28.5 17.5 14.4 12.5 20.4

ns has a mean of 14.72 and a standard deviation of 6.20, while sm has a mean of 20.41 and a standard deviation 6.81.

Confidence Interval for a Population Mean. To find a 95% confidence interval for the mean of ns, make sure you are in the List Editor and hit $\text{2nd}[F7](\text{Ints}) \rightarrow 2: \text{TInterval}$. In the first screen that comes up, choose **Data**, hit ENTER , and then fill in the second screen as in Figure 33. Then hit ENTER . You are given (11.64,17.8) as the confidence interval, along with the point estimate ($\bar{x}=14.7222$), margin of error ($\text{ME}=3.08251$), degrees of freedom ($\text{df}=17$), sample standard deviation ($\text{Sx}=6.19863$), and sample size ($n=18$). See Figure 34.



Figure 33

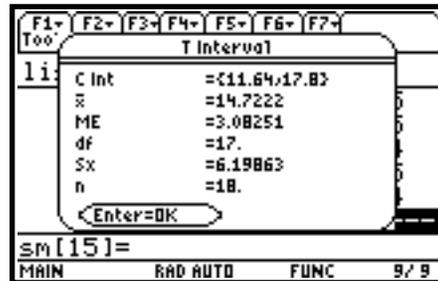


Figure 34

If a data list isn't in the calculator, but you know the standard deviation and mean, when you get to the choice of **Data** vs. **Stats**, choose **Stats**, hit ENTER , and then fill in the boxes as shown in Figure 35. Here you also get the same confidence interval of (11.64,17.8), although some of the other statistics are just a bit different from above since more rounding was done here for the mean and standard deviation.



Figure 35

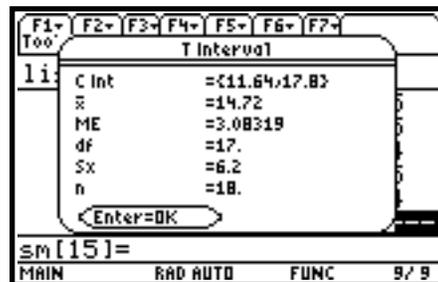


Figure 36

If the population standard deviation σ is known, you can make use of the normal distribution by choosing $\text{2nd}[F7](\text{Ints}) \rightarrow 1: \text{ZInterval}$ instead of $\text{2nd}[F7](\text{Ints}) \rightarrow 2: \text{TInterval}$.

Confidence Interval for the Difference Between Two Population Means. Use ns and sm as data. To find a 95% confidence interval for the difference of the means of ns and sm, hit $\text{2nd}[F7](\text{Ints}) \rightarrow 4: \text{2-SampTInt}$. In the first window that comes up, choose **Data**. Again, do this since the data has been entered as lists. Now hit ENTER and fill in the boxes of the second window with ns for List1, sm for

List2, 1 for both Freq1 and Freq2, and .95 for C Level. For Pooled (pooled variance), assuming that it is not known that the population variances are equal, choose NO (YES for equal variances). See Figure 37. Then hit **[ENTER]** to get the results. As you can see from Figure 38, you are given a confidence interval of $(-10.5, -8.99)$ along with other relevant results.

If the population standard deviations are known, you can use **[2nd][F7](Ints)→4:3-SampZInt** instead of **[2nd][F7](Ints)→4:2-SampTInt**, making use of the normal distribution.

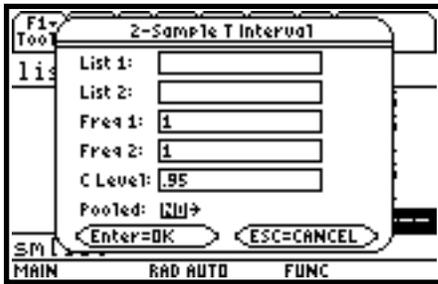


Figure 37

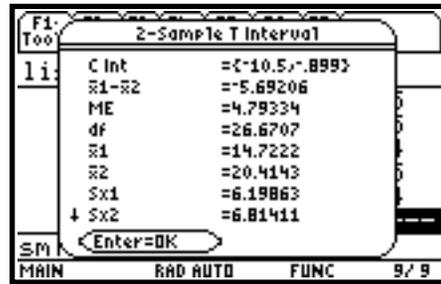


Figure 38

Confidence Interval for a Population Proportion. You want a 99% confidence interval for the proportion of a certain population of boys who have attempted suicide. Of a sample of 96 boys, 18 had attempted suicide. Hit **[2nd][F7](Ints)→5:1-PropZInt**. For Successes, x, enter 18; for n, enter 96; and for C Level, enter .99. Then hit **[ENTER]**. You are given an interval of $(.0849, .29013)$ with a p-hat of .1875.

Confidence Interval for the Difference between Two Population Proportions. 60 of 123 girls from a related population have attempted suicide. Hit **[2nd][F7](Ints)→6:2-PropZInt**. For Successes, x1, enter 18; for n1, enter 96; for Successes, x2, enter 60; for n2, enter 123; and for C Level, enter .99. Then hit **[ENTER]**. You are given an interval of $(-.455, -.1453)$ with a p-hat1 of .1875 and a p-hat2 of .487805.

Confidence Interval for Linear Regression using t. Return to the earlier linear regression example using listx and listy. Hit **[2nd][F7](Ints)→7:1-LinRegTInt**. One of the choices in the page that opens is Response or Slope.

In the Response case, an X Value is required to determine a calculated y value, $y_{\hat{}}$, at which point a prediction confidence interval around $y_{\hat{}}$ is determined, as well as a confidence interval for the mean. Complete the window as in Figures 39 and 40, noticing the use of an X Value of 10. Notice also the arrows on the left side of the window indicating some values are off screen, necessitating scrolling.



Figure 39



Figure 40

Then hit **[ENTER]**. The results screen is shown in Figures 41 and 42, scrolling again being necessary to see it all. In Figure 41, the 99% confidence interval C Int= $(6.729, 9.27)$ is for the mean of $y_{\hat{}}(10)$, and in Figure 42 the 99% confidence interval pred Int= $(3.786, 12.213)$ is for $y_{\hat{}}(10)$. You can also

observe the regression data in Figure 42.

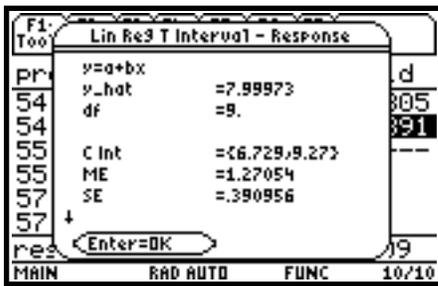


Figure 41

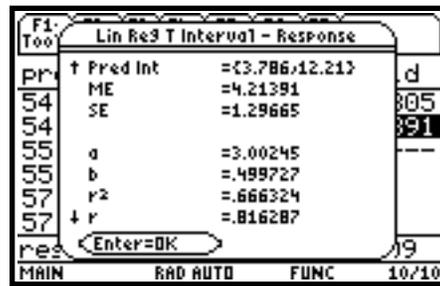


Figure 42

In the Slope case, LinRegTInt computes a linear regression T confidence interval for the slope coefficient b . If the confidence interval contains 0 this is insufficient evidence to indicate that the data exhibits a linear relationship. Entering the data as above, except for X Value, which is inaccessible, you get a 99% confidence interval $C\ Int=(.1166,.88283)$ for the slope b . Since 0 is not in the interval, you can conclude the existence of a linear relationship. Again, the regression data is available.

Confidence Interval for Multiple Regression. Enter the following lists: listx1, listx2 and listy1 as given below.

listx1:	1	2	3	3.5	4.5
listx2:	4	3	2	1	1
listy1:	4	5	6	7	8

We are assuming that y_1 is a function of x_1 and x_2 . Hit $\text{2nd}[F7](\text{Ints}) \rightarrow 8:1\text{-MultRegInt}$. This corresponds to the Response option above. In the first window that opens, choose 2 for Num of Ind vars and then hit ENTER . In the second window, fill in the boxes as shown in Figure 43. The X Value List of $\{2,3\}$ corresponds to the point $(x_1,x_2)=(2,3)$. Then press ENTER . The results screen is shown in Figures 44 and 45. In Figure 44, the 95% confidence interval $C\ Int=(3.928,6.189)$ is for the mean of $y_hat(2,3)$, and in Figure 45 the 99% confidence interval $pred\ Int=(2.687,7.433)$ is for $y_hat(2,3)$. You can also observe the regression data in both figures, with the regression equation, using B List. To find the values of Blist, after hitting ENTER , move the cursor onto a blank list name, hit $\text{2nd}[VAR-LINK]$, and scroll down to $blist$ under STATVARS and hit ENTER . From $blist$ in the List Editor (see Figure 46), you can determine that the regression equation is $y_1=3.5882 + x_1 - .1765 x_2$.



Figure 43



Figure 44

If the population standard deviations σ_1 and σ_2 are known, you can make use of the normal distribution by choosing $2^{nd}[F6](Tests) \rightarrow 3: 2\text{-SampZTest}$ instead of $2^{nd}[F6](Tests) \rightarrow 4: 2\text{-SampTTest}$.

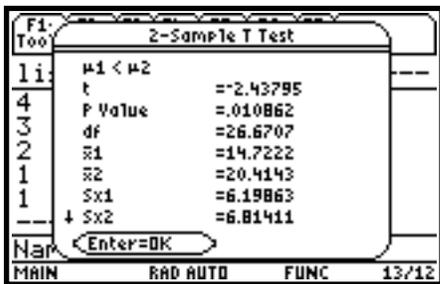


Figure 51

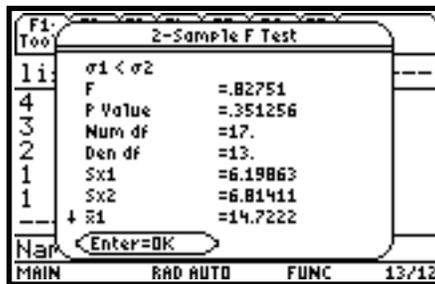


Figure 52

Hypothesis Testing for comparing Two Standard Deviations. Use as a null hypothesis $H_0: \sigma_1 = \sigma_2$ for the data sets ns and sm and use an F-test. We will also use as an alternate hypothesis $H_A: \sigma_1 < \sigma_2$. Hit $2^{nd}[F6](Tests) \rightarrow 9: 2\text{-SampFTest}$. See Figure 42. Choose Data in the first window that opens and then press ENTER , filling in the rest of the boxes as in previous example (Figure 50). Then hit ENTER . The results window gives $F=.82751$ and $p=.351256$, along with other results. See Figure 52.

To get a graphical representation instead, choose Draw instead of Calculate for Results. The F and p values are given below the graph with the p equaling the shaded area. Recall that you are now in the graph page.

Hypothesis Testing for a Single Population Proportion. In a survey of injection drug users in a large city, 18 out of 423, i.e. $\hat{p} = .0426$, were HIV positive. Can one conclude that fewer than 5% of the population of injection drug users in the city are HIV positive. Use $H_0: p = .05$, so $H_A: p < .05$. Hit $2^{nd}[F6](Tests) \rightarrow 5: 1\text{-PropZTest}$. Put in .05 for p_0 , 18 for Successes, x, 423 for n, Prop< p_0 for Alternate Hyp., and Calculate for Results. Then hit ENTER . The results window gives $z=-.702738$ and $p=.241109$, along with other results. See Figure 53.

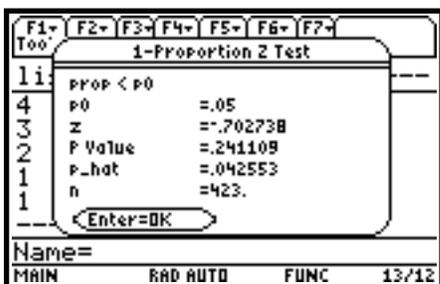


Figure 53

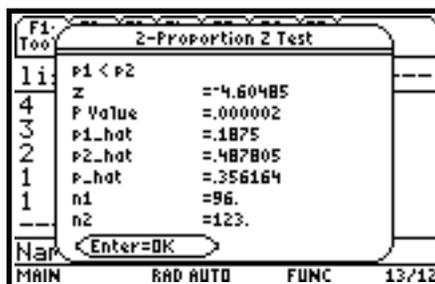


Figure 54

To get a graphical representation instead, choose Draw instead of Calculate for Results. The z and p values are given below the graph with the p equaling the shaded area. Recall that you are now in the graph page.

Hypothesis Testing for the Difference between Two Population Proportions. Return to the situation where 18 of 96 boys and 60 of 123 girls attempted suicide. Use as a null hypothesis $H_0: p_1 = p_2$ with $H_A: p_1 < p_2$. Hit $2^{nd}[F6](Tests) \rightarrow 5: 2\text{-PropZTest}$. For Successes, x_1 , enter 18; for n_1 , enter 96; for Successes, x_2 , enter 60; for n_2 , enter 123; and for Alternate Hyp., $p_1 < p_2$. Then hit ENTER . The results window gives $z=-4.60485$ and $p=.000002$, along with other results. See Figure 54.

One-Way Anova. Enter three lists in the calculator, $a_1=\{7, 4, 6, 6, 5\}$, $a_2=\{6,5,5,8,7\}$, and $a_3=\{4,7,6,7,6\}$. The null hypothesis here is $H_0: \mu_1=\mu_2=\mu_3$ with H_A : not all of μ_1, μ_2, μ_3 are equal. To run the test, hit $2^{nd}[F6](Tests) \rightarrow C: ANOVA$. In the first window that opens, choose Data and 3 for Number of Groups, and then hit ENTER . Complete the second window as in Figure 55. Then hit

[ENTER]. The results window gives $F=.311111$ and $p=.738367$, along with other results, some of which you have to scroll to see. See Figure 56.

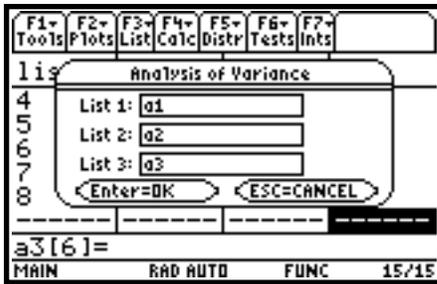


Figure 55

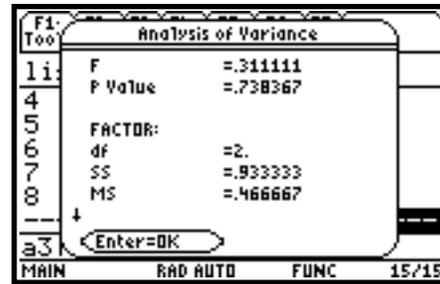


Figure 56

Three new lists appear in the List Editor, as seen in Figure 57. The three lists are \bar{x} list (the means of the three lists) and lowlist and uplist, the left and right endpoints of the 95% confidence interval for each mean. For instance, the mean of list a1 is 5.6 and the 95% confidence interval for that mean is (4.4066,6.7934).

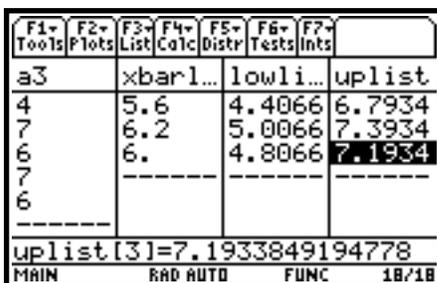


Figure 57



Figure 58

We see the means \bar{x} of the three lists are 5.6, 6.2, and 6. We can find that the standard deviations S_x are 1.14018, 1.30384, and 1.22474, and each list has a sample size of 5. If you had chosen the **Stats** option instead of **Data**, for each group you enter a list $\{n,\bar{x},s_x\}$ as prompted on the screen. See Figure 58. Then press [ENTER] to get the same results as before.

Two-Way Anova. Enter four lists in the calculator, $a21=\{7, 4, 6, 6, 5,6\}$, $a22=\{6,5,5,8,7,7\}$, $a23=\{4,7,6,7,6,6\}$, and $a24=\{4,7,8,9,5,7\}$. **ANOVA2-Way** computes a two-way analysis of variance for comparing the means of two to twenty populations (levels of factor A called **Lvls of Col Factor**). In the **2 Factor, Equal Repetitions** design, each of the considered populations has an equal number of levels of factor B (**Lvls of Row Factor**). In the **Block** design, the levels of factor B are equal to the block. The **ANOVA2-Way** procedure compares the means of the experimental factors, factor A, factor B, and factor AB (the interaction effect). For each of the experimental factors, the null hypothesis $H_0: \mu_1=\mu_2=\dots=\mu_k$ is tested against the alternative hypothesis H_A : not all of $\mu_1, \mu_2, \dots, \mu_k$ are equal. In the case of the **Block** design, there is no interaction effect.

Consider the **Block** design first. To run the test, hit [2nd][F6](Tests)→D: ANOVA2-WAY. In the first window that opens, choose **Block** for **Design** and **4** for **Lvls of Col Factor**, and then hit [ENTER]. Complete the second window as in Figure 59. Then hit [ENTER]. The results window gives first, under **Factor**, an $F=.704225$ and $p=.56416$ for the treatment (column) factor. See Figure 60. Scrolling down, in Figure 61 you see the $F=1.56338$ and $p=.229969$ for the **Block** factor. You can also see that further scrolling will provide the **Error** results.

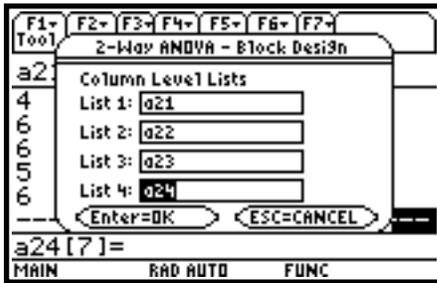


Figure 59

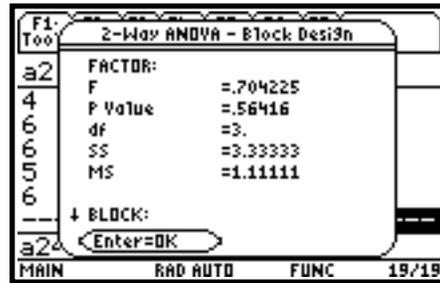


Figure 60

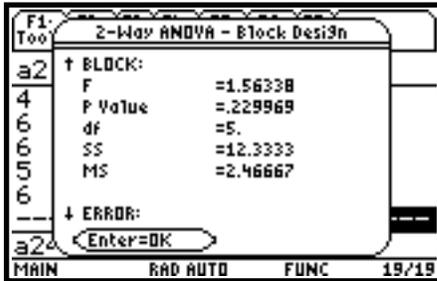


Figure 61

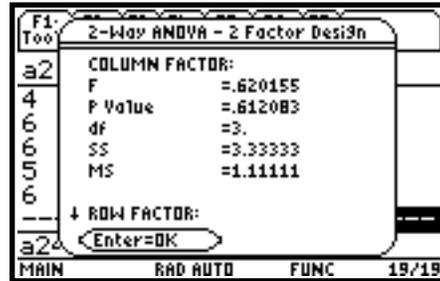


Figure 62

Now to the 2 Factor, Equal Repetitions design. Hit $\boxed{2\text{nd}}\boxed{[F6]}$ (Tests) \rightarrow D: ANOVA2-WAY. In the first window that opens, choose 2 Factor, Eq Reps for Design, 4 for Lvl's of Col Factor, 2 for Lvl's of Row Factor, and then hit $\boxed{\text{ENTER}}$. Complete the second window as in Figure 59 above. Then hit $\boxed{\text{ENTER}}$. The results window gives first, under Column Factor, an $F=.620155$ and $p=.612083$. See Figure 62. Scrolling down, under Row Factor, you get $F=2.32558$ and $p=.146785$, and under Interaction, you get $F=.589147$ and $p=.630932$. You can also see that further scrolling will provide the Error results.

Chi-Square Goodness of Fit. Chi2 GOF performs the chi square goodness of fit test to confirm that sample data is from a population that conforms to a specified distribution. For example, **Chi2 GOF** can confirm that the sample data came from a normal distribution. Enter two lists in the calculator, $ch1=\{16,25,22,8,10\}$ (the observed values) and $ch2=\{9,12,9,8,7\}$ (the expected values if the data were from a particular distribution). To run the test, hit $\boxed{2\text{nd}}\boxed{[F6]}$ (Tests) \rightarrow 7: Chi2 GOF. In the window that opens, choose $ch1$ for Observed List, $ch2$ for Expected List, Calculate for Results, and then hit

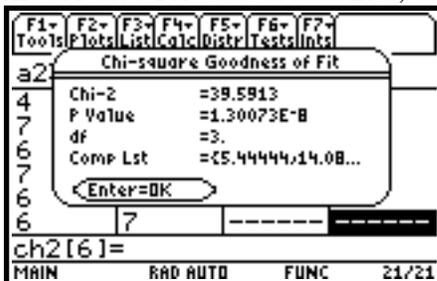


Figure 63

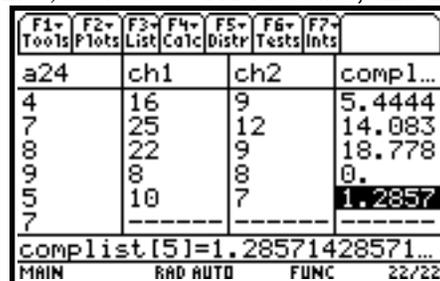


Figure 64

$\boxed{\text{ENTER}}$. The results window gives $\chi^2=39.5913$ and $p=1.30073E-8=.000000013$. See Figure 63. You will also find a new list in the List Editor, **complst**, which gives the element by element contributions to χ^2 , the sum of the items in the list. See Figure 64.

To get a graphical representation instead, choose Draw instead of Calculate for Results. The χ^2 and p values are given below the graph with the p equaling the shaded area.

Chi-Square Test of Independence. First enter a matrix of observed values. Call this matrix ob. Here

use $ob = \begin{bmatrix} 23 & 4 & 10 \\ 10 & 14 & 35 \end{bmatrix}$. To enter the matrix, return to the home page (HOME) and hit

[APPS]→6:Data/Matrix Editor→3:New. Choose Matrix for Type, main for folder, type in ob for Variable, 2 for Rows, 3 for Columns, and then hit [ENTER]. See Figure 65. Then continue by hitting each number in succession followed by [ENTER]. See Figure 66. When you are finished, hit [HOME]. Then return to the List Editor.

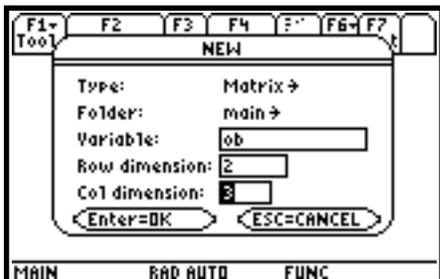


Figure 65

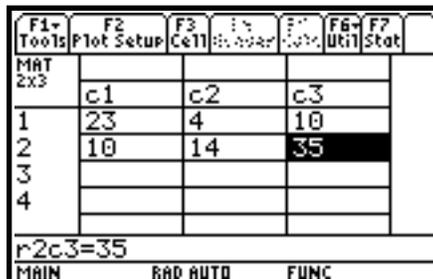


Figure 66

To run the test, hit [2nd][F6](Tests)→8: Chi2 2-way. In the window that opens, enter ob for Observed Mat, statvars\expmat (the default) for Store Expected to, statvars\compmat (the default) for Store CompMat to, Calculate for Results (see Figure 67), and then hit [ENTER].



Figure 67

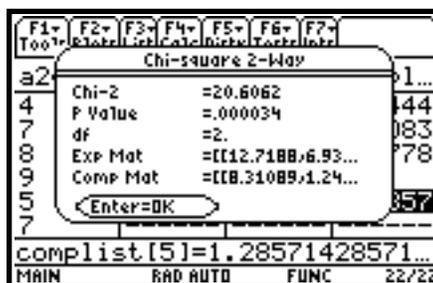


Figure 68

The null hypothesis is that there is no association between the row and column variable, with the alternative hypothesis being that the variables are related. From Figure 68, you get a χ^2 of 20.6062 and a p-value of .000034.

To see the expected matrix, from the home page hit [APPS]→6:Data/Matrix Editor→2:Open. In the window that opens, choose Matrix for Type, statvars for folder, expmat for Variable, and hit [ENTER]. The matrix is in Figure 69. You can do the same to get compmat, the matrix of component contributions whose sum is χ^2 . See Figure 70.

To get a graphical representation instead, choose Draw instead of Calculate for Results. The χ^2 and p values are given below the graph with the p equaling the shaded area

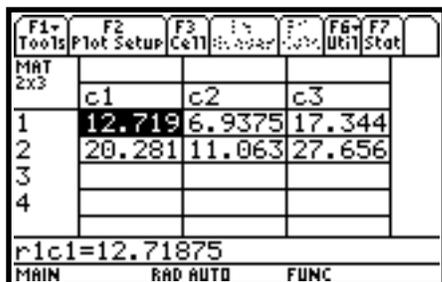


Figure 69

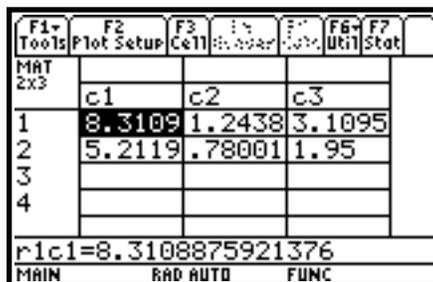


Figure 70

Hypothesis Testing for the slope and correlation coefficient in Linear Regression using t . Return to the earlier linear regression example using listx and listy. LinRegTTest (linear regression t test) computes a linear regression on the given data and a t test on the value of slope b and the correlation coefficient r for the equation $y=a+bx$. It tests the null hypothesis $H_0: b=0$ (equivalently, $r=0$) against one of the following alternatives: $H_A: b \neq 0$ and $r \neq 0$, $H_A: b < 0$ and $r < 0$, or $H_A: b > 0$ and $r > 0$. The first option will be used here. To run the test, from within the List Editor hit $[2nd][F6](Tests) \rightarrow A: LinRegTTest$. Fill in the window that opens as in Figure 71. Then hit $[ENTER]$ to get the results window. See Figure 72. You see that you get $t=4.23937$ and $p=.002176$. Thus you can conclude that there is a linear relationship between the variables. You can see that the regression equation is $y=3.00245+.499727x$ with a standard error of the estimate $s=1.23631$, and by scrolling down, that the coefficient of determination $r^2=.666324$ and the correlation coefficient is $r=.816287$. Resid, the list of residuals of the regression, is also added to the List Editor.



Figure 71



Figure 72

Hypothesis Testing for Multiple Regression. Return to the earlier multiple regression example using listx1, listx2, and listy1. MultRegTests computes a multiple regression on the given data yielding an equation $Y=B_0+B_1*X_1+B_2*X_2$, an F test on the hypotheses $H_0: B_1=B_2=0$ with H_A : not both B_1, B_2 equal to 0, t tests on the coefficients B_1, B_2, B_3 , and the coefficient of determination. To run the test, from within the List Editor hit $[2nd][F6](Tests) \rightarrow B: MultRegTests$. Fill in the window that opens as in Figure 73. Then hit $[ENTER]$ to get the results window. See Figure 74. You see that you get $F=112.333$ and $p=.008824$. Thus you can conclude that there is a linear relationship between the variables. You can see that the coefficient of multiple determination $R^2=.991176$ and the standard error of the estimate is $s=.210042$. Several columns have been added to the List Editor. From the column blist we get the coefficients for the regression, yielding the equation $Y=3.5882+1.000*X_1-.1765*X_2$. Two columns to the right of blist is tlist, giving the t values for the corresponding B 's, and one column to the right of that is plist, giving the corresponding p -values.

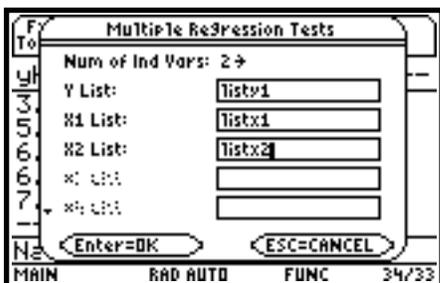


Figure 73

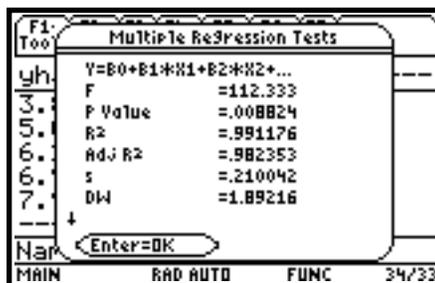


Figure 74