INTRODUCTION TO THE TI-83 AND TI-83 PLUS

Basics

Keyboard

Each key on the TI-83 and TI-83 Plus accesses up to three objects, operations, or menus. The primary object, operation, or menu is written on the key. Above each key are other objects, operations, and menus written in yellow or green.

Press the yellow $\boxed{\text{2nd}}$ key before any other key to access the object, operation, or menu that is written in yellow above the respective key. For example, to access the List menu, press $\boxed{\text{2nd}}$ followed by $\boxed{\text{STAT}}$. Because the 2nd command for the $\boxed{\text{STAT}}$ key is LIST, this Calculator Guide will refer to these keystrokes as $\boxed{\text{2nd}}$ [LIST]. That is, the command above the key will be set in brackets, [ ].

Press the green $\boxed{\text{ALPHA}}$ key before any other key to access the object or operation that is written in green above the respective key. In general, $\boxed{\text{ALPHA}}$ is used to type letters, double quotation marks, spaces, question marks, and colons. For example, to type the letter E, press $\boxed{\text{ALPHA}}$ followed by $\boxed{\text{SIN}}$, which will be denoted as $\boxed{\text{ALPHA}}$ [E] in this Calculator Guide.

Menus

Objects and operations that are not written on the keyboard can usually be found within menus. Many menus, such as the List menu, have multiple submenus. Use the left and right arrow keys to move among submenus. Use the up and down arrow keys to select an item from the menu, or press the number or letter associated with the item. For example, to select the median(function, press $\boxed{\text{2nd}}$ [LIST]; arrow to the MATH submenu; and arrow down to 4:median(and press $\boxed{\text{ENTER}}$, or simply press $\boxed{4}$. This Calculator Guide will refer to this sequence of keystrokes as $\boxed{\text{2nd}}$ [LIST] MATH 4:median(.

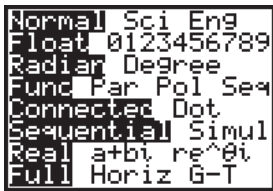### Home Screen $\boxed{\text{2nd}}$ [QUIT]
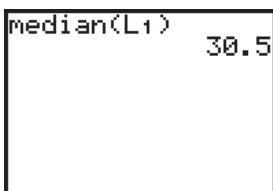
The Home screen is where you'll do most of your calculations. You access the Home screen from any other screen by pressing $\boxed{\text{2nd}}$ [QUIT]. The screen at left shows a calculation on the Home screen.

Mode Screen $\boxed{\text{MODE}}$

The Mode screen is where you set operating modes for the calculator. You access the Mode screen by pressing $\boxed{\text{MODE}}$. Among the settings you can change are the numeric notation, the number of decimal places displayed, the unit of angle measurements, and several graphing modes. This Calculator Guide generally refers to these settings as "modes." For example, the screen on next page shows

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```
Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real a+bi re^θi
Full Horiz G-T
```

the calculator in Normal mode, Radian mode, Function mode, Connected mode, Sequential mode, Real mode, and Full mode. It also shows the number of decimal places as floating. For a statistics course, it will be most beneficial for the calculator to be set in Function mode (**Func**) and Connected mode (**Connected**). Alternative settings will be discussed when necessary.

Lists

```
NAMES OPS MATH
2↑L₂
3:L₃
4:L₄
5:L₅
6:L₆
7:RESID
8↓TIME
```
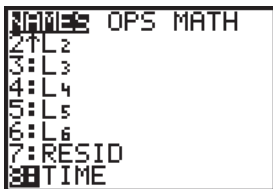
The TI-83 and TI-83 Plus use lists to store and manipulate sets of data. The calculator has six default lists, L₁ through L₆. Other lists can be named and created. To use lists L₁ through L₆ on the Home screen, press 2nd [L₁] through 2nd [L₆]. To see and use all lists, including user-created lists, press 2nd [LIST] and look at the NAMES submenu.
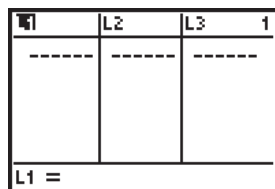
Creating Other Lists

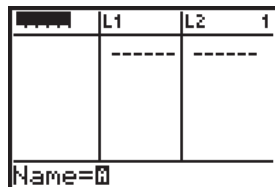Lists other than L₁ through L₆ can be named and created by following these steps:

a. Press STAT 1:**Edit** to enter the List Editor screen.

```
L1      L2      L3      1
------  ------  ------
------  ------

L1(1)=
```
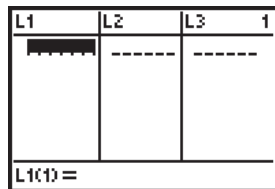
b. Arrow up and highlight the name of a list.

```
L1      L2      L3      1
------  ------  ------
------  ------

L1 =
```

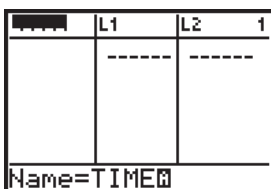**c.** To insert the new list before any preexisting list, press insert, 2nd [INS]. To place the new list after all preexisting lists, arrow right past the last list.

```
____    L1      L2      1
------  ------
------  ------

Name=▮
```

(continued)

d. Enter the name of your list, for example, TIME. Press ENTER to accept the new list name.

```
      L1     L2      1
     ------ ------



Name=TIME■
```
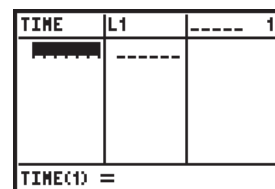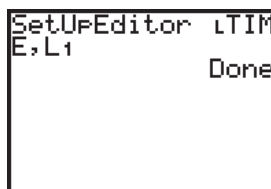
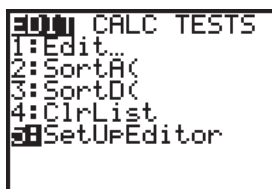**e.** Arrow down and begin entering data.

The new list, TIME, is now listed under the NAMES submenu when you press 2nd [LIST].

Manipulating the List Editor Screen

The default List Editor screen displays lists L1 through L6. To change it to any combination of lists, press STAT 5:SetUpEditor. Enter the names of the desired lists, separated by commas. (Press 2nd [LIST] and use the NAMES submenu to select user-defined lists.) Then press ENTER. The List Editor screen will now contain only the lists specified.

```
EDIT CALC TESTS
1:Edit…
2:SortA(
3:SortD(
4:ClrList
5▊SetUpEditor
```
```
SetUpEditor ∟TIM
E,L1
           Done
```
```
TIME   L1    -----  1
      ------


TIME(1) =
```
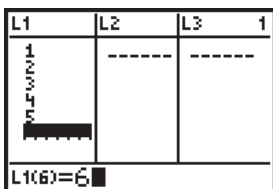
To return to the default, lists L1 through L6, execute the SetUpEditor command with no lists specified.

Entering Data into Lists

There are two ways to enter data into lists.

```
{1,2,3,4,5}→L1
     {1 2 3 4 5}
■
```
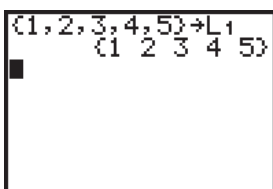
a. Enter the elements into the Home screen, separated by commas and enclosed in braces. Then press the store key, (STO→), enter the name of the list, and press ENTER.

```
L1    L2    L3     1
1    ------ ------
2
3
4
5

L1(6)=6■
```

b. Alternatively, press STAT 1:Edit and enter the elements directly into the List Editor screen. Place the cursor in the desired cell, type the value, and press ENTER.

(continued)

Clearing a List of Its Elements

There are three ways to clear lists.

a. Press STAT 4:ClrList, enter the names of the lists separated by commas, and press ENTER. For example, to clear list L1, enter ClrList L1 into the Home screen.

b. Alternatively, enter the List Editor screen, arrow up and left or right to highlight the name of the list, and press CLEAR ENTER.

c. To clear all lists, press 2nd [CATALOG], scroll down to ClrAllLists, and press ENTER ENTER.

List Submenus   2nd [LIST]

When you press 2nd [LIST], there are three major submenus used for manipulating lists: list names (NAMES), list operations (OPS), and mathematical functions (MATH).

While you will use several of these functions for a statistics course, you do not need all of them. Pertinent functions will be discussed in more detail when appropriate.

Graphing

Before detailing the substantial graphing powers of the TI-83 and T1-83 Plus, let's discuss some of the foundational issues that underlie all graphing.

(continued)

```
WINDOW
 Xmin=-9.4
 Xmax=9.4
 Xscl=1
 Ymin=-6.2
 Ymax=6.2
 Yscl=1
 Xres=1
```

Window Settings   WINDOW

This Window screen controls the section of the rectangular coordinate system that is viewed when a function plot or a statistical plot is graphed. Press WINDOW and enter these values:

Xmin = the minimum *x*-value you want to display

Xmax = the maximum *x*-value you want to display

Xscl = the number of units between tick marks on the *x*-axis

Ymin = the minimum *y*-value you want to display

Ymax = the maximum *y*-value you want to display

Yscl = the number of units between tick marks on the *y*-axis

Xres = 1

In this Calculator Guide, window settings for a graph are listed in the form [Xmin, Xmax, Xscl, Ymin, Ymax, Yscl]. For example, the window settings above would be listed as $[-9.4, 9.4, 1, -6.2, 6.2, 1]$.

Zoom Commands   ZOOM

Zoom commands allow you to zoom in or out, or to set the Window screen to pre-set settings. You access the Zoom menu by pressing ZOOM.
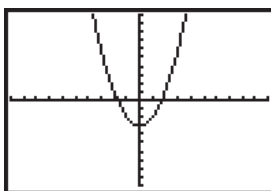
```
ZOOM MEMORY
1:ZBox
2:Zoom In
3:Zoom Out
4:ZDecimal
5:ZSquare
6:ZStandard
7↓ZTrig
```
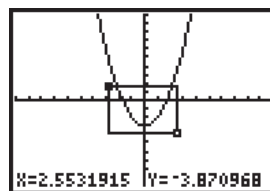
```
8:ZInteger
9:ZoomStat
0:ZoomFit
```

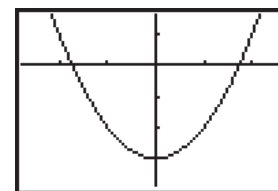There are three zoom commands that allow you to zoom in and out: 1:ZBox, 2:Zoom In, and 3:Zoom Out.

1. ZBox lets you draw a box around the region of interest. When you press ENTER, this region fills the screen.

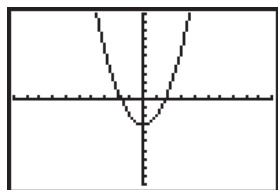

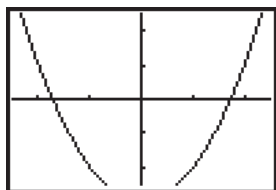$[-10, 10, 1, -10, 10, 1]$ $[-10, 10, 1, -10, 10, 1]$ $[-2.77, -2.55, 1, -3.87, 1.61, 1]$
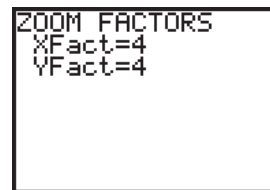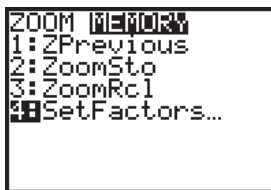
(continued)

2. **Zoom In** lets you position the cursor at a center point for the zoom. When you press ENTER, the graph will be magnified about the center by factors defined by **XFact** and **YFact**. To change the factors, press ZOOM **Memory 4:SetFactors.**

$[-10, 10, 1, -10, 10, 1]$ $[-2.5, 2.5, 1, -2.5, 2.5, 1]$

3. **Zoom Out** behaves similar to **Zoom In**, but the graph reduces about the center by factors defined by **XFact** and **YFact**.

There are three pre-set window settings: **4:ZDecimal**, **6:ZStandard**, and **7:ZTrig**.

4. **ZDecimal** uses the settings $[-4.7, 4.7, 1, -3.1, 3.1, 1]$.

5. **ZStandard** uses $[-10, 10, 1, -10, 10, 1]$.

6. **ZTrig** uses a window that is approximately $[-2\pi, 2\pi, \pi/2, -4, 4, 1]$.

Lastly, there are four zoom commands that reformat the window settings to match specific criteria: **5:ZSquare**, **8:ZInteger**, **9:ZoomStat**, and **0:ZoomFit**.

7. **ZSquare** adjusts either **Xmin** and **Xmax** or **Ymin** and **Ymax** such that the coordinate axes are square.
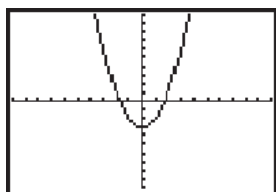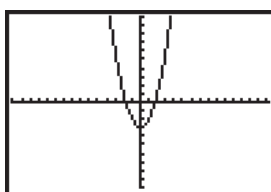
$[-10, 10, 1, -10, 10, 1]$ $[-15.16, 15.16, 1, -10, 10, 1]$

8. **ZInteger** adjusts the window settings such that the cursor moves in integer increments.

$[-10, 10, 1, -10, 10, 1]$ $[-47, 47, 10, -31, 31, 10]$

(continued)

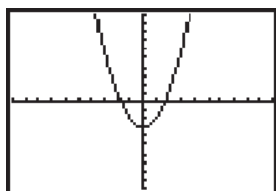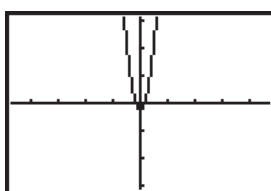9. ZoomStat is of particular interest for a statistics course. It adjusts the window settings to contain the data used for all active statistical plots. (See the following section "Statistical Plots" for more information about defining statistical plots.)

10. ZoomFit adjusts Ymin and Ymax to include the minimum and maximum within the current domain of all active function plots. It does not change Xmin and Xmax.

Tracing   TRACE
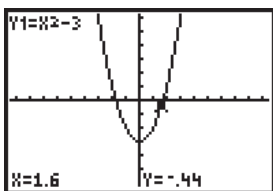
$[-9.4, 9.4, 1, 6.2, 6.2, 1]$

Pressing TRACE takes you to the Graph screen and gives you a trace cursor on the function plot or statistical plot. The plot being traced is shown in the upper-left corner, and the approximate coordinates of the trace point are shown at the bottom of the screen. Pressing the right or left arrow keys moves the trace cursor along the plot. If multiple plots are turned on, pressing the up or down arrow keys moves the trace cursor to another plot.

Function Plots   Y=
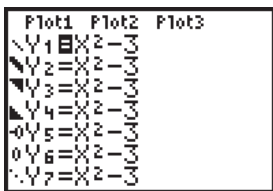
In Function mode, the TI-83 and TI-83 Plus can graph up to ten rectangular functions, Y1 through Y0. To enter a function, press Y= and enter the equation in *y=* form. When you enter a new function, the = symbol becomes highlighted, which means it will graph when you press GRAPH. You can turn off the graph of a function without clearing it from the Y= screen by arrowing left to its = symbol and pressing ENTER. When the = symbol is not highlighted, the equation is turned off and will not graph. In the screen at left, only Y1 is turned on.

Graph Styles

The calculator provides seven graphing styles: thin line, thick line, shade above, shade below, ball with path, ball without path, and dotted line. These styles are selected by arrowing left to the segment beside each Y and pressing ENTER to cycle through the styles. The screen above shows all seven styles selected for functions Y1 through Y7, respectively.

In Connected mode, the default style is the thin line. In Dot mode, the default is the dotted line. You can change this mode setting by pressing MODE and changing the fifth line. It is recommended, however, that you leave the calculator in Connected mode.

Statistical Plots [2nd] [STAT PLOT]

In any mode, the calculator allows you to graph up to three statistical plots, or stat plots. Press [2nd] [STAT PLOT] and select the number of the plot to define. Follow these steps:
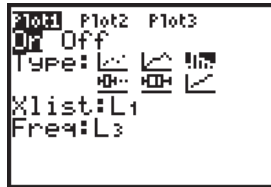
a. Select On.

b. Select one of the six plot forms: scatterplot, xyline plot, histogram, modified boxplot with outliers, boxplot, or normal probability plot.

c. Enter the lists and frequencies to be used into the stat plot. The information required depends on the type of plot. Scatterplots and xyline plots require two lists; histograms, modified boxplots, and boxplots require one list, and a number or list for frequencies. Normal probability plots require one list and a data axis. (*Note:* For plots that require frequencies, the frequencies can be entered into one of the lists.)

Scatterplot	**xyline Plot**	**Histogram**
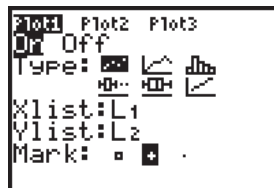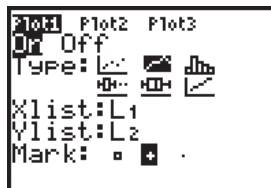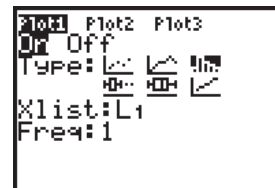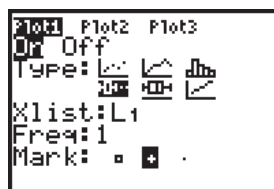
Modified Boxplot	**Boxplot**	**Normal Probability Plot**
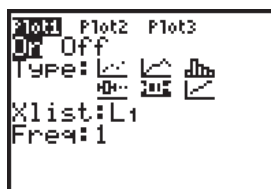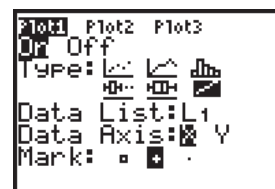
d. For scatterplots, xyline plots, and modified boxplots, select the mark to use in the plot. If you graph several plots at once, it is wise to use a different mark for each plot.

e. Set a window and press [GRAPH], or press [ZOOM] **9:ZoomStat** to see the plot.
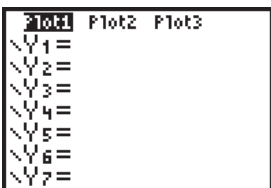
After you have a stat plot defined, you can turn it on or off from the Y= menu. Press [Y=] and arrow up to the line of plot names; arrow left or right to select the plot and press [ENTER] to turn it on or off. When the plot name is highlighted, it is turned on.

Statistics Submenus STAT

When you press STAT, there are three submenus used for critical statistical capabilities: EDIT, CALC, and TESTS.

The EDIT submenu allows you to enter the List Editor screen in order to edit lists, sort a list (or lists) in ascending or descending order, clear the contents of lists, or set up the List Editor screen.

Pertinent functions in the CALC and TESTS submenus will be discussed in more detail when appropriate.

```
EDIT CALC TESTS
1:Edit…
2:SortA(
3:SortD(
4:ClrList
5:SetUpEditor
```

```
EDIT CALC TESTS
1:1-Var Stats
2:2-Var Stats
3:Med-Med
4:LinReg(ax+b)
5:QuadReg
6:CubicReg
7↓QuartReg
```

```
EDIT CALC TESTS
1:Z-Test…
2:T-Test…
3:2-SampZTest…
4:2-SampTTest…
5:1-PropZTest…
6:2-PropZTest…
7↓ZInterval…
```

```
8:LinReg(a+bx)
9:LnReg
0:ExpReg
A:PwrReg
B:Logistic
C:SinReg
```

```
8:TInterval…
9:2-SampZInt…
0:2-SampTInt…
A:1-PropZInt…
B:2-PropZInt…
C:X²-Test…
```

```
D:2-SampFTest…
E:LinRegTTest…
F:ANOVA(
```

Variables Submenus VARS

The Variables submenus allow you to reference all of the variables that the calculator uses. For example, if you wish to reference Xmax for a graph, you can access its current value by pressing VARS 1:Window 2:Xmax. There are two submenus: VARS (generally single-value variables) and Y-VARS (equation and function definitions that would be entered into the Y= screen).

```
VARS Y-VARS
1:Window…
2:Zoom…
3:GDB…
4:Picture…
5:Statistics…
6:Table…
7:String…
```

```
VARS Y-VARS
1:Function…
2:Parametric…
3:Polar…
4:On/Off…
```

For a statistics course, the variables accessed by pressing VARS 5:Statistics are of particular importance and will be discussed in more detail when appropriate. The variables are stored under five submenus. Here are the summary statistic

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variables (XY), the regression variables (EQ), and the test variables (TEST) submenus.
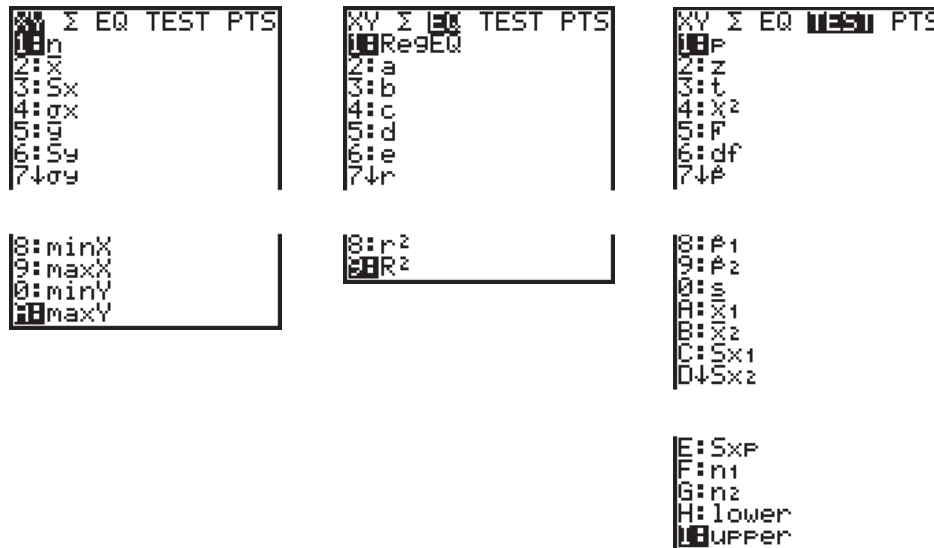
The rectangular function variables, VARS Y-VARS 1:Function, are also valuable to any course. For example, to evaluate the function stored in Y1, when $x = 3$, enter Y1(3) into the Home screen.
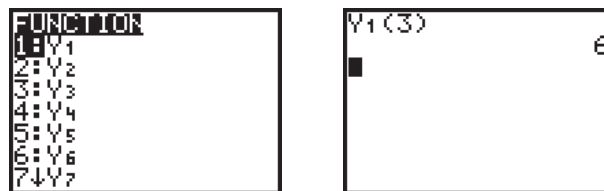
Distribution Menus   2nd [DISTR]

When you press 2nd [DISTR], there are two submenus that contain a wealth of functions regarding important statistical distributions. The distribution submenu, DISTR, contains probability density functions (pdf) and cumulative distribution functions (cdf) for the following distributions: normal, *t*, chi-square, F, binomial, Poisson, and geometric. (*Note:* F and Poisson distributions are not covered in *Statistics in Action.*)

For discrete random variables, the pdf functions return either the probability of $X = c$ or the distribution for all *X*. The cdf functions return the cumulative sum of the probabilities between a lower bound and an upper bound.

For continuous random variables, the pdf functions provide the distribution curve (for graphing purposes). The cdf functions return the area under the pdf curve between a lower bound and an upper bound.

(continued)

These functions will be discussed in more detail when appropriate.

```
DISTR DRAW
1▶normalpdf(
2:normalcdf(
3:invNorm(
4:tpdf(
5:tcdf(
6:X²pdf(
7↓X²cdf(
```

```
8:Fpdf(
9↑Fcdf(
0:binompdf(
A:binomcdf(
B:poissonpdf(
C:poissoncdf(
D:geometpdf(
E▶geometcdf(
```

```
DISTR DRAW
1▶ShadeNorm(
2:Shade_t(
3:ShadeX²(
4:ShadeF(
```

The DRAW submenu provides commands to draw distributions with shaded areas. For example, ShadeNorm(10,20,18,5) graphs a normal curve with mean 18 and standard deviation 5, and shades the area under the curve between *x*-values 10 and 20. (*Note:* These commands do *not* adjust the window settings. You must manually set the window before using these commands.)

Math Submenus   MATH

```
MATH NUM CPX PRB
1▶rand
2:nPr
3:nCr
4:!
5:randInt(
6:randNorm(
7:randBin(
```

Pressing MATH gives you four submenus of mathematical functions, such as cube roots, the absolute value function, and converting rectangular coordinates to polar coordinates. For statistics, the Probability submenu, PRB, contains frequently used counting commands and random number generators. The counting commands include permutations (nPr), combinations (nCr), and factorial (!). The random number generators include rand, which generates random numbers between 0 and 1; randInt, which generates a random integer within a specified interval; randNorm, which generates a random number from a specified normal distribution; and randBin, which generates a random integer from a specified binomial distribution.

Programs   PRGM

The TI-83 and TI-83 Plus are programmable calculators. To run a program, you press PRGM and choose the program name from the execute submenu, EXEC. You similarly edit a program by choosing its name from the EDIT submenu. You can also enter a new program by pressing PRGM NEW 1:Create New. Once a program

(continued)

Statistics in Action Calculator Guide for the TI-83 and TI-83 Plus

exists on one calculator, it can be shared by linking two calculators or by using Texas Instruments' TI Connect computer software.

Deleting a Program

To delete a program, press 2nd [MEM] 2:**Mem Mgmt/Del**. Then press 7:**Prgm**. Arrow down to the name of the program and press DEL. The calculator will ask you to confirm your deletion, 1:**No** or 2:**Yes**.

You can use 2nd [MEM] 2:**Mem Mgmt/Del** to delete other items, such as lists, functions, and applications.

Programs in This Calculator Guide

The CD-ROM that comes with the *Statistics in Action Instructor's Resource Book* contains several pre-written programs for this course. One such program is FREQTABL, which organizes the data in list L1 into a frequency table with values in list L2 and frequencies in list L3. Before running the program, enter your data into list L1. Run the program by pressing PRGM EXEC, choosing FREQTABL, and pressing ENTER.

For each program that is provided in this Calculator Guide, the code is printed. You can manually enter the code into your calculator, or you can use the TI Connect software to transfer the program from the CD-ROM to the calculator. To manually enter the program, press PRGM NEW 1:**Create New**, type the program's name, press ENTER, and then enter the code. Note that control and input/output commands, such as If, Then, Input, or Disp, are found by pressing PRGM while entering a new program. For more information about the programming

(continued)

capabilities of the TI-83 and TI-83 Plus, including the programming code, refer to your calculator's *Graphing Calculator Guidebook.*

```
CTL I/O EXEC          CTL I/O EXEC
1:If                  1:Input
2:Then                2:Prompt
3:Else                3:Disp
4:For(               4:DispGraph
5:While              5:DispTable
6:Repeat             6:Output(
7↓End                7↓getKey
```

Other programs are available through many sources, including Texas Instruments' website, http://education.ti.com. You may want to search the Internet for programs that could be worthwhile to your statistics course. (*Note:* Students planning to take the AP Statistics examination should not become dependent on programs. Some programs that surpass the standard commands on the calculator may be considered as "unacceptable enhancements" and may not be allowed during the examination.)

```
PROGRAM:FREQTABL              L₁(1)→L₂(1)
ClrHome:FnOff :PlotsOff       sum(L₁=L₂(1))→L₃(1)
Disp "FREQUENCY TABLE"        For(I,2,dim(L₁),1)
Disp ""                       If L₁(I)=L₁(I-1)
Disp "DATA MUST BE            Goto A
Disp "ENTERED INTO L₁"        N+1→N
Disp "PRESS ENTER"            L₁(I)→L₂(N)
Pause                         sum(L₁=L₂(N))→L₃(N)
Disp ""                       Lbl A
Disp "PROCESSING..."          End
ClrList L₂,L₃                 Disp ""
SortA(L₁)                     Disp "TABLE IN L₂, L₃"
1→N
```

Applications   APPS

Many Texas Instruments calculators—including the TI-83 Plus—allow you to add Handheld Software Applications (Apps) that increase the calculator's functionality, in much the same way that you add software to a computer. (*Note:* You cannot add Apps to a TI-83.) An App is different from a program because you can neither edit nor modify an App. Also, an App is often registered to a specific calculator, so you cannot share it by linking calculators.

New TI-83 Pluses may come with some Apps pre-installed. You can view the calculator's list of applications by pressing APPS.

```
APPLICATIONS
1:Finance…
2:CBL/CBR
3:CtlgHelp
4:DataMate
5:Inequal
```
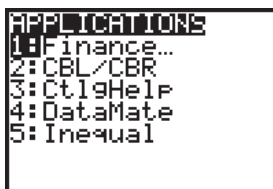
(continued)

A variety of sources provide Apps. Some Apps are free while others require that you purchase them. You may find a few Apps that are beneficial to your statistics course. Again, Texas Instruments' website, http://education.ti.com, is a good place to begin searching.

Catalog Help Application

Catalog Help (**CtlgHelp**) is an App that provides the necessary syntax for every calculator command. Catalog Help is preloaded on many newer-model TI-83 Pluses, and it is available free-of-charge through Texas Instruments' website. This application is helpful for a statistics course because it reminds you of the parameters required for statistical functions.

To begin running Catalog Help, press APPS and select it from the Applications menu. Now, from any menu or the catalog, you can press + to see the syntax of any command. For example, pressing MATH **NUM 2:round** + shows that the round command requires a value and the number of decimal places. The number of decimal places is optional, however, because this parameter is in square brackets.

Once you know the syntax, you can press GRAPH to escape or you can enter the parameters on the Catalog Help screen and press TRACE to paste. To quit using Catalog Help, press APPS, choose **CtlgHelp**, and select **2:Quit CtlgHelp**.

CHAPTER 1 | A CASE STUDY OF STATISTICS IN ACTION

Section 1.1 ▪ Discrimination in the Workplace: Data Exploration

Dot Plots

The TI-83 and TI-83 Plus do not have the built-in capability to produce dot plots. For small to medium data sets, you can use the program DOTPLOTS. Before running the program, enter your data into any list on your calculator (L1 to L6, or any user-defined list). Press PRGM EXEC, choose DOTPLOTS, and press ENTER. At the prompt, enter the name of the list that contains your data and press ENTER. (Press 2nd [LIST] NAMES to select user-defined lists.) The calculator will show a dot plot on the Graph screen. You can press TRACE to see the value of each dot and to count the number of dots in each column.

```
DOT PLOTS
WHICH LIST? L1■
```

```
P1:L,A


         ×
X=2            Y=5
```
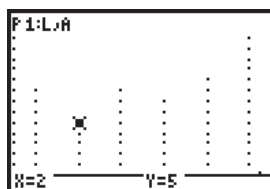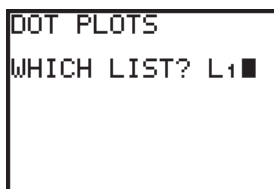
See "Programs" in the previous section for more information about programs. If you are manually entering this program, refer to your calculator's *Graphing Calculator Handbook* for information about programming code.

```
PROGRAM:DOTPLOTS              Then
ClrHome:FnOff :PlotsOff        ʟA(I-1)+1→ʟA(I)
Disp "DOT PLOTS"               Goto A
Disp ""                        End
Input "WHICH LIST? ",ʟL        1→ʟA(I):Goto B
Disp ""                        Lbl A
Disp "PROCESSING..."           End
dim(ʟL)→dim(ʟA)                Lbl B
SortA(ʟL)                      End
1→ʟA(1)                        Plot1(Scatter,ʟL,ʟA,·)
For(I,2,dim(ʟL),1)             ZoomStat
If ʟL(I)=ʟL(I-1)
```

Section 1.2 ▪ Discrimination in the Workplace: Inference

Activity 1.1 By Chance or by Design?

Activity 1.1 should be performed as directed in the text. Performing this activity as a concrete simulation—physically drawing random index cards—gives you invaluable insight into the process of simulation.

After you have done the concrete simulation, you may want to repeat the activity using a calculator. Doing so reinforces the results of the concrete simulation. The four-step process that is outlined below is consistent with the AP Statistics examination's requirements for simulations. You can apply this four-step process to any simulation—using concrete objects, using random number tables, or using technology.

a. Assignment of Code Numbers
Code each of the ages using a reasonable scheme. For example, you may choose to assign the integers 1 to 10 to the respective ages of the employees.

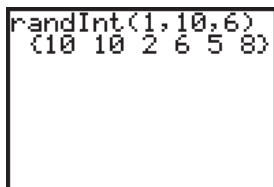| Digit	1	2	3	4	5	6	7	8	9	10
Age	25	33	35	38	48	55	55	55	56	64

Now, with a TI-83 or TI-83 Plus, you can use the **randInt(** command to select one of the code digits. You find this command by pressing MATH **PRB 5:randInt(**. The syntax of the command is **randInt(***start, end, n*), such that it will select *n* random integers from the closed interval [*start, end*].

b. Address the Issue of a Selection of Duplicate Code Numbers
In the concrete simulation, once a card is selected it is not returned, guaranteeing that an employee cannot be selected a second time. Therefore, in this simulation, duplicates are not allowed.

```
randInt(1,10,6)
  {10 10 2 6 5 8}
```

Unfortunately, on the TI-83 and TI-83 Plus, random number generators sample with replacement. Therefore, if you execute **randInt(1,10,3)**, you might not select three unique values. One solution is to generate more integers than are required. For example, **randInt(1,10,6)** generates six random integers from which you will choose the first three unique values.

In the screen at left, you select code numbers 10, 2, and 6, corresponding to the ages 64, 33, and 55. The duplicate 10 is ignored.

c. Stopping Rule
State a rule that indicates when the simulation is completed. In Activity 1.1, each trial consists of three selections and the simulation continues for ten trials.
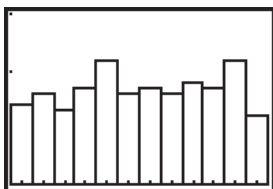
d. Result
You should clearly indicate the result of the simulation.
There are, of course, programs and applications that will perform simulations without replacement. If time allows, you may want to search for these alternatives and present them to your class.

Section 2.1 ▪ The Shape of Things: Visualizing Distributions

Uniform or Rectangular Distribution

[0.5, 12.5, 1, 0, 30, 10]

As suggested on page 26 of the *Statistics in Action* student text, the TI-83 and TI-83 Plus have two commands that generate approximately uniform distributions. Under the MATH **PRB** submenu, **rand(**n**)** randomly selects n numbers from the open interval (0, 1), and **randInt(***start, end, n***)** selects n integers from the closed interval [*start, end*]. For example, if you enter **randInt(1,12,200)** → **L1** into the Home screen, a histogram of list **L1** will look something like the screen at left. This particular example could represent the number of births per month for a sample of size 200. (For more information about histograms, see Section 2.2.)

Normal Distribution   2nd [DISTR] DISTR 1:normalpdf(

To graph a normal curve, go to the Y= screen and define a function in the form **Y=normalpdf(X,** *mean, standard deviation*). You find the **normalpdf(** command by pressing 2nd [DISTR] DISTR **1:normalpdf(**. If you do not specify the mean and standard deviation, the calculator assumes they are 0 and 1. The pdf suffix stands for *probability density function*. Using **normalpdf(** as the definition of a function provides the *y*-coordinates of the normal curve.

There is no zoom command that gives a "friendly" graph of a normal curve. Instead, use these guidelines to set the Window screen:

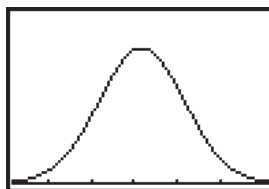$$\text{Xmin} = mean - 3\ SD$$

$$\text{Xmax} = mean + 3\ SD$$

$$\text{Xscl} = SD$$

$$\text{Ymin} = 0$$

$$\text{Ymax} = \frac{1}{2\ SD}$$

$$\text{Yscl} = 0$$

[14, 86, 12, 0, 0.042, 0]

(continued)

If you are interested in graphing more than one normal curve to show, for example, the effect of changes in standard deviation, you can enter two separate functions into the Y= screen. Or you can enclose the standard deviations in braces and use a single function. In either case, use the following "friendly" window:

$$\text{Xmin} = mean - 3(Largest\ SD)$$

$$\text{Xmax} = mean + 3(Largest\ SD)$$

$$\text{Xscl} = Largest\ SD$$

$$\text{Ymin} = 0$$

$$\text{Ymax} = \frac{1}{2\ Smallest\ SD}$$

$$\text{Yscl} = 0$$
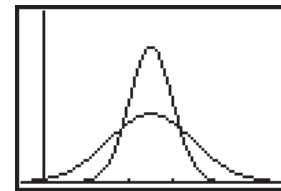
$[-10, 110, 20, 0, 0.05, 0]$

Section 2.2 ▪ Graphical Displays for Distributions

Histograms

The TI-83 and TI-83 Plus display frequency histograms and allow control over the attributes of the plot via the Window screen. First, enter the data values into a list, say, list L1. If you have frequencies associated with the data values, enter the frequencies into another list, say, list L2. (See "Lists" in the introduction for information about entering data into lists.) The examples below use the speeds of mammals from Display 2.24 on page 39 of the Statistics in Action student text. The data were entered in list L1.

Second, go to the Stat Plot screen, 2nd [Stat Plot], and define a histogram. Histograms are the third option under Type.

(continued)
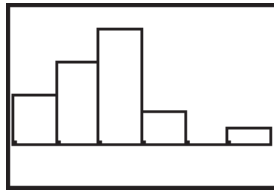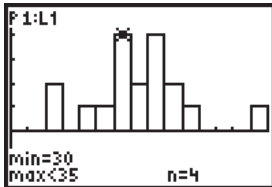
If you press ZOOM **9:ZoomStat**, the histogram will fill the Graph window. The bars, however, may have unusual widths and dividing lines.

$[11, 81.8, 11.8, -2.10, 8.19, 10]$
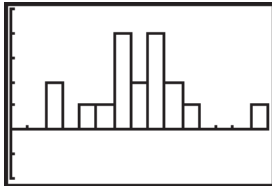
$[0, 75, 5, -2, 5, 1]$

The width of the bars is determined by **Xscl**, starting at **Xmin**. To change the width dividing lines of the bars, reset the Window screen. For example, the window $[0, 75, 5, -2, 5, 1]$ starts the first bar at 0 and starts a new bar every 5 units. Needless to say, as the bar width changes and data values are redistributed, you may need to adjust **Ymax**, too.

$[0, 75, 5, -2, 5, 1]$

When you trace the histogram, you see the lower and upper bounds of each bar and the number of data values (the frequency) of each bar. Please note that a value that falls at the dividing line between two bars is put in the bar on the right.

Unfortunately, the TI-83 and TI-83 Plus do not provide relative frequency histograms. One way to work-around this is to divide each frequency by the total number of data values. For example, enter your data values into list L1 and enter your frequencies into list L2. Then arrow up and right to highlight the name of list L3 and enter L2/**dim**(L2). Find the **dim(** command by pressing 2nd [**LIST**] **OPS** **3:dim(**. (*Note:* If you enter the expression in quotation marks, ALPHA ["], the definition will be dynamic and the values will update whenever list L2 changes.) Then create a histogram using lists L1 and L3. You should remember, however, that the shape of the relative frequency histogram is identical to that of the frequency histogram.

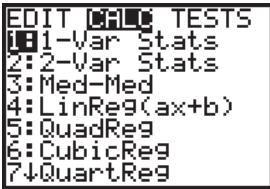## Stem Plots

Stem plots are not a built-in feature of the TI-83 and TI-83 Plus. If desired, you could do an Internet search for programs that add this functionality.

Bar Graphs for Categorical Data

Bar graphs are not a built-in feature of the TI-83 and TI-83 Plus. Some bar graphs with numerical categories can be simulated with histograms, but using computer software may be more efficient.
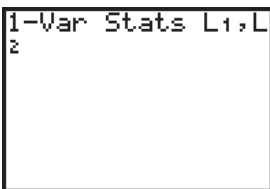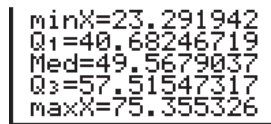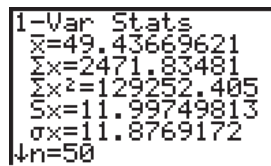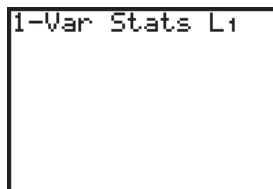
Section 2.3 ▪ Measures of Center and Spread

Numerical Summaries   STAT CALC 1:1-Var Stats

EDIT **CALC** TESTS
1▪1-Var Stats
2:2-Var Stats
3:Med-Med
4:LinReg(ax+b)
5:QuadReg
6:CubicReg
7↓QuartReg

Consistent with the discussion throughout Section 2.3 of the student text, the TI-83 and TI-83 Plus provide summary statistics. Using the 1-Var Stats command from the STAT CALC submenu, you can calculate a variety of summary statistics for any data set stored in a list. The summary statistics include mean, median, standard deviation, and quartiles.

In general, you enter 1-Var Stats into the Home screen followed by the name of the list.

1-Var Stats L₁

1-Var Stats
$\bar{x}$=49.43669621
Σx=2471.83481
Σx²=129252.405
Sx=11.99749813
σx=11.8769172
↓n=50

minX=23.291942
Q₁=40.68246719
Med=49.5679037
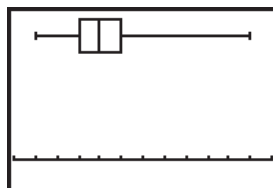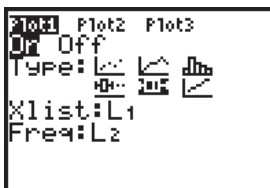Q₃=57.51547317
maxX=75.355326

1-Var Stats L₁,L₂

If your data set is contained in a frequency table, you enter the names of two lists separated by a comma—first, the list that contains the data values, and second, the list that contains the frequencies.

Please note that the mean is listed as $\bar{x}$. The calculator does not distinguish between sample mean and population mean. The calculator does, however, provide two standard deviations. Sx is the sample standard deviation calculated with division by $(n - 1)$. σx is the population standard deviation calculated with division by n.

Also, please note the complete five-number summary is displayed on the lower portion of the 1-Var Stats screen.

Five-Number Summaries, Outliers, and Boxplots

The TI-83 and TI-83 Plus provide two types of boxplots: regular and modified. The regular boxplot (the fifth option for Type within a Stat Plot screen) does not indicate outliers, whereas the modified boxplot (sixth option) does. As with histograms, you specify a list for frequencies if your data is contained in a frequency table.

Plot1 Plot2 Plot3
On Off
Type:
Xlist:L₁
Freq:L₂

$[5, 65, 5, -1, 6, 0]$

Plot1 Plot2 Plot3
On Off
Type:
Xlist:L₁
Freq:L₂
Mark: □ ■ ·

$[5, 65, 5, -1, 6, 0]$

(continued)

P1:L1,L2

X=35
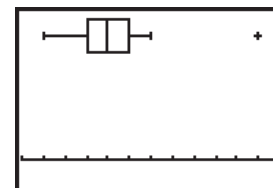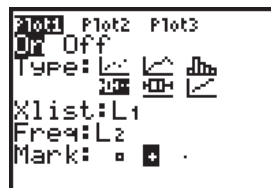
[5, 65, 5, −1, 6, 0]

Pressing TRACE when a boxplot is displayed traces the values of the five-number summary. For modified boxplots, you can trace the values of the whiskers and the outliers.

Percentiles and Cumulative Frequency Plots

The TI-83 and TI-83 Plus can construct a cumulative frequency plot using the following procedure:

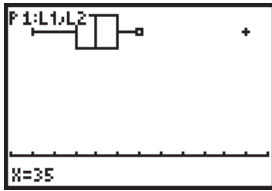**a.** Enter data values and frequencies into lists L_1 and L_2, respectively.

L1	L2	L3	3
10	3		
15	5		
20	8		
25	12		
30	9		
35	6		
60	2		

L3(1)=

b. Arrow up and right to highlight the name of list L_3. Enter **cumSum(L_2)**. The **cumSum(** command is found by pressing 2nd [**LIST**] **OPS 6:cumSum(**. (*Note:* If you enter the expression in quotation marks, ALPHA ["], the definition will be dynamic and the values will update whenever list L_2 changes.)

NAMES	OPS	MATH
1:SortA(		
2:SortD(		
3:dim(		
4:Fill(		
5:seq(		
6:cumSum(		
7↓ΔList(		

L1	L2	L3	3
10	3		
15	5		
20	8		
25	12		
30	9		
35	6		
60	2		

L3 ="cumSum(L₂)"

c. Press ENTER to have list L_3 calculate the cumulative sums.

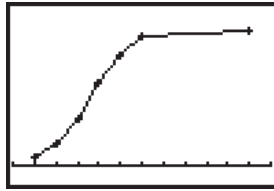| L1	L2	L3	3
10	3	3	
15	5	8	
20	8	16	
25	12	28	
30	9	37	
35	6	43	
60	2	45	

L3(1)=3

d. Press 2nd [**STAT PLOT**] to define an xyline plot that is a cumulative frequency plot. Use lists L_1 and L_3.

Plot1 Plot2 Plot3
On Off
Type: 〳 〱 〸
Xlist:L₁
Ylist:L₃
Mark: □ ✛ ·

(continued)

e. Press ZOOM 9:**ZoomStat** to display the cumulative frequency plot.

[5, 65, 5, −4.14, 52.14, 0]
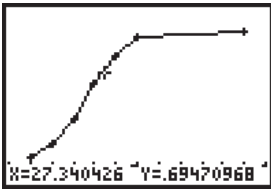
[5, 65, 5, −0.92, 1.159, 0]

A cumulative relative frequency plot can be constructed by entering **cumSum(L2)/sum(L2)** as the definition of list L3. Find the **sum(** command by pressing 2nd [LIST] **MATH** 5:**sum(**. With a cumulative relative frequency plot, you can move the cursor to identify the data value for any percentile. For example, to find the value that is at the 70th percentile, move the cursor to the point on the graph whose *y*-coordinate is approximately .70. The *x*-coordinate is the data value for the 70th percentile.

Measuring Spread About the Mean: The Standard Deviation

Many calculators and computers have efficient, built-in functions for calculating the standard deviation. Nonetheless, performing the calculations by hand may help you understand the meaning in the formula. The TI-83 and TI-83 Plus can support hand calculations with the spreadsheet capabilities of the List Editor.

a. Enter the data into list L1.

b. Define list L2 to be the deviations, $x - \bar{x}$. You do this with either the expression L1-**mean(L1)** or L1-**sum(L1)/dim(L1)**. Find **mean(** and **sum(** in the mathematical functions submenu, 2nd [LIST] **MATH**. Find **dim(** in the list operations submenu, 2nd [LIST] **OPS**. (*Note:* If you enter the expression in quotation marks, ALPHA ["], the definition will be dynamic and the values will update whenever list L1 changes.)

c. Define list L3 to be the squared deviations, $(x - \bar{x})^2$. Use the expression L2².

d. Complete the calculations on the Home screen. The expression $\sqrt{}$(**sum(L3)/(dim(L3)-1))** calculates the sum of the square deviations, divides by one less than the number of data values, and takes the square root.

(continued)

Properties of Summary Statistics

The 1-Var Stats command makes it relatively easy for you to explore and recall the effects of recentering or rescaling. For example, to determine the effect of tripling each data value in any data set, first enter a small, hypothetical data set into list L1. Use 1-Var Stats on the original data set. Then define list L2 as the triple of each value, 3∗L1, and use 1-Var Stats on the rescaled data. You can see which of the summary statistics are likewise tripled.

Summaries from a Frequency Table

See "Numerical Summaries" in this chapter for information about calculating summaries from a frequency table.

Section 2.4 ▪ The Normal Distribution

Unknown Percentage and Unknown Value Problems

Normal Cumulative Distribution Function   2nd [DISTR] DISTR 2:normalcdf(

On the Home screen, a command in the form normalcdf(x_1, x_2, *mean*, *standard deviation*) returns the area under a normal curve and on the interval $[x_1, x_2]$ for the normal distribution specified by *mean* and *standard deviation*. You find the normalcdf(command by pressing 2nd [DISTR] DISTR 2:normalcdf(. The cdf suffix stands for *cumulative distribution function*. Technically, a cumulative distribution function returns the percentage of area under a continuous distribution curve from negative infinity to the value of interest. The normalcdf(command, however, is designed such that the lower bound of the interval can be specified as any value. For example, to find the percentage of area below a normal curve with mean 50 and standard deviation 12 over the interval $[45, 65]$, enter normalcdf(45,65,50,12) into the Home screen.

(continued)
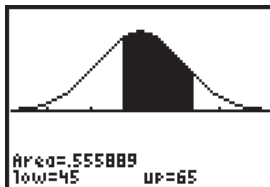
Shading a Normal Curve   2nd [DISTR] DRAW 1:ShadeNorm(

To see a graph of the shaded area, use the ShadeNorm(command. You find this command by pressing 2nd [DISTR] DRAW 1:ShadeNorm(. You enter ShadeNorm(into the Home screen.

$$[14, 86, 12, -0.03, 0.042, 0]$$

Please note that the ShadeNorm(command does not adjust the window settings. Use these guidelines to set the Window screen:

$$\text{Xmin} = mean - 3\ SD$$

$$\text{Xmax} = mean + 3\ SD$$

$$\text{Xscl} = SD$$

$$\text{Ymin} = -0.03$$

$$\text{Ymax} = \frac{1}{2\ SD}$$

$$\text{Yscl} = 0$$

(*Note:* If you use ShadeNorm(repeatedly, press 2nd DRAW 1:ClrDraw to clear the drawing between each use.)

Using Infinity as a Bound

If one of the bounds of the interval is infinite, use 1×10^{99} or -1×10^{99} to represent positive or negative infinity, respectively. You enter scientific notation using 2nd [EE] to place E between the coefficient and the exponent on 10. You can use 1E99 and −1E99 with both normalcdf(and ShadeNorm(. For example, to find the area below a normal curve with mean 50 and standard deviation 12 over the interval $[-\infty, 42]$, use normalcdf(−1E99,42,50,12) or ShadeNorm(−1E99,42,50,12).
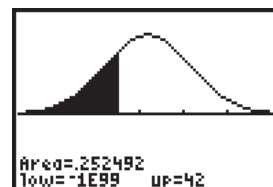
$$[14, 86, 12, -0.03, 0.042, 0]$$

The Standard Normal Curve

Defaults for the Normal Curve Commands

All of the normal curve commands—normalpdf(, normalcdf(, ShadeNorm(, and invNorm(—assume the standard normal distribution as a default. If you do not specify the mean and standard deviation, the calculator assumes 0 and 1,

(continued)

```
invNorm(.32,0,1)
       -.4676988012
■
```

respectively. However, it may be beneficial for you to always specify a mean and standard deviation, even if they are 0 and 1.
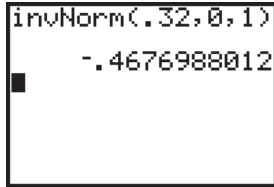
Z-scores   [2nd] [DISTR] DISTR 3:invNorm(

In order to find a *z*-score, the calculator includes the command **invNorm(**, which is found by pressing [2nd] [DISTR] DISTR 3:invNorm(. This command returns the value of *z* for the specified area to the right of *z*. The command is entered in the form **invNorm(***area, mean, standard deviation*). For example, to find the *z*-score that corresponds to a percentage of .32 (left tail area) under the standard normal curve, enter **invNorm(.32,0,1)** into the Home screen.

(*Note:* The **invNorm(** command can give the *z*-score that corresponds to the specified left tail area for *any* normal distribution, not just the standard normal distribution.)

Central Intervals for Normal Distributions

The central intervals shown on page 88 of the student text can be verified with great accuracy using the **ShadeNorm(** command. For example, to verify the 68% interval, enter **ShadeNorm(−1,1,0,1)**.

```
ShadeNorm(-1,1,0
,1)■
```



```
Area=.682689
low=-1      up=1
```
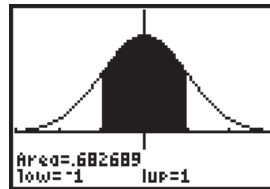
$[-3, 3, 1, -0.2, 0.5, 0]$

CHAPTER 3 RELATIONSHIPS BETWEEN TWO QUANTITATIVE VARIABLES

Section 3.1 ▪ Scatterplots

Setup
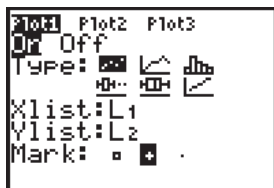
The TI-83 and TI-83 Plus can display scatterplots of bivariate data contained in any two lists, say, lists L1 and L2. This particular example uses the mean net income for family practitioners from Display 3.20 on page 119 of the student text.

Go to the Stat Plot screen, [2nd] [STAT PLOT], and define a scatterplot. Scatterplots are the first option under Type.

Press [ZOOM] 9:ZoomStat to fill the Graph window.
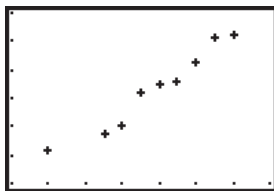
[80, 94, 2, 60, 120, 10]

When you trace the scatterplot, you see the coordinates of the data points.
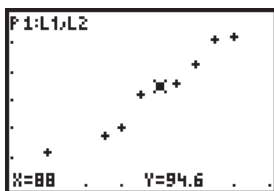
[80, 94, 2, 60, 120, 10]

It is important that you keep straight which is the independent variable (Xlist) and which is the dependent variable (Ylist).

Section 3.2 ▪ Getting a Line on the Pattern

Lines as Summaries

In order to graph a line on a scatterplot, you must separately define the scatterplot and enter the equation of the line into one of the functions on the Y= screen. This particular example corresponds to the family practitioners' income example on pages 119–120 of the student text.
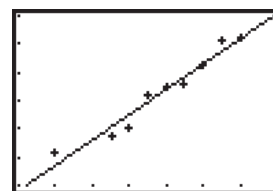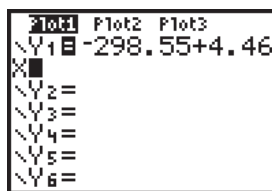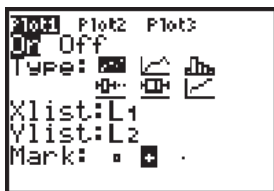
[80, 94, 2, 60, 120, 10]

(continued)

Using Lines for Prediction

Interpolation and Extrapolation

Once an equation is entered into the Y= screen, you can evaluate the function at any value of the independent variable on the Home screen. You access the function names by pressing VAR Y-VARS 1:Function.

For example, with $Y_1 = -298.55 + 4.46X$ defined, you can predict the y-coordinate when $x = 88$, by entering $Y_1(88)$.

```
FUNCTION
1:Y1
2:Y2
3:Y3
4:Y4
5:Y5
6:Y6
7↓Y7
```

```
Y1(88)
              93.93
```

Finding Residuals

The TI-83 and TI-83 Plus will efficiently calculate residuals for any line of fit using the spreadsheet capabilities of the List Editor.

a. First make sure that your data are entered into lists L_1 and L_2, and that the equation of your fitted line is entered into the Y= screen.

b. Define list L_3 as the predicted y-coordinates, $Y_1(L_1)$.

```
L1      L2        ▮    ♦ 3
82      71.4      67.17
85      77.9      80.55
86      80.3      85.01
87      91.5      89.47
88      94.6      93.93
89      95.9      98.39
90      102.7     102.85
L3 ="Y1(L1)"
```

c. Then define list L_4 as the residuals, $L_2 - L_3$.

```
L2       L3    ♦  ▮    ♦ 4
71.4     67.17     4.23
77.9     80.55    -2.65
80.3     85.01    -4.71
91.5     89.47     2.03
94.6     93.93     .67
95.9     98.39    -2.49
102.7    102.85   -.15
L4 ="L2-L3"
```

As an alternative, you could directly define list L_3 as the residuals using the expression $L_2 - Y_1(L_1)$.

```
L1      L2        ▮    ♦ 3
82      71.4      4.23
85      77.9     -2.65
86      80.3     -4.71
87      91.5      2.03
88      94.6      .67
89      95.9     -2.49
90      102.7    -.15
L3 ="L2-Y1(L1)"
```

(continued)

Least Squares Regression Lines

Sum of Squared Errors (SSE)

If the residuals for a fitted line are contained in a list, say, list L4, the Sum of Squared Errors (SSE) can be calculated. The examples below uses the DC9 data from pages 123–126 of the student text.

a. Define list L5 as the squares of the residuals, L4².

```
L3      ┃ L4     ┃ L5    ┃ 5
1737.5  ┃ 12.5   ┃ 156.25
1825    ┃ -25    ┃ 625
1912.5  ┃ 12.5   ┃ 156.25
------  ┃ ------ ┃ ------

L5 ="L4²"
```

b. On the Home screen, calculate the sum of list L5. Find the **sum(** command by pressing 2nd [LIST] MATH 5:**sum(**. The result is the SSE.

```
sum(L5)
            937.5
■
```

Using the Calculator to Find the Least Squares Regression Line

The TI-83 and TI-83 Plus provide two forms of the least squares regression line: $y = ax + b$ and $y = a + bx$. The **LinReg(ax+b)** and **LinReg(a+bx)** commands, as well as other regressive techniques, are found in the STAT CALC submenu. As explained on page 86 of the *Statistics in Action Instructor's Guide,* the form $y = a + bx$ has been accepted as the standard notation in statistics.

Although the regression commands default to lists L1 and L2, it is strongly recommended that you *always* include the names of the lists—independent then dependent—separated by commas.

```
EDIT CALC TESTS
4↑LinReg(ax+b)
5:QuadReg
6:CubicReg
7:QuartReg
8▊LinReg(a+bx)
9:LnReg
0↓ExpReg
```
```
LinReg(a+bx) L1,
L2■
```
```
LinReg
y=a+bx
a=862.5
b=8.75
```

If you'd like the calculator to calculate and display the correlation, r, and coefficient of variation, r^2, you must first turn Diagnostics on. Press 2nd [Catalog] [D], arrow down to **DiagnosticOn**, and press ENTER ENTER.

```
CATALOG        ▊
 Degree
 DelVar
 DependAsk
 DependAuto
 det(
 DiagnosticOff
▶DiagnosticOn
```
```
DiagnosticOn
            Done
```
```
LinReg
y=a+bx
a=862.5
b=8.75
r²=.9423076923
r=.9707253434
■
```

(continued)

You may paste the equation of the least squares line into the Y= screen in one of two ways. First, when using the regression command, you can specify a function after specifying the lists, for example **LinReg(a+bx)L1,L2,Y1**. The calculator will immediately put the equation into the Y= screen.

```
LinReg(a+bx) L₁,
L₂,Y₁
```

```
Plot1 Plot2 Plot3
\Y₁■862.5+8.75X
\Y₂=
\Y₃=
\Y₄=
\Y₅=
\Y₆=
\Y₇=
```

Second, you can paste the equation into the Y= screen after running the regression command. Press Y= and position the cursor beside one of the available functions. Press VARS **5:Statistics EQ 1:RegEq** to paste the equation in place.

```
Plot1 Plot2 Plot3
\Y₁=■
\Y₂=
\Y₃=
\Y₄=
\Y₅=
\Y₆=
\Y₇=
```

```
XY Σ EQ TEST PTS
1■RegEQ
2:a
3:b
4:c
5:d
6:e
7↓r
```

```
Plot1 Plot2 Plot3
\Y₁■862.5+8.75X
\Y₂=
\Y₃=
\Y₄=
\Y₅=
\Y₆=
\Y₇=
```

Section 3.3 ▪ Correlation: The Strength of a Linear Trend

See "Using the Calculator to Find the Least Squares Regression Line" above to learn how to get the correlation as part of regression. There is no way to calculate correlation automatically other than by performing a regression.

A Formula for the Correlation, r

If desired, the spreadsheet capabilities of the List Editor can aid the calculation of the correlation. This process resembles Display 3.41 on page 138 of the student text.

a. Enter the bivariate data into two lists, say, lists L1 and L2.

```
2-Var Stats L₁,L
₂
```

b. Press STAT CALC **2:2-VarStats** and specify the lists. Doing a 2-Var Stats calculates and stores the means, $\bar{x}$ and $\bar{y}$, the standard deviations, Sx and Sy, and the number of data values, n. All of these variables can now be accessed by pressing VARS **5:Statistics**.

c. Press STAT **1:Edit** to return to the List Editor screen.

d. Define list L3 with the expression $(L1-\bar{x})/Sx$.

e. Define list L4 with the expression $(L2-\bar{y})/Sy$.

f. Define list L5 with the expression L3*L4.

(continued)

g. On the Home screen, enter sum(L5)/(n−1). The result is the correlation, *r*. Find sum(by pressing 2nd [LIST] MATH 5:sum(.

Alternatively, after running the 2-Var Stats, you can directly calculate *r* on the Home screen by entering $sum(((L1−\bar{x})/Sx)((L2−\bar{y})/Sy))/(n−1)$.

Section 3.4 ▪ Diagnostics: Looking for Features That the Summaries Miss

Which Points Have Influence?

A calculator can support the investigation of potentially influential points. By eliminating questionable data points and rerunning the regression, you can numerically and graphically ascertain the effect of removing points that do not fit the general pattern of the scatterplot. Please note, however, that you must separately delete both the *x*- and *y*-coordinates of the data point in question. Within the List Editor screen, position the cursor on the *x*-coordinate to be deleted and press DEL. Repeat for the corresponding *y*-coordinate.

Residual Plots: Putting Your Data Under a Microscope

sum(LRESID)
                0

Each time The TI-83 and TI-83 Plus performs a regression, the calculator *automatically* computes the residuals and stores them in a list called RESID. Access this list by pressing 2nd [LIST] and going to the NAMES submenu.

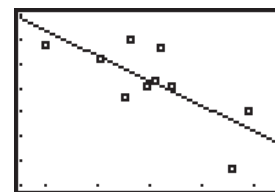Note that you can easily verify a necessary condition of residuals—that they sum to zero—by summing the values in RESID.

You can easily make a residual plot by creating a scatterplot with RESID as the Ylist. Here is the original plot and the residual plot for the data on percentage of on-time arrivals versus mishandled baggage from pages 161–162 of the student text.

[3.5, 8.5, 1, 45, 80, 5]
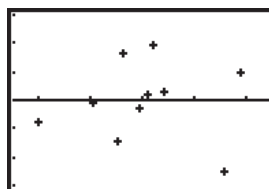
[3.5, 8.5, 1, −12, 12, 4]

Section 3.5 ▪ Shape-Changing Transformations

The TI-83 and TI-83 Plus can accomplish all of the transformations that are discussed in this section. However, the calculator always returns the coefficients of an equation in the form $y = a + bx$. It is up to you to note which transformations were used on which variables. For example, consider this small hypothetical data set that appears to exhibit an exponential relationship. Assume this data set relates days and growth, or data points in the form (d, g).
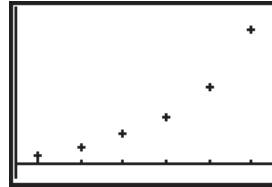
$[0.5, 6.5, 1, -15.5, 185.5, 1]$

A least squares regression on the original data gives the equation $y = -36.333 + 28x$. You should interpret this as $\hat{g} = -36.333 + 28d$.

A residual plot confirms that a linear equation is a bad fit.
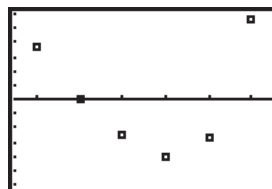
$[0.5, 6.5, 1, -30, 30, 5]$

Now use the List Editor screen to take the logarithm (base 10) of each of the growth values (list L2). Store these transformed values in list L3.

(continued)

Performing a least squares regression on the transformed data, $(d, \log(g))$, gives the equation $y = 0.806 + 0.234x$. You should interpret this as $\widehat{\log(g)} = 0.806 + 0.234d$.

```
LinReg(a+bx) L₁,
L₃,Y₂
```

```
LinReg
 y=a+bx
 a=.806317327
 b=.2336152028
 r²=.9956910377
 r=.997843193
```

A residual plot shows that the new equation is a better fit.
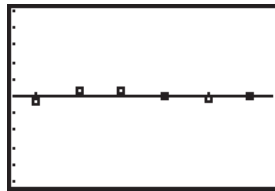
$[0.5, 6.5, 1, -0.5, 0.5, 0.1]$

The chapter presents several opportunities for concrete simulations using tools such as a deck of cards, coins, and so on. It is recommended that you use these concrete tools in order to build deeper understanding of random number generation and simulation. You may, however, want to use a calculator to generate random numbers as a complement to the concrete simulations. If you do, be sure to determine whether or not duplication is allowed. See "Section 1.2 Discrimination in the Workplace: Inference" for more help with calculator simulations.

Section 5.1 ▪ Sampling from a Population

Sampling with Random Digits

The opening discussion in this section, regarding the assignment of random digits, applies to random digit tables as well as the calculator. For example, to use Display 5.2 on page 269 of the student text, you can repeatedly use randInt(0,9,3) to create triples of random digits. You could also use rand, which generates a random number between 0 and 1, and use the first three digits of the result. Recall that you find the random number generators in the MATH PRB submenu.

Sampling with a Program

You can use the program SAMPLE, which selects N values at random from a distribution given in a relative frequency table. Before running the program, enter the values of x into list L1 and enter the probabilities associated with the values of the variable x (PF) or the cumulative probabilities up to and including each value of x (CDF) into list L2. Run the program by pressing PRGM EXEC, choosing SAMPLE, and pressing ENTER. At the prompt, enter the sample size, N, and press ENTER. The program stores the random sample in list L3 and pauses to display L3 on the screen. You can use the right and left arrow keys to scroll through the list. Press ENTER to end the program.

```
PROGRAM:SAMPLE
ClrHome
Disp "SAMPLING"
Disp ""
Disp "VALUES IN L1"
Disp "PF OR CDF IN L2"
Disp "RESULT IN L3"
DelVar LCDF
SetUpEditor L1,L2,L3
ClrList L3
If sum(L2)=1
Then
cumSum(L2)→LCDF
Else
L2→LCDF
End
Disp ""
```

```
Input "SAMPLE SIZE? ",N
Disp ""
Disp "PROCESSING..."
dim(L1)→M
For(I,1,N,1)
rand→X
For(J,1,M,1)
If X≤LCDF(M-J+1)
Then
L1(M-J+1)→L3(I)
End
End
End
DelVar LCDF
Disp ""
Pause L3
Stop
```

(continued)

The Mean and Standard Deviation of a Population

The TI-83 and TI-83 Plus can calculate the mean and standard deviation for probability distributions as well as for data distributions. Data values should be entered into one list, say, list L1, and relative frequencies should be entered into a second list, say, list L2. For example, here are the data for the number of motor vehicles from Display 5.1 on page 268 of the student text.

Execute **1-Var Stats** for these lists.

Notice these three characteristics of the output:

a. The value x̄=2.171 is the mean of the distribution, although the calculator does not label it μ.

b. The sample standard deviation is blank. The calculator assumes that this is a population calculation because the relative frequencies sum to 1.

c. The value $n = 1$ indicates the sum of the relative frequencies.

Section 5.2 ▪ Generating Sampling Distributions

Many statistics computer programs efficiently perform sampling from data sets and offer the option of sampling with and without replacement. Parallel programs for the TI-83 and TI-83 Plus can be written and executed but frequently without the efficiency and control of statistics computer programs.

Below is a procedure that generated a sampling distribution without requiring a program. This example uses the **randNorm(** command to create samples from a normally distributed population. You can also use the **randInt(** command or the **randBin(** command to create three uniformly distributed populations or binomially distributed populations, respectively. All three commands are under the MATH **PRB** submenu.

This example takes 50 random samples of size 5 from a normal distribution with mean 100 and standard deviation 12. Then the sample means are calculated and displayed.

(continued)

a. Enter randNorm(100,12,50)÷L₁ to load 50 randomly selected numbers from the population into list L₁.
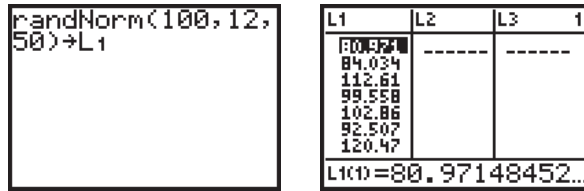
b. Repeat step a for lists L₂, L₃, L₄, and L₅.

c. Each row of the List Editor screen constitutes a random sample of size 5. Define list L₆ as the sum of the rows divided by 5.

List L₆ now contains 50 sample means from a normal population with mean 100 and standard deviation 12.

d. Analyze the sampling distribution in list L₆ both numerically and graphically.
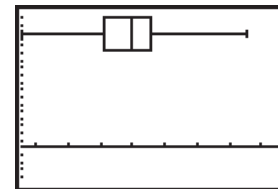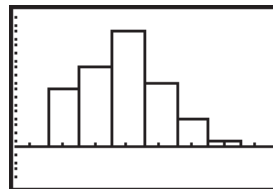
[84.89, 121.49, 4.58,   [84.89, 121.49, 4.58,
−4.81, 18.72, 1]   −4.81, 18.72, 1]

Needless to say, a greater number of samples would produce a more accurate picture of the sampling distribution.

Section 5.3 ▪ Sampling Distribution of the Sample Mean

The Central Limit Theorem

In order to demonstrate the Central Limit Theorem for a Sample Mean, you can use a calculator procedure similar to the one described in the section above. Look back at the 1-Var Stats screen for the example. Notice that, for a population that was normally distributed with mean 100 and standard deviation 12, 50 samples gave $\mu_{\bar{x}} = 100.076$ and $\sigma_{\bar{x}} = 5.729$.

(continued)

These values are consistent with the values dictated by the Central Limit Theorem, $\mu_{\bar{x}} = \mu = 100$ and $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} = 5.367$. The slight differences can be attributed to the fact that only 50 samples were considered.

To demonstrate the Central Limit Theorem for the Sample Mean from a skewed population, you can perform the same procedure on a highly skewed population, such as a binomial distribution with $p = 0.20$.

As an alternative to the sampling procedure, you can use the program SAMPMEAN, which selects random samples (with replacement) from a population stored in list L1, displays a sampling distribution, and calculates the mean of the sampling distribution and the standard error of the mean. Although the program may be slow, it is valuable for demonstrating the Central Limit Theorem for both normal and non-normal distributions.

Before running the program, enter the population data into list L1. Run the program by pressing [PRGM] EXEC, choosing SAMPMEAN, and pressing [ENTER]. At the prompts, enter the number of samples, S, and the sample size, N. Press [ENTER] after each value. The program collects samples and stores the sample means in list L2. A menu will appear from which you can view the statistics for the sampling distribution (mean and standard error), the statistics for the population data (mean and standard deviation), a histogram of the sampling distribution, or a histogram of the population. After viewing any of the statistics or histograms, press [ENTER] to return to the menu. To collect a new sampling distribution, choose 5:AGAIN. To end the program, choose 6:END.

```
PROGRAM:SAMPMEAN
PlotsOff :FnOff :ClrHome
Disp "SAMPLE MEANS"
Disp ""
Lbl C
ClrList L2,L3
1-Var Stats L1
Input "NUM SAMPLES? ",S
Input "NUM IN EACH? ",N
For(J,1,S,1)
For(I,1,N,1)
L1(randInt(1,dim(L1)))→L3(I)
End
mean(L3)→L2(J)
ClrList L3
End
```

```
min(L1)-2→Xmin:max(L1)+2→
       Xmax:(max(L1)-
       min(L1))/10→Xscl
Lbl E
ClrHome
Menu("CHOOSE:","STATS
       MEANS",A,"STATS
       DATA",F,"HIST
       MEANS",B,"HIST
       DATA",G,"AGAIN",C,
       "END",D)
Lbl A
ClrHome
Disp "NUM IN EACH",N
Disp "MEAN",mean(L2)
```

(continued)

(PROGRAM: SAMPMEAN continued)

```
Disp "SD",stdDev(L₂)
Pause
Goto E
Lbl B
PlotsOff
Plot1(Histogram,L₂)
S/2→Ymax:-
      .5→Ymin:1→Yscl:Xscl/2→
      Xscl
DispGraph
Pause
Xscl*2→Xscl
Goto E
Lbl F
```

```
ClrHome
Disp "DATA"
Disp "MEAN",x̄
Disp "SD",σx
Pause
Goto E
Lbl G
PlotsOff
Plot1(Histogram,L₁)
dim(L₁)/2→Ymax:-
      .5→Ymin:1→Yscl
DispGraph
Pause
Goto E
Lbl D
```

Finding Probabilities for Sample Means
Finding Probabilities for Sample Totals

```
normalcdf(-1E99,
30,35,15/√(50))
           .0092110461
```

Because the Central Limit Theorem applies to sampling distributions of sample means and sample totals, you know that the respective sampling distributions are approximately normal. Therefore, the **normalcdf(** command can be used to calculate probabilities for each statistic. For example, if you were to conduct random samples of size 50 from a large population that is approximately normal with mean 35 and standard deviation 15, then the probability of a sample mean less than or equal to 30 is found with **normalcdf($-$1E99,30,35,15/$\sqrt{}$(50))**.

Section 5.4 ▪ Sampling Distribution of the Sample Proportion

Activity 5.3 Buckle Up!

On the TI-83 and TI-83 Plus, the random binomial command, **randBin(**, generates a random integer from a specified binomial distribution. A binomial distribution counts the number of successes for a success-or-failure probability experiment, so you can use **randBin(** to create sampling distributions for this activity. (You will learn more about binomial distributions in Chapter 7 of the student text.)

```
MATH NUM CPX PRB
1:rand
2:nPr
3:nCr
4:!
5:randInt(
6:randNorm(
7▮randBin(
```

You find the **randBin(** command by pressing MATH PRB **7:randBin(**. The syntax of the command is **randBin(***sample size, probability of success, number of samples*). If the number of samples is not specified, the calculator assumes 1.

For example, to select a random sample of size 10 and count the number of successes, enter **randBin(10,.6)** into the Home screen. To calculate the sample proportion, divide the result by 10, or **randBin(10,.6)/10**. To do 100 samples and

(continued)

store the sample proportions into list L1, enter **randBin(10,.6,100)/10_L1**. You can now create a histogram of list L1. When setting the window, use **Xscl** = 1/*sample size.*
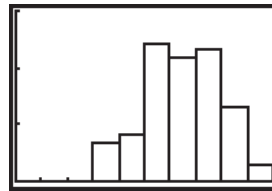
[0, 1, 0.1, 0, 30, 10]

If you want to create a relative frequency histogram, similar to those shown at the bottom of page 301 in the student text, run the FREQTABL program (see the "Programs" in the Introduction), which puts data values in list L2 and frequencies in list L3. Then define list L4 with the expression **L3/100**. Now create a relative frequency histogram using L2 for **Xlist** and L4 for **Freq**. Be sure to adjust **Ymin**, **Ymax**, and **Yscl**.
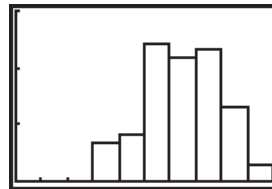
[0, 1, 0.1, 0, 0.3, 0.1]

Follow a similar procedure to do sampling distributions for $n = 20$ and $n = 40$. Change the value of **Xscl** accordingly. If you use relative frequency histograms, you'll need to run FREQTABL for each new distribution, and redefine L4 (unless you use a dynamic definition).

Center and Spread for Sample Proportions

The Central Limit Theorem for a Sample Proportion indicates that the sampling distribution for the sample proportion and the sample number of successes are approximately normal. Therefore, you can use the **normalcdf(** command to calculate probabilities in either context. Be careful to use the correct mean and standard error values.

CHAPTER 6 PROBABILITY MODELS

Section 6.1 ▪ Sample Spaces with Equally Likely Outcomes

Where Do Probabilities Come From?

A frequency table can easily be converted into a relative frequency table using the List Editor of the TI-83 and TI-83 Plus. This allows you to assign probabilities based on observed data (long-run relative frequencies). First enter the possible values into list L1 and enter the frequencies into list L2. Then define list L3 as the relative frequencies with the expression L2/sum(L2). You find the **sum(** command by pressing 2nd [LIST] **MATH 5:sum(**.

For example, here are the data from Display 6.2 on page 330 of the *Statistics in Action* student text.

The Law of Large Numbers

You can use the TI-83 and TI-83 Plus to simulate flipping a coin, keep track of the cumulative proportion of heads, and make a graph similar to Display 6.4 on page 334 of the *Statistics in Action* student text.

a. Enter the flip numbers into list L1, for example, the whole numbers 1 to 150. The sequence command, found by pressing 2nd [LIST] **OPS 5:seq(**, is a convenient way to enter these whole numbers. Enter the command in the form **seq(***formula, variable, start, end, increment***)**. For example, define list L1 with the expression **seq(x,x,1,150,1)**.

b. Enter the outcomes of the flips into list L2: 1 = heads or 0 = tails. To simulate flipping fair coin that has .5 probability of heads, use the random integer generator **randInt(0,1,150)**. You find the **randInt(** command by pressing MATH PRB **5:randInt(**. The command's syntax is **rantInt(***lower integer, upper integer, number of trials***)**. That is, **randInt(0,1,150)** randomly selects 0 or 1 one hundred fifty times with equally likely results.

To simulate a coin that has a different probability of heads, for example .4, use the random binomial generator **randBin(1,.4,150)**. You find the **randBin(** command by pressing MATH PRB **7:randBin(**. The command's syntax is **randBin(***number of trials, probability of success, number of simulations***)**. Because you want the individual results from 150 flips, *number of trials* equals 1 and number of simulations equals 150. That is, **randBin(1,.4,150)** randomly selects 0 or 1 one hundred fifty times where the probability of success (1 = heads) is .4. You'll learn more about binomial probability in Chapter 7 of the *Statistics in Action* student text, and you'll learn more about the **randBin(** command in Chapter 8 of this Calculator Guide.

c. Define list L3 as the cumulative number of heads, **cumSum(**L2**)**. Find the **cumSum(** command by pressing [2nd] [**LIST**] **OPS 6:cumSum(**.

L1	L2	▮L3	3
1	0	------	
2	0		
3	1		
4	0		
5	1		
6	0		
7	1		

L3 =cumSum(L2)

d. Define list L4 as the proportion of heads accumulated after each flip, or L3 divided by L1.

L2	L3	▮L4	4
0	0	------	
0	0		
1	1		
0	1		
1	2		
0	2		
1	3		

L4 =L3/L1

L2	L3	L4	4
0	0	0	
0	0	0	
1	1	0	
0	1	.33333	
1	2	.25	
0	2	.4	
1	3	.33333	
		.42857	

L4(1)=0

e. Make a scatterplot of the proportion of heads accumulated after each flip (L4) versus the number of the flip (L1). Tracing the plot supports the law of large numbers. For this simulation, as the sample size gets larger, the sample proportion approaches the population proportion of .5.
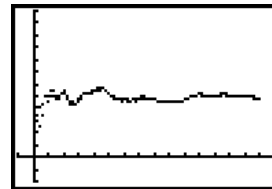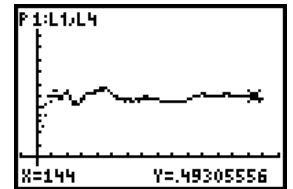
$[-10, 160, 10, -0.2, 1.2, 0.1]$ $[-10, 160, 10, -0.2, 1.2, 0.1]$

Section 7.1 ▪ Random Variables and Expected Value

Expected Value and Standard Deviation

You can practice computing the expected value, variance, and standard deviation of a probability distribution table by using the spreadsheet capabilities of the List Editor. For example, consider the data in Display 7.3 and the calculations on pages 381–382 of the *Statistics in Action* student text.

a. Enter the probability distribution table into lists L1 and L2.

b. Define list L3 as the products of the values and the probabilities.

c. The expected value is the sum of list L3. On the Home screen, calculate **sum(L3)**. Find the **sum(** command by pressing [2nd] **[LIST] MATH 5:sum(**.

d. Define list L4 as the products of the squares of the deviations from the mean and the probabilities, $(L1 - 13.78)^2 * L2$.

e. The variance is the sum of list L4. The standard deviation is the square root of the variance.

```
sum(L4)
          184.0766
√(Ans)
          13.56748319
■
```

More directly, the expected value and standard deviation can be calculated using the 1-Var Stats command. You find this command by pressing STAT CALC 1:1-Var Stats, and, for a frequency table, you follow the command with the names of two lists separated by a comma. The first list you enter must contain the values, and the second list must contain the relative frequencies.

```
1-Var Stats L1,L
2
```

```
1-Var Stats
x̄=13.78
Σx=13.78
Σx²=373.965
Sx=
σx=13.56748319
↓n=1
■
```

Note that the calculator displays no value for Sx when list L2 contains relative frequencies. The calculator assumes that you are summarizing a probability distribution for a population and therefore omits the sample standard deviation.

Rules for Means and Variances

The 1-Var Stats command makes it relatively easy for you to explore and recall the rules listed on page 385 of the *Statistics in Action* student text. For more information on how to do this, review "Properties of Summary Statistics" in Chapter 2, page 23, of this Calculator Guide.

Section 7.2 ▪ The Binomial Distribution

Binomial Probabilities   2nd [DISTR] DISTR 0:binompdf(
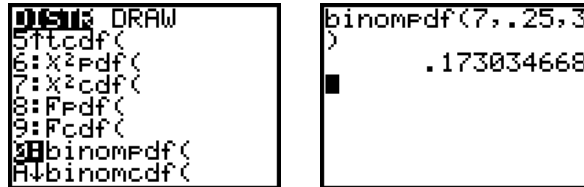
The TI-83 and TI-83 Plus can calculate binomial probabilities in two ways:

1. Use the formula $P(X = k) = \binom{n}{k}p^k(1 - p)^{n-k}$ and enter each factor individually. To get the binomial coefficient $\left(\frac{n}{k}\right)$, first enter the number to choose from, then press MATH PRB 3:nCr, and then enter the number to choose.

```
MATH NUM CPX PRB
1:rand
2:nPr
3:nCr
4:!
5:randInt(
6:randNorm(
7:randBin(
```
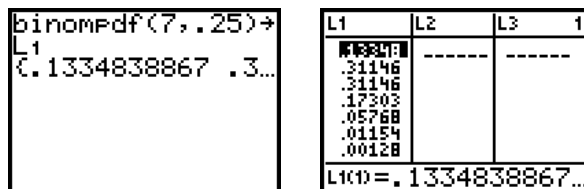
```
(7 nCr 3)(.25)^3
(.75)^4
          .173034668
```

2. Use the binomial probability density function. You find the **binompdf(** command by pressing [2nd] [DISTR] **DISTR 0:binompdf(**. The syntax is **binompdf(**n, p, k). This command calculates the binomial probability for k successes out of n trials when the probability of success on any one trial is p.

```
DISTR DRAW
5:tcdf(
6:X²pdf(
7:X²cdf(
8:Fpdf(
9:Fcdf(
0:binompdf(
A↓binomcdf(
```

```
binompdf(7,.25,3
)
          .173034668
■
```

The number of successes can also be entered as a list of numbers set in braces.

```
binompdf(7,.25,{
3,4})
{.173034668 .05…
```
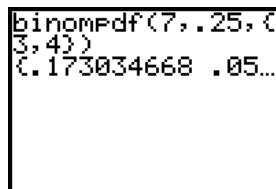
If k is omitted, the entire binomial probability distribution is displayed. You can scroll through the list of probabilities using the left and right arrow keys. You could also store the probabilities in a list. There are three ways to do this: press [STO→] and the name of a list after the **binompdf** command; press [STO→] and the name of a list immediately after calculating the **binompdf** (the Home screen will automatically begin the entry line with **Ans**); or define the list with the **binompdf** command in the List Editor.

```
binompdf(7,.25)→
L₁
{.1334838867 .3…
```

```
L1      L2      L3      1
.13348  ------  ------
.31146
.31146
.17303
.05768
.01154
.00128
L1(1)=.1334838867…
```

Note that a binomial distribution is a discrete distribution, as opposed to a normal distribution, which is continuous. Therefore, **binompdf(** cannot be used in the Y= screen in the same way that **normalpdf(** is. For example, Y₁=**binompdf(**7,.25,X) does not result in a graph. See the next section for instructions about graphing a binomial distribution.

The Shape, Center, and Spread of a Binomial Distribution

If you enter all values of X into list L₁ and the binomial probabilities of k successes out of n trials into list L₂, you can use the **1-Var Stats** command to calculate the expected value and standard deviation of the binomial distribution. This example shows a binomial distribution with $n = 20$ and $p = .7$. The section "The Law of

Large Numbers" in Chapter 6 of this Calculator Guide showed you how to use the sequence command to enter a sequence of integers.

Once the binomial distribution is entered into two lists, you can display the distribution in a histogram. This histogram is the same as the bottom-right plot in Display 7.7 on page 396 of the *Statistics in Action* student text. (*Note:* In order to duplicate the histogram as it appears in the *Statistics in Action* student text, be sure to set the window [0, 21, 1, 0, 0.3, 0.075], especially setting Xscl=1.)
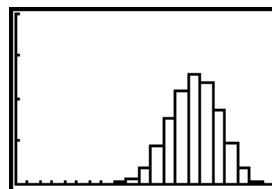
[0, 21, 1, 0, 0.3, 0.075]

Binomial Cumulative Distribution   2nd [DISTR] DISTR
A:binomcdf(

To calculate the cumulative probability of a binomial distribution, use the binomial cumulative distribution function. You find this command by pressing 2nd [DISTR] DISTR A: binomcdf(, and the syntax is binomcdf(*n, p, k*). For example, for Exercise 9 on page 398 of the *Statistics in Action* student text, binomcdf(60,1/6,4) gives the probability of fewer than five doubles (or the cumulative probability of 0, 1, 2, 3, or 4 doubles) when you roll a pair of dice 60 times.
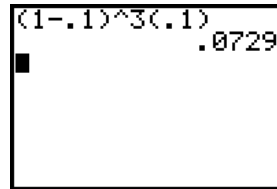
To find the probability of five or more doubles, subtract the result from 1.
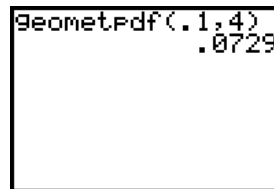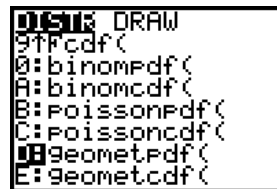
Section 7.3 ▪ The Geometric Distribution

The Geometric Distribution   2nd [DISTR] DISTR D:geometpdf(

Similar to binomial probabilities, geometric probabilities can be calculated in two ways:

1. Use the formula $P(X = k) = (1 - p)^{k-1}p$.

```
(1-.1)^3(.1)
          .0729
■
```

2. Use the geometric probability density function. You find the **geometpdf(** command by pressing 2nd [DISTR] **DISTR D:geometpdf(**. The syntax is **geometpdf(** p, k). This command calculates the probability that the first success occurs on the kth trial, where p is the probability of each success.

```
DISTR DRAW
9:Fcdf(
0:binompdf(
A:binomcdf(
B:poissonpdf(
C:poissoncdf(
D:geometpdf(
E:geometcdf(
```

```
geometpdf(.1,4)
          .0729
```

The parameter k can also be entered as a list of numbers set in braces.
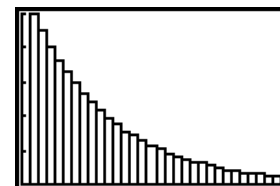
```
geometpdf(.1,{1,
2,3,4})
{.1 .09 .081 .0…
```
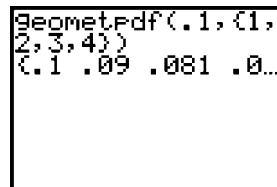
Because any geometric distribution has an infinite number of values, k cannot be omitted.

The probabilities for a finite sequence of values of k can be calculated, stored in the List Editor, and graphed. Here is the geometric distribution for $p = .1$, as shown in the first plot in Display 7.8 on page 401 of the *Statistics in Action* student text.

```
seq(X,X,1,30,1)→
L1
{1 2 3 4 5 6 7…
geometpdf(.1,L1)
→L2
{.1 .09 .081 .0…
■
```
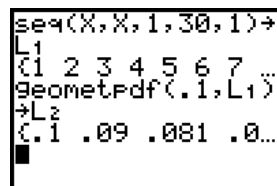
L1	L2	L3	2
1	.1	------	
2	.09		
3	.081		
4	.0729		
5	.06561		
6	.05905		
7	.05314		
L2(1)=.1			

$[0, 31, 1, 0, 0.1, 0.02]$

Geometric Cumulative Distribution   2nd [DISTR] DISTR
E:geometcdf(

```
geometcdf(.91,3)
            .999271
■
```

To calculate the cumulative probability of a geometric distribution, use the geometric cumulative distribution function. You find this command by pressing 2nd [DISTR] **DISTR E:geometcdf(**. For example, for Practice 11b on page 404 of the *Statistics in Action* student text, **geometcdf(.91,3)** gives the probability of the first nondefective engine before the fourth trial (or the probability of success on the first, second, or third trial).

Expected Value and Standard Deviation

Although a geometric distribution has an infinite number of values, you can only store a finite sequence of values of *k* in the List Editor. So, if you use the **1-Var Stats** command to approximate the expected value and standard deviation, the resulting values will be too small. To get exact values, use the formulas given on page 405 of the *Statistics in Action* student text.

Section 8.1 ▪ Estimating a Proportion with Confidence

Discussion: Reasonably Likely Outcomes

Several times in this section and chapter, you are asked to simulate the reasonably likely outcomes for a binomial experiment. For example, Discussion 2a on page 415 of the *Statistics in Action* student text asks you to simulate the number of successes in a sample of size 40 from a population with 60% successes. The random binomial generator, **randBin(**, allows you to do this. You find the command by pressing $\boxed{\text{MATH}}$ **PRB 7:randBin(**. The command's syntax is **randBin(***number of trials, probability of success, number of simulations*); if *number of simulations* is omitted, the default is 1. For example, **randBin(40,.6)** returns a single number that represents the number of successes in a sample of 40. The command **randBin(40,.6,100)** returns the number of successes for 100 simulations, which can be stored in a list.

The Meaning of a Confidence Interval $\boxed{\text{STAT}}$ TESTS
A:1-PropZInt

The TI-83 and TI-83 Plus calculate the confidence interval for a proportion with the command **1-PropZInt**. You find this command by pressing $\boxed{\text{STAT}}$ **TESTS A:1-PropZInt**. Enter the number of successes in the sample, **x**, the sample size, **n**, and the level of confidence, **C-Level**. Arrow down and select **Calculate** to get the confidence interval and sample proportion. These screens show the calculations for discussion question D5 on page 419 of the *Statistics in Action* student text. The results show that then 95% confidence interval for the percentage of toddlers who know Barney's color is approximately 74% to 96%.

Section 8.2 ▪ Testing a Proportion

Types of Errors

The program **ERRORS** can help you understand Type II errors and power. The program graphically shows the effects that changing parameters has on the probability of a Type II error and the power of the test.

a. Run the program: press PRGM **EXEC**, choose **ERRORS**, and press ENTER. Read the introductory screens, which emphasize that the program uses a normal approximation and a one-tailed test where $p > p_0$. Press ENTER after each screen.

```
ERRORS TESTING
A PROPORTION

PLEASE MAKE
P > P0

PRESS ENTER
```
```
ASSUME NORMAL
APPROXIMATION

ASSUME
ONE-TAILED TEST

PRESS ENTER
```

b. At the prompts, enter the hypothesized proportion you are testing, **p0**, the true value of the population proportion, **p**, the sample size, and the significance level, α(**ALPHA**). The hypothesized proportion, **p0**, can be any value less than the true proportion. Press ENTER after each value.

For example, suppose you plan to take a sample of size 25 to test that $p = .3$. Although you don't know it, the true proportion is $p = .4$. The null hypothesis that $p = .3$ is false.

```
P0?  .3
P?   .4
SAMP SIZE?  25
ALPHA?  .05■
```

c. The program first graphs a normal approximation of the sampling distribution for the hypothesized proportion p_0. The critical value $p^\star$ is labeled. The null hypothesis will (correctly) be rejected if $\hat{p}$ falls above this critical value. The null hypothesis will not (incorrectly) be rejected if $\hat{p}$ falls below $p^\star$.

```
N=25


                  .3    P*
ALPHA=.05
```

d. Pressing ENTER graphs a normal approximation of the sampling distribution for the true population proportion. The tail is highlighted below the critical value $p^\star$, which represents the probability of *not* rejecting this false null hypothesis. The area of this tail, called BETA, or β, represents the probability of a Type II error.
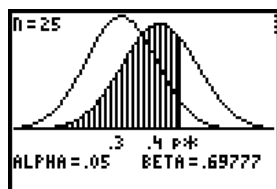
e. Pressing ENTER again shades the second curve above the critical value. This area, $1 - \beta$, represents the power of the test. It represents the probability of rejecting this false null hypothesis.
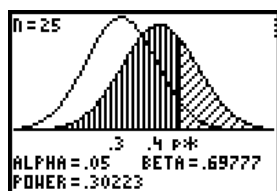
f. Pressing ENTER gives you the option to change the true population proportion, the sample size, or the significance level. Changing the parameters shows the effects on the probability of a Type II error. For example, if you increase the significance level, the probability of a Type II error decreases. But if you were correct in the first place that $p = .3$, then you have increased the probability of a Type I error.
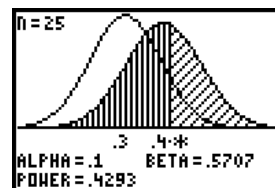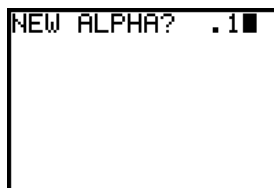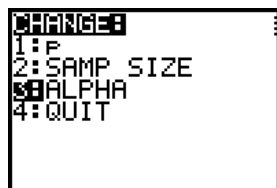
In practice, it is usually impossible to compute the probability of a Type II error and the power of the test because you have to know the value of p. In that way, ERRORS only allows you to explore the effects of changing parameters.

```
PROGRAM:ERRORS              Disp ""
ClrHome                     Disp "PRESS ENTER"
PlotsOff                    Pause
FnOff                       ClrHome
AxesOn                      Disp "ASSUME NORMAL"
Disp "ERRORS TESTING"       Disp "APPROXIMATION"
Disp "A PROPORTION"         Disp ""
Disp ""                     Disp "ASSUME"
Disp "PLEASE MAKE"          Disp "ONE-TAILED TEST"
Disp "p > p0"               Disp ""
```

(continued)

(PROGRAM: ERRORS continued)

```
Disp "PRESS ENTER"
Pause
ClrHome
Input "p0?   ",P
Input "p?   ",Q
If P≥Q
Then
Disp "PLEASE MAKE"
Disp "p > p0"
Disp "p0   ",P
Input "p?   ",Q
End
Input "SAMP SIZE?   ",N
Input "ALPHA?   ",A
Lbl D
invNorm(1-A,P,√(P(1-P)/N)→Z
"normalpdf(X,P,
        √(P(1-P)/N)"→Y₁
"normalpdf(X,Q,
        √(Q(1-Q)/N)"→Y₂
FnOff
P-3√(P(1-P)/N)→Xmin
Q+3√(Q(1-Q)/N)→Xmax
0→Xscl
max(Y₁(P),Y₂(Q))+.02→Ymax
-Ymax/2→Ymin
0→Yscl
ClrDraw
DrawF Y₁
Text(0,0,"N= ",N)
Text(43,round(91(P-Xmin)/
        (Xmax-Xmin),0)-2,P)
Text(43,round((91(Z-Xmin)/
        (Xmax-Xmin)),0),"p*")
Text(50,0,"ALPHA = ",A)
```

```
Line(Z,0,Z,Y₁(Z))
Pause
Text(43,round(91(Q-Xmin)/
        (Xmax-Xmin),0)-2,Q)
Shade(0,Y₂,Xmin,Z,1,2)
Line(Z,0,Z,Y₂(Z))
normalcdf(-1E99,Z,Q,
        √(Q(1-Q)/N)→B
round(B,5)→B
Text(50,47,"BETA = ",B)
Pause
Shade(0,Y₂,Z,Xmax,4,4)
Text(57,0,"POWER = ",1-B)
Pause
ClrHome
Menu("CHANGE:","p",A,"SAMP
        SIZE",B,"ALPHA",C,
        "QUIT",E)
Lbl A
Input "NEW p?   ",Q
If P≥Q
Then
Disp "PLEASE MAKE"
Disp "p > p0"
Disp "p0   ",P
Input "NEW p?   ",Q
End
Goto D
Lbl B
Input "NEW SAMP SIZE?   ",N
Goto D
Lbl C
Input "NEW ALPHA?   ",A
Goto D
Lbl E
ClrHome
```

P-Values   [STAT] TESTS 5:1-PropZTest

The TI-83 and TI-83 Plus conduct a significance test for a proportion and calculate the *P*-value with the command 1-PropZTest. You find the command by pressing [STAT] TESTS 5:1-PropZTest. At the prompts, enter the proportion under the null hypothesis, p_0, the number of successes in the sample, x, and the sample size, n. (*Note:* If you are given $\hat{p}$ instead of *x*, calculate *x* by multiplying $\hat{p} \cdot n$ and rounding to the nearest integer.) Select the type of test: two-tailed ($\neq p_0$) or one-tailed ($< p_0$ or $> p_0$). Arrow down and select Calculate to get the value of the test statistic, z, the *P*-value, p, the sample proportion, $\hat{p}$, and the sample size.
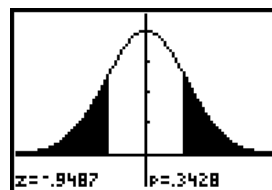
Select **Draw** to get a shaded distribution. The screens below show the process for Jenny and Maya as shown on pages 445–446 of the *Statistics in Action* student text.

As outlined on page 439 of the *Statistics in Action* student text, statisticians have chosen clear and definitive guidelines for the presentation of a test of significance. It is critical that you understand the appropriate use of calculator technology within this presentation. You should use your calculator only after writing the name of the test, checking the criteria for its use, stating the hypotheses, and stating the test statistic. At that point, it is appropriate to have the calculator perform the test and calculate the *P*-value. Complete the significance test by stating whether or not you reject H_0 and writing a conclusion in context.

Section 8.3 ▪ A Confidence Interval for the Difference of Two Proportions

The Formula for the Confidence Interval   [STAT] TESTS
B:2-PropZInt

The TI-83 and TI-83 Plus calculate the confidence interval for the difference of two proportions with the command **2-PropZInt**. You find this command by pressing [STAT] TESTS **B:2-PropZInt**. At the prompts, enter the number of successes in each sample, **x1** and **x2**, both sample sizes, **n1** and **n2**, and the level of confidence, **C-Level**. Arrow down and select **Calculate** to get the confidence interval, both sample proportions, and both sample sizes. Note that **2-PropZInt** does not ask for the sample proportions. So, if you are given the proportions instead of the number of successes, multiply the proportions by the sample size and round to the nearest whole number. For example, with the dog-ownership example on pages 456–457 of the *Statistics in Action* student text, use x1 = **457** and x2 = **437**.

Section 8.4 ▪ A Significance Test for the Difference of Two Proportions

The Theory of a Significance Test for the Difference of Two Proportions   STAT TESTS 6:2-PropZTest

The TI-83 and TI-83 Plus conduct a significance test for the difference of two proportions with the command 2-**PropZTest**. You find this command by pressing STAT TESTS 6:2-**PropZTest**. The command behaves similar to the 1-**PropZTest** explained in the section "*P*-Values." These screens show the calculations for the AZT example on pages 466–467 of the *Statistics in Action* student text. Note that the input requires the numbers of successes instead of proportions and that the output includes the test statistic, the *P*-value, the sample proportions, and the pooled estimate, $\hat{p}$.
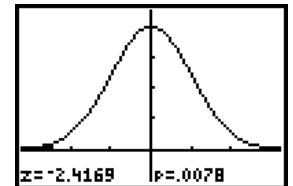
Section 9.1 ▪ Toward a Confidence Interval for a Mean

Confidence Intervals   STAT TESTS 7:ZInterval

The TI-83 and TI-83 Plus calculate the confidence interval for a mean when σ is known with the command ZInterval. You find this command by pressing STAT TESTS 7:ZInterval. If your sample is stored in a list or as a frequency table stored in two lists, select Data for Inpt and specify list(s), and the calculator will calculate the sample mean. If you know the sample mean, select Stats for Inpt and enter the sample mean and sample size. Either way, you must enter the population standard deviation, σ, and the confidence level, C-Level. Arrow down and select Calculate to get the confidence interval.

or

Section 9.2 ▪ Toward a Significance Test for a Mean

### The Formal Structure of Tests of Significance
STAT TESTS 1:Z-Test

The TI-83 and TI-83 Plus conduct a significance test for a mean with the command Z-Test. You find this command by pressing STAT TESTS 1:Z-Test. Similar to the ZInterval command, you can use sample data saved in a list or lists and the calculator will calculate the sample mean, or you can enter the sample mean and sample size as statistics. Either way, you must enter the population mean and population standard deviation and select whether the test is one-tailed or two-tailed. Select Calculate to get the test statistic, z, and the P-value, p, or select Draw to see the results with a shaded distribution. For a fixed-level test, you'll need

to compare the test statistic with the critical value. The following screens use the pennies example from pages 495–499 of the *Statistics in Action* student text.

Because the calculator does not use rounded values, the results below vary slightly from those in the *Statistics in Action* student text.
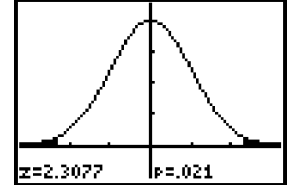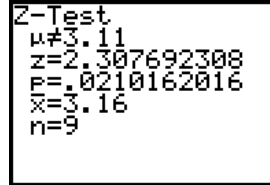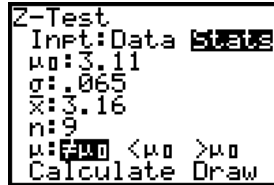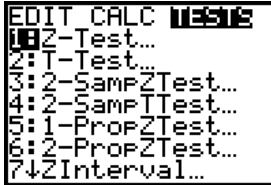
Types of Errors (Revisited)

If you would like to further explore Type II errors and the power of a significance test for a mean, you can use the program ERRORS2. The program graphically shows the effects that changing parameters has on the probability of a Type II error and the power of the test. This program behaves similarly to the program ERRORS that was introduced in Chapter 8.

a. Run the program: press PRGM EXEC, choose ERRORS2, and press ENTER. Read the introductory screens, which emphasize that the program uses a normal approximation and a one-tailed test where $\mu > \mu_0$. Press ENTER after each screen.
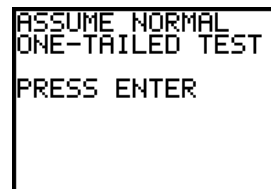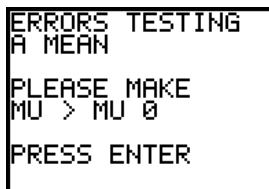
b. At the prompts, enter the hypothesized mean for the population mean, μ_0 (MU 0), the true value of the population mean, μ (MU), the population standard deviation, σ (SIGMA), the sample size, and the significance level, α (ALPHA). The true mean can be any value greater than the hypothesized mean. Press ENTER after each value.

As an example, here you test $H_0: \mu = 50$ when, in fact, $\mu = 56$. Your sample size will be 64 and you are using $\alpha = .05$.
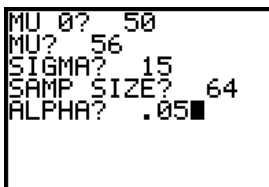
c. The program first graphs a sampling distribution for the hypothesized population mean. The critical value is labeled as $\bar{x}^*$. If $\bar{x} > \bar{x}^*$, you will (correctly) reject H_0. If $\bar{x} < \bar{x}^*$, you will (incorrectly) fail to reject H_0.
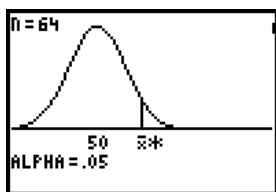

d. Press ENTER to graph a sampling distribution for the true population mean. The tail is highlighted below the critical value $\bar{x}^*$, which represents the probability of not rejecting this false null hypothesis. The area of this tail, called BETA, or β, represents the probability of a Type II error.
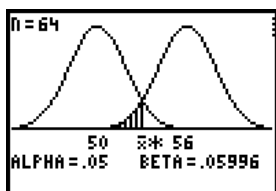
e. Press ENTER again to shade the second curve above the critical value. This area, $1 - \beta$, represents the power of the test. It represents the probability of rejecting this false null hypothesis.
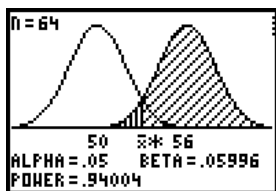
f. Press ENTER to get options to change the true population mean, the sample size, or the significance level. Changing the parameters shows the effects on the probability of a Type II error. For example, if you increase the significance level, you see that the probability of a Type II error decreases. However, if you were correct in the first place that $\mu = 50$, you have increased the probability of a Type I error.
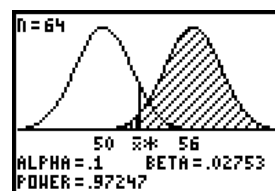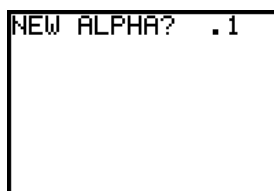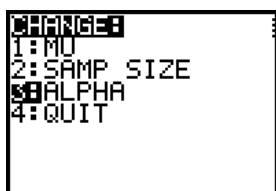
In practice, it is usually impossible to compute the probability of Type II error and the power of the test because you have to know the true value of μ.

```
PROGRAM:ERRORS2
ClrHome
PlotsOff
FnOff
AxesOn
Disp "ERRORS TESTING"
Disp "A MEAN"
Disp ""
Disp "PLEASE MAKE"
Disp "MU > MU 0"
Disp ""
Disp "PRESS ENTER"
Pause
ClrHome
Disp "ASSUME NORMAL"
Disp "ONE-TAILED TEST"
Disp ""
Disp "PRESS ENTER"
Pause
ClrHome
Input "MU 0?   ",M
Input "MU?   ",A
If M≥A
Then
Disp "PLEASE MAKE"
Disp "MU > MU 0"
Disp "MU 0   ",M
Input "MU?   ",A
End
Input "SIGMA?   ",S
Input "SAMP SIZE?   ",N
Input "ALPHA?   ",L
Lbl D
"0"→Y₁
"normalpdf(X,M,S/√(N))"→Y₂
"normalpdf(X,A,S/√(N))"→Y₃
FnOff 3
(M-3*S/√(N))→Xmin
(A+3*S/√(N))→Xmax
0→Xscl
(Y₂(M)+.02)→Ymax
-Ymax/2→Ymin
0→Yscl
ClrDraw
Line(Xmin,0,Xmax,0)
DispGraph
Text(0,0,"N = ",N)
```

```
Text(43,round((91*M-
        91*Xmin)/(Xmax-
        Xmin),0)-2,M)
(invNorm(1-L,M,S/√(N))→J
Line(J,0,J,Y₂(J))
Text(43,round((91*(J-Xmin)/
        (Xmax-Xmin)),0),"x̄*")
DrawF Y₂
Text(50,0,"ALPHA = ",L)
Pause
FnOn 3
Text(43,round((91*A-
        91*Xmin)/(Xmax-
        Xmin),0)-2,A)
Line(J,0,J,Y₃(J))
Shade(0,Y₃,J-3*S/√(N),J,1,2)
normalcdf(-1ᴇ99,J,A,S/
        √(N))→B
round(B,5)→B
Text(50,47,"BETA = ",B)
Pause
Shade(0,Y₃,J,1ᴇ10,4,4)
Text(57,0,"POWER = ",1-B
Pause
ClrHome
Menu("CHANGE:","MU",A,
        "SAMP SIZE",B,"ALPHA",
        C,"QUIT",E)
Lbl A
Input "NEW MU?   ",A
If M≥A
Then
Disp "PLEASE MAKE"
Disp "MU > MU 0"
Disp "MU 0   ",M
Input "NEW MU?   ",A
End
Goto D
Lbl B
Input "NEW SAMP SIZE?   ",N
Goto D
Lbl C
Input "NEW ALPHA?   ",L
Goto D
Lbl E
ClrHome
```

Section 9.3 ▪ When You Estimate *σ*: The *t*-Distribution

How to Adjust for Estimating *σ* |STAT| TESTS 8:TInterval

The TI-83 and TI-83 Plus calculate the confidence interval for a mean when *σ* is unknown with the command **TInterval**. You find this command by pressing |STAT| TESTS 8:TInterval. You can use sample data saved in a list or a frequency table saved in two lists and the calculator will calculate the sample mean and standard deviation, or you can enter the statistics yourself. Either way, you must specify the confidence level. Arrow down and select **Calculate** to get the confidence interval and sample statistics. These screens show the 95% confidence interval for the mean body temperature of men from pages 507–508 of the *Statistics in Action* student text. The data from Display 9.7 were first saved in list L1.

Using a Calculator Instead of a *t*-Table to Find *t**

When a *t*-table does not provide a sufficiently exact confidence level or degrees of freedom, the calculator provides several methods for finding the critical value *t**. One method uses the Equation Solver, which you find by pressing |MATH| MATH 0:Solver. Follow these steps to find the value of *t** for a 95% confidence interval based on a sample of size 47. (Note that *df* = 46 is not in the *t*-table on page 701 of the *Statistics in Action* student text.)

a. Start the Equation Solver. If the screen does not say EQUATION SOLVER and give you a place to edit the equation (**eqn:**), press the up arrow once.
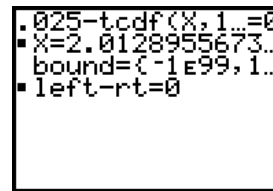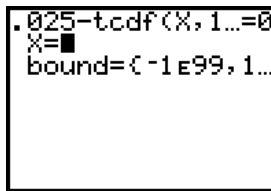
b. A 95% confidence interval means that you want a tail area of .025 on either side. Consequently, you need to find the value of *t** for which the cumulative distribution function equals .025 to the right of *t**. Find the cumulative distribution function by pressing |2nd| [DISTR] DISTR 5:tcdf(, and the syntax is **tcdf**(*lower bound, upper bound, degrees of freedom*). Enter the equation 0=.025−**tcdf**(X,1E99,46). Solving this equation for X gives the value of *t** with area .025 above it.

c. Press ENTER, place the cursor after X=, and press ALPHA [SOLVE]. The result means that t^* is approximately 2.013.

```
.025-tcdf(X,1…=0       .025-tcdf(X,1…=0
X=■                   ▪X=2.0128955673…
bound={-1ᴇ99,1…        bound={-1ᴇ99,1…
                      ▪left-rt=0
```
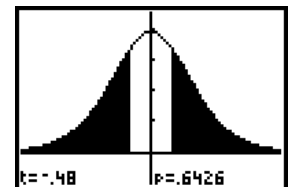
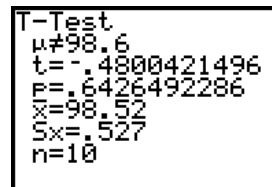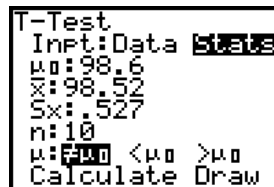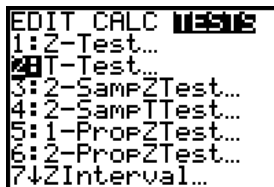**d.** To modify the level of confidence or degrees of freedom, arrow up to the equation and you'll return to the Equation Editor screen.

```
EQUATION SOLVER
eqn:0=.005-tcdf(
X,1ᴇ99,46)■
```
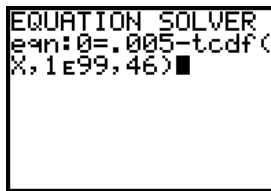
Hypothesis Tests for a Mean when σ is Unknown
STAT TESTS 2:T-Test

The TI-83 and TI-83 Plus conduct a significance test for a mean when σ is unknown with the command **T-Test**. You find the command by pressing STAT TESTS 2:T-Test. You can use data saved in lists or enter the sample mean and sample standard deviation yourself. **Calculate** outputs the *t*-statistic, **t**, the *P*-value, **p**, and the sample statistics. **Draw** gives a shaded distribution. Here's the test for the mean body temperature of women, from page 514 of the *Statistics in Action* student text.

```
EDIT CALC TESTS        T-Test                 T-Test                    
1:Z-Test…              Inpt:Data Stats        μ≠98.6                 
2▮T-Test…             μ0:98.6                t=-.4800421496    
3:2-SampZTest…        x̄:98.52                p=.6426492286     
4:2-SampTTest…        Sx:.527                x̄=98.52           
5:1-PropZTest…        n:10                   Sx=.527           
6:2-PropZTest…        μ:≠μ0 <μ0 >μ0          n=10              
7↓ZInterval…          Calculate Draw
```
```
t=-.48   p=.6426
```

Remember that whenever you make a written report about a *t*-test, you should report the number of degrees of freedom for the sampling distribution. The degrees of freedom specifies which *t*-distribution is the appropriate one for the test and should not be omitted, even though it is not part of the calculator's output.

## Graphing *t*-Distributions     2nd [DISTR] DISTR 4:tpdf(

Using a TI-83 or TI-83 Plus, you can visually explore the effect that the degrees of freedom has on the *t*-distribution. Use the *t* probability density function, **tpdf(**, which is found by pressing 2nd [DISTR] DISTR 4:**tpdf(**. On the Y= screen, define functions in the form **tpdf(**X, *degrees of freedom*).
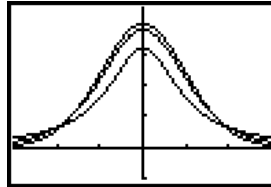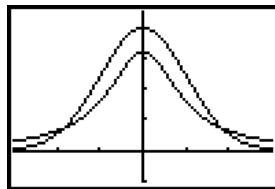
$[-3, 3, 1, -0.1, 0.45, 0.1]$

You can similarly compare a *t*-distribution to the standard normal distribution. This allows you to see that the *t*-distribution is "flatter" than the standard normal distribution, but as the degrees of freedom increases, the *t*-distribution approaches the standard normal distribution.
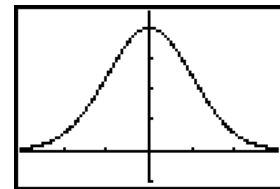
$[-3, 3, 1, -0.1, 0.45, 0.1]$      $[-3, 3, 1, -0.1, 0.45, 0.1]$

## *P*-Values Instead of Fixed-Level Testing     2nd [DISTR] DISTR 5:tcdf(

The TI-83 and TI-83 Plus calculate the *P*-value given *t* and *df* with the command **tcdf(**. You find this command by pressing 2nd [DISTR] DISTR 5:**tcdf(**. Enter this command on the Home screen using the syntax **tcdf(***lower bound, upper bound, degrees of freedom*). For the body-temperatures example on page 513 of the *Statistics in Action* student text, you can enter either 1–**tcdf(**−4.1,4.1,9), which subtracts from 1 the area between the tails and gives the area remaining in the two tails, or **tcdf(**4.1,1E99,9), which gives the area in one tail.

# Section 9.4 ▪ The Effect of Long Tails and Outliers

Similar to Section 3.5 on page 31 of this Calculator Guide, the TI-83 and TI-83 Plus can be used to transform data to achieve a roughly normal sample prior to using a *t*-procedure. As the 15/40 rule indicates, you should consider a transformation for small sample sizes that appear to come from skewed populations.

When you are exploring evidence to assert that a population is approximately normal, it is acceptable to display, for example, parallel boxplots as the basis of your conclusion. However, displays are not sufficient. You should routinely supply verbal arguments to support a conclusion about the shape of a population.

# Section 9.5 ▪ Inference for the Difference Between Two Means

The TI-83 and TI-83 Plus have four commands that support Section 9.5:

**2-SampZInt:** Confidence interval for the difference between two means, $\sigma_1$ and $\sigma_2$ known

**2-SampTInt:** Confidence interval for the difference between two means, $\sigma_1$ and $\sigma_2$ unknown

**2-SampZTest:** Significance test for the difference between two means, $\sigma_1$ and $\sigma_2$ known

**2-SampTTest:** Significance test for the difference between two means, $\sigma_1$ and $\sigma_2$ unknown
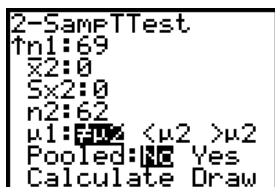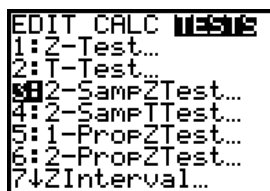


All four commands are found in the **TESTS** submenu when you press $\boxed{\text{STAT}}$. These commands function similarly to the other interval and test commands in this chapter, giving you the option to use sample data saved in list(s) or to enter sample statistics yourself.

Note that the **2-SampTTest** gives you the choice of **pooled**. As stated in the *Statistics in Action* student text, pooling should be used only when you have been told that $\sigma_1 = \sigma_2$.

# Section 9.6 ▪ Paired Comparisons

Because a paired comparison involves the differences of the paired values, inference for this situation should be done with the one-sample techniques previously discussed. As always, you should use great care to check the criteria for a particular type of inference before calculating a confidence interval or conducting a significance test.

# CHAPTER 10 CHI-SQUARE TESTS

## Section 10.1 ▪ Testing a Probability Model: The Chi-Square Goodness-of-Fit Test

### A Test Statistic

The TI-83 and TI-83 Plus's List Editor screen can help calculate the chi-square test statistic.

**a.** Enter the observed frequencies into list L1, and enter the expected frequencies into list L2.



**b.** Define list L3 as $(observed - expected)^2/expected$, or $(\text{L1}-\text{L2})^2/\text{L2}$.



**c.** The sum of list L3 gives the value of $\chi^2$. Find the **sum(** command by pressing 2nd [LIST] MATH 5:**sum(**.



For Activity 10.1, "Generating the Chi-Square Distribution," you can first use the random integer generator **randInt(1,6,60)** to store 60 rolls of a die in list L1. Then use the program FREQTABL to create a list of observed frequencies in list L3. (See pages 12–13 of this Calculator Guide for information about FREQTABL.) Now you can enter the expected frequencies into list L4 and calculate $\chi^2$ as described above.

### The Distribution of Chi-Square  2nd [DISTR] DISTR 6:$\chi^2$pdf(

The *Statistics in Action* student text leads you through an examination of chi-square distribution using simulations of dice with different numbers of sides. On your calculator, you can similarly graph and explore the chi-square probability density function for different degrees of freedom. You find the

function by pressing ⌷2nd⌷ [DISTR] DISTR 6:$\chi^2$**pdf**(. Enter the function in the form $\chi^2$**pdf**(X, *degrees of freedom*).

```
Plot1 Plot2 Plot3
\Y1▤X²pdf(X,5)
\Y2▤X²pdf(X,10)
\Y3▤X²pdf(X,20)■
\Y4=
\Y5=
\Y6=
\Y7=
```

$[-5, 40, 5, -0.1, 0.2, 0.1]$

Exploring the probability density function illustrates that as the degrees of freedom increases, the chi-square distribution approaches a normal distribution. You'll come to recognize that the mean of a chi-square distribution equals the number of degrees of freedom of the distribution.

The Chi-Square Goodness-of-Fit Test

```
X²cdf(18.04,1ᴇ99
,5)
        .002896689
```

The TI-83 and TI-83 Plus do not perform a chi-square goodness-of-fit test. Nonetheless, you can use your calculator to precisely calculate the *P*-value associated with χ^2. You do this by entering an expression in the form χ^2**cdf**(χ^2, **1E99**, *degrees of freedom*). You find the χ^2**cdf**(command by pressing ⌷2nd⌷ [DISTR] DISTR 7:χ^2**cdf**(. For example, you calculate the *P*-value for the M&M's example on pages 585–586 of the *Statistics in Action* student text with χ^2**cdf**(**18.04,1E99,5**).

This is a more exact method than approximating the P-value from a chi-square table.

Section 10.2 ▪ The Chi-Square Test of Homogeneity

The TI-83 and TI-83 Plus can perform a chi-square test of homogeneity by using a chi-square test of independence for data stored in a two-way table—the calculations are identical for both tests. However, it is critical to understand that there are different conditions for the two tests and that the calculation of the expected values arises from very different situations. See the next section to learn how to perform a chi-square test of independence.
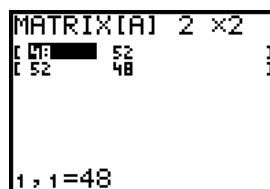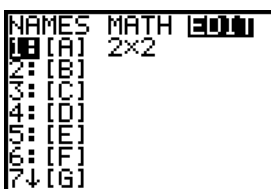
Section 10.3 ▪ The Chi-Square Test of Independence
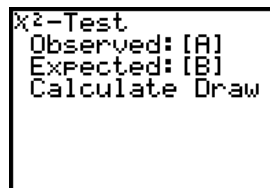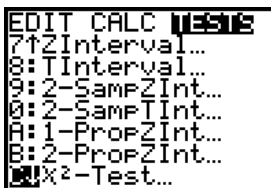
Procedure for a Chi-Square Test of Independence
STAT TESTS C:χ^2-Test

The TI-83 and TI-83 Plus conduct a chi-square test of independence with the χ^2-**Test** command. You find this command by pressing STAT **TESTS C:χ^2-Test**. The following example uses the responses from Sample 1 in Display 10.33 on page 619 of the *Statistics in Action* student text.

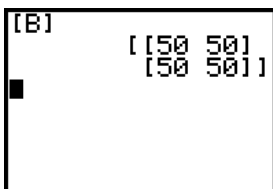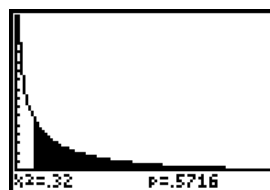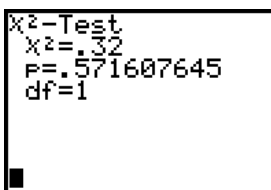**a.** First enter the two-way table in a matrix. Press 2nd [MATRIX], arrow to the EDIT submenu, and select a matrix. Enter the dimensions of the matrix, in this case 2×2, and enter the observed values.

```
NAMES MATH EDIT        MATRIX[A] 2 ×2
1:[A]  2×2             [ 48    52      ]
2:[B]                  [ 52    48      ]
3:[C]
4:[D]
5:[E]
6:[F]
7↓[G]                  1,1=48
```

b. Start the χ^2-**Test**. Enter the name of the matrix with the observed frequencies, and name a second matrix into which the expected frequencies will be stored.

```
EDIT CALC TESTS        X²-Test
7↑ZInterval…            Observed:[A]
8:TInterval…           Expected:[B]
9:2-SampZInt…          Calculate Draw
0:2-SampTInt…
A:1-PropZInt…
B:2-PropZInt…
C:X²-Test…
```

c. Selecting **Calculate** gives the value of the test statistic, χ^2, the *P*-value, **p**, and the degrees of freedom, **df**. Selecting **Draw** gives χ^2, **p**, and a shaded distribution, but not the degrees of freedom.

```
X²-Test                
 X²=.32                
 p=.571607645          
 df=1                  
                       
                       X²=.32        p=.5716
```

```
[B]
        [[50 50]
         [50 50]]
```

d. To check the expected frequencies, display matrix [B]. Press 2nd [MATRIX] NAMES 2:[B]. Scroll right and left to read the entire matrix. In some cases, it may be easier to inspect the matrix if you first round the values to one decimal place. To do this, enter **round([B],1)** on the Home screen. You find the **round(** command by pressing MATH NUM 2:**round(**.

As with all tests, you should use your calculator as an aid in the complete solution. A complete solution includes a check of the conditions, a statement of the hypotheses, a summary of the calculations, and a written conclusion.

Section 11.1 ▪ Variation in the Estimated Slope

Activity 11.2   What Affects the Variation in b_1?

Use the TI-83 and TI-83 Plus's **randNorm(** command to generate the values from the normal, conditional distributions listed in each case. You find the **randNorm(** command by pressing MATH **PRB 6:randNorm(**. You generate *n* random numbers from a normal distribution with mean μ and standard deviation σ with an expression in the form **randNorm(**μ, σ, n**)**.

For example, for Case 1 in Activity 11.2, first define list L1 as {0, 0, 0, 0, 1, 1, 1, 1}. Define list L2 as **randNorm(10,3,4)**—four random values from a normal distribution with mean 10 and standard deviation 3. Similarly define list L3 as **randNorm(12,3,4)**.

Now move the values in list L3 to the bottom of list L2 using the **augment(** command, found by pressing 2nd [LIST] **OPS 9:augment(**. Store the results back in list L2.

You can now perform a linear regression, calculate the slope, and make a scatterplot using lists L1 and L2.

Section 11.2 ▪ Making Inferences About Slopes

Significance Test for a Slope

Check Conditions

The TI-83 and TI-83 Plus can help check conditions for a significance test for a slope. As explained in Chapter 3 of this Calculator Guide, the calculator automatically calculates residuals and stores them in the list RESID after performing a regression. Therefore, you can easily make a residual plot, check that the residuals stay about the same size across all values of *x*, and make a univariate plot of the residuals to see if it's reasonable to assume that they came from a normal distribution.

Compute Values [STAT] **TESTS E:LinRegTTest**

The TI-83 and TI-83 Plus conduct a significance test for a slope with the command **LinRegTTest**. You find this command by pressing [STAT] **TESTS E:LinRegTTest**. At the prompts, enter the lists containing the data and select two-tailed or the appropriate one-tailed test. At **RegEQ** you may specify a function in which the regression equation will be stored; this is optional. Select **Calculate** to get the test statistic, **t**; the *P*-value, **p**; the degrees of freedom, **df**; the coefficients of the regression equation, **a** and **b**; the standard error, **s**; and the correlation coefficient and the coefficient of determination, **r** and **r²**. Here's the price-versus-horsepower example from pages 647–649 of the *Statistics in Action* student text.

```
EDIT CALC TESTS
9↑2-SampZInt…
0:2-SampTInt…
A:1-PropZInt…
B:2-PropZInt…
C:X²-Test…
D:2-SampFTest…
E:LinRegTTest…
```

```
LinRegTTest
Xlist:L₁
Ylist:L₂
Freq:1
β & ρ:≠0 <0 >0
RegEQ:Y₁
Calculate
```

```
LinRegTTest
y=a+bx
β≠0 and ρ≠0
t=5.791781722
p=6.25992ᴇ-5
df=13
↓a=-1.543914712
```

```
LinRegTTest
y=a+bx
β≠0 and ρ≠0
↑b=.1255613121
s=4.448401335
r²=.7206988104
r=.8489398155
```

```
b/t
      .0216792203
```

Note that the calculator's output does not include the standard error of the slope, s_{b_1}. However, because the null hypothesis is $\beta_1 = 0$, the formula for the test statistic is $t = \dfrac{b_1}{s_{b_1}}$. This means $s_{b_1} = \dfrac{b_1}{t}$, and the calculator does give you b_1 (called **b**) and *t*. So, to calculate s_{b_1}, divide **b/t**. Find **b** by pressing [VARS] **VARS 5:Statistics EQ 3:b**. Find **t** by pressing [VARS] **VARS 5:Statistics TEST 3:t**.

Section 11.3 ▪ Transforming for a Better Fit

Review Section 3.5 on pages 31–32 of this Calculator Guide for information about transformations to achieve linearity.

CHAPTER 12 STATISTICS IN ACTION: CASE STUDIES

Section 12.1 ▪ Mum's the Word!

The data set in Display 12.3 is large and is best analyzed with statistics computer software. However, the TI-83 and TI-83 Plus can help you with some of the practice exercises. For example, in P4, the calculator can perform the test using the summary statistics listed in the *Statistics in Action* student text.

Section 12.2 ▪ Baseball: Does Money Buy Success?

The TI-83 and TI-83 Plus can accomplish all of the regressions necessary for this case study. However, as displayed in the *Statistics in Action* student text, computer printouts are much more informative and efficient for the purposes of the chapter.

Section 12.3 ▪ *Martin v. Westvaco* Revisited: Testing for Employment Discrimination

This section requires boxplots, which the calculator can do, but the focus is on whether or not inference is appropriate. Therefore, there is not a great need for calculator support.