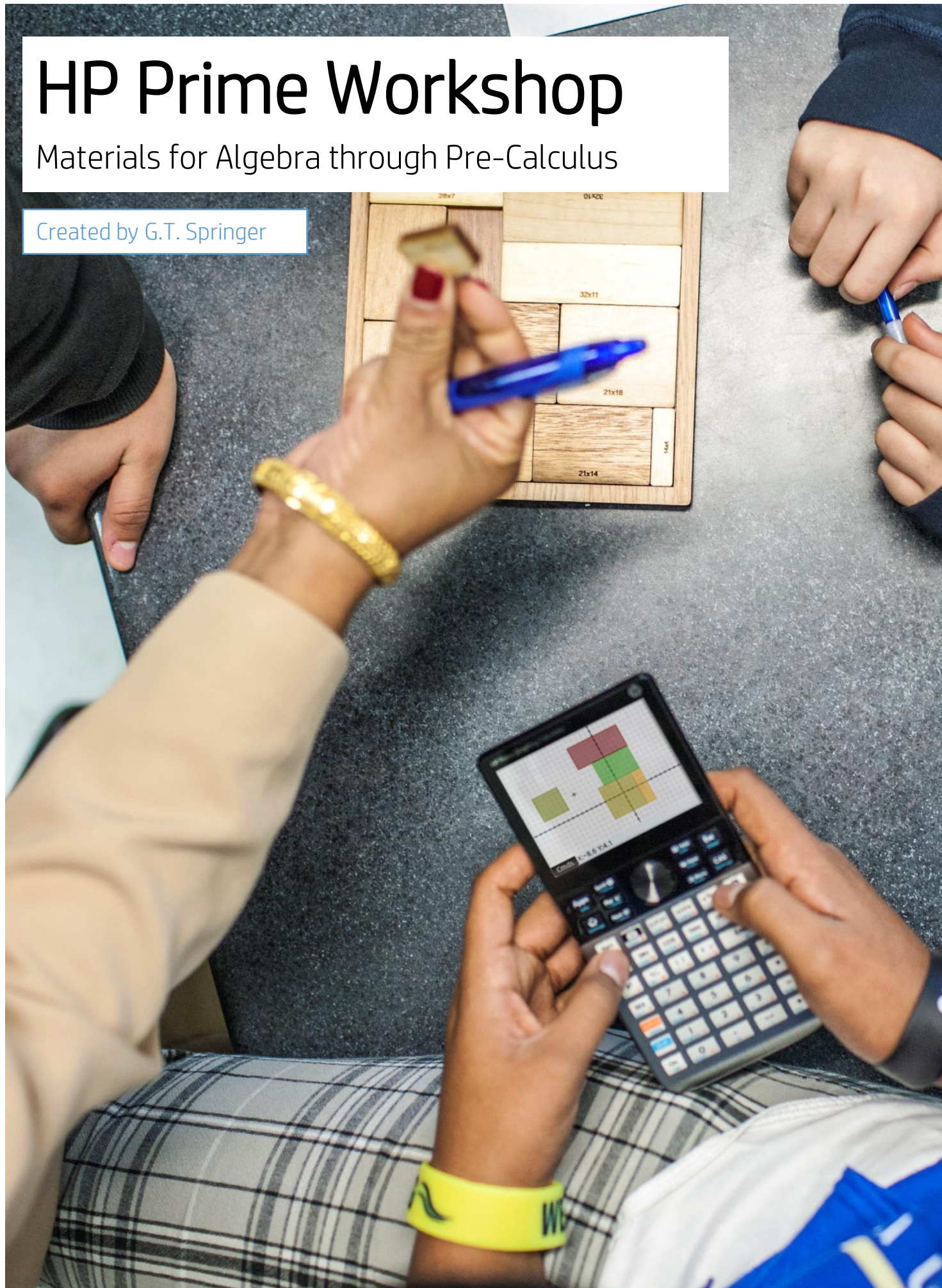# HP Prime Workshop

Materials for Algebra through Pre-Calculus

Created by G.T. Springer

Getting Acquainted With HP Prime

HP Prime is a color, touchscreen graphing calculator, with multi-touch capability, a Computer Algebra System (CAS), and a set of apps for exploring mathematical concepts and solving problems. For example, there is an Advanced Graphing app that lets you graph any relation in two variables (graphing something like $\sin(xy) = \cos(xy)$ for example), and a set of three

apps for statistics (Statistics 1Var, Statistics 2Var, and Inference). In this section, we'll take a look at how to find your way around HP Prime, and get acquainted with the Prime app structure.

Document Conventions

First, here are a few conventions we'll use in this document:

- A key that initiates an un-shifted function is represented by an image of that key: ⌨, ⌨, ⌨ and so on.
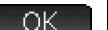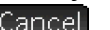- A key combination that initiates a shifted function (or inserts a character) is represented by the appropriate shift key (⌨ or ⌨) followed by the key for that function or character:
  ⌨ ⌨ initiates the natural exponential function and ⌨ ⌨ inserts the letter F.
- The name of the shifted function may also be given in parentheses after the key combination:
  ⌨ ⌨ (Clear), ⌨ ⌨ (Plot Setup)
- A key pressed to insert a digit is represented by that digit:
  5, 7, 8, and so on.
- All fixed on-screen text—such as screen and field names—appear in bold:
  CAS Settings, **Xstep**, **Decimal Mark**, and so on.
- A menu item selected by touching the screen is represented by an image of that item:
  ⌨ , ⌨ , ⌨ , and so on.

  NOTE: You must use your finger or a capacitive stylus to select a menu item, or navigate to the selection and press ⌨ .

- Cursor keys are represented by ⌄, ⌃, ⌄, and ⌃. You use these keys to move from field to field on a screen, or from one option to another in a list of options.

The ON-OFF key is at the bottom left of the keyboard. When a new HP Prime is turned on for the first time, a "splash" screen appears that invites the user to select a language and to make some initial setup choices. For most users, accepting the default options is the way to go.

The screen brightness can be increased by pressing and holding ⌨ and ⌨ or decreased by pressing and holding ⌨ and ⌨.

Take a minute to look at the layout of the keyboard. The top group of keys, with the black background, is primarily for navigating from one environment to another. Pressing ⌨ takes you to the home calculation screen, and pressing ⌨ takes you to a similar calculation environment for doing symbolic or exact computations. Pressing ⌨ takes you to a menu

where you can select from all the applications in the HP Prime, like **Advanced Graphing** or **Function**. The bottom group of keys is mainly for entering or editing mathematical expressions. There are also environments for entering lists, [Shift] [7 List Q] , matrices, [Shift] [4 Matrix U] , and user programs, [Shift] [1 Program Y] .

Some care was taken when deciding where to place certain keys. The number π for instance, is [Shift] [3 π #] . The list delimiters, {}, appear just to the right of the LIST key, [Shift] [8 {} R] and the matrix delimiters, [], appear just to the right of the MATRIX key, [Shift] [5 [] V] .

Things you can do in both CAS and Home views:

- Tap an item to select it or tap twice to copy it to the command line editor
- Tap and drag up or down to scroll through the history of calculations
- Press [≡Menu Paste] to retrieve a previous entry or result from the other view
- Press the Toolbox key ([Mem B]) to see the Math and CAS menus as well as the Catalog
- Press [▯,√,▯ Units C] to open a menu of easy-to-use templates
- Press [Esc Clear] to exit these menus without making a selection
- Tap [Sto ►] , [Copy] , and [Show] menu buttons

Home View

Turn on your HP Prime and take a look at the different sections of the screen in the **HOME** view. The top banner across the top is called the Title Bar, and it tells you what operating environment you are currently working in (like **HOME** or **FUNCTION SYMBOLIC VIEW**). If you press a shift key, an annunciator comes on at the left of the Title Bar. On the right, you see a battery level indicator, a clock, and the current angle mode. You can tap this Quick Settings section at the top right to see a calendar (by tapping the date and time), connect to a wireless classroom network (by tapping the wireless icon), or change the angle mode (by tapping the angle mode indicator).
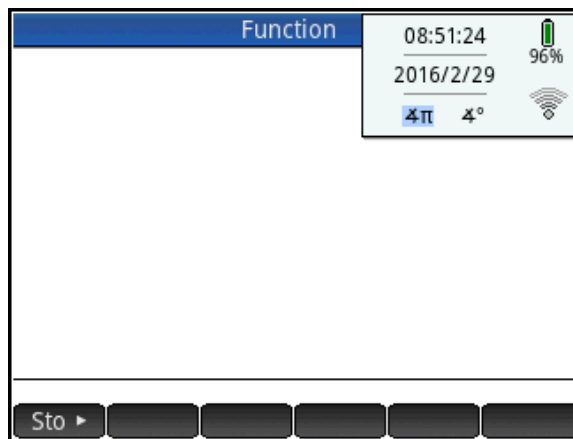
The middle section of the **HOME** view contains a history of past calculations. You can navigate through the history with the cursor keys, or using your finger to select (by tapping) or scroll (by swiping). The edit line is just below the history section. This is where you enter mathematical expressions to evaluate numerically. At the bottom are the menu keys, consisting of [Sto ►] in the **HOME** view. These menu keys are context sensitive. Their labels and function change depending on the environment you're in.

Home view is for numerical calculations. Press 🏠 (Settings) to open Home view if you are not already there. Press **Shift** $\boxed{\sqrt{\ }^{x^2}}$ to enter the square root radical, then 8 and press $\boxed{\text{Enter}}$. A numerical approximation to $\sqrt{8}$ is returned.
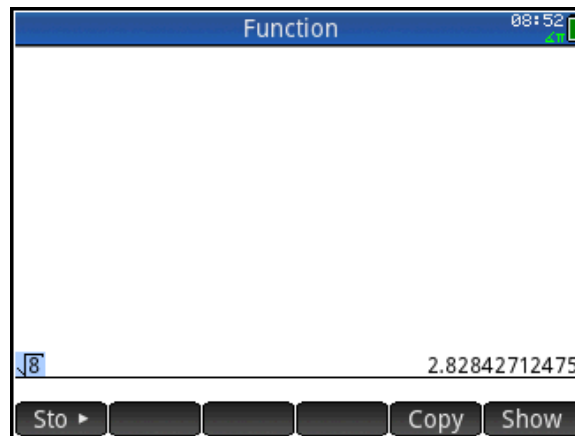
In Home view, all results evaluate to a real or a complex number, or a matrix, list, etc. of real and/or complex numbers. You can tap on any previous input or result in the history to select it. When you do, two new menu buttons appear: **Copy** and **Show**. The former copies the selection to the command line at the cursor position while the later typesets the selection in textbook format in full-screen mode.

CAS View

CAS view, on the other hand, is for symbolic or exact numerical results. Press **CAS** (Settings) to open CAS view. Let's repeat our first calculation. Complete the command as shown and press $\boxed{\text{Enter}}$. The result is an exact numerical value. Similarly, $\dfrac{5}{2}!$

and $\displaystyle\int_{-\infty}^{\infty} \dfrac{1}{e^{t^2}}\,dt$ evaluate exactly, as shown in the figure,
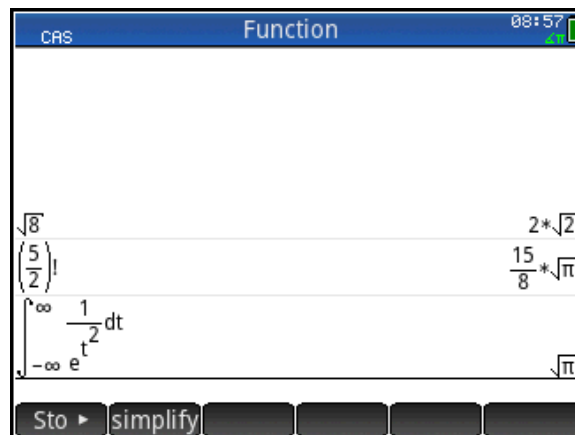
Copy and Paste

As mentioned earlier, both the CAS and Home view histories use **Copy** to copy the selection to the command line. There is also **Shift** 📋(View/Copy) (Copy) and **Shift** 📋(Menu/Paste) (Paste) that copies the selection to the Prime clipboard and pastes from that clipboard to the cursor position. This functionality makes it possible to copy and paste from one environment to another anywhere in your HP Prime. With data, you can tap and hold, then drag to select a rectangular array of cells, then copy and paste anywhere else. With the HP Prime Virtual Calculator, you can copy an array of cells in a spreadsheet on your PC and paste the numerical data anywhere in the Prime Virtual Calculator. You can then send the data to another HP Prime.

Delete and Clear

In both CAS and Home views, you can select an item in history and press $\boxed{\text{⌫ Del}}$ to delete it. Press **Shift** $\boxed{\text{Esc Clear}}$ (Clear) to delete the entire history. If you are in any view (Symbolic, Plot Setup, etc.), **Shift** $\boxed{\text{Esc Clear}}$ (Clear) will reset (clear) all settings in the current page of the view back to their factory defaults.

Example: Infinite Series

Suppose we wish to explore the series $1 + \dfrac{3}{2} + \dfrac{5}{4} + \dfrac{7}{8} + \dfrac{9}{16} ...$

To begin with, we can compute the first few partial sums.

1. Press [⌂ Settings] to enter the Home view.
2. Type 1 and press [Enter ≈]
3. Press [+ Ans ;] [3 π #] [÷ x⁻¹ T] [2 i Z] [Enter ≈]
4. Press [a b/c oııı E] to cycle through its decimal, proper fraction, and improper fraction forms

If no entry from Home History is selected, [a b/c oııı E] operates on the last answer. You can tap on an entry to select it and then [a b/c oııı E] will operate on that selection.

5. Continue as shown to the right until you have the first 5 partial sums

Use [a b/c oııı E] to see that the partial sums are now greater than 5. What is the limit as n approaches ∞? Use the CAS to find out.

We observe that the sum can be rewritten symbolically as

$$1 + \frac{3}{2} + \frac{5}{4} + \frac{7}{8} + \frac{9}{16} ... = \sum_{n=0}^{\infty} \frac{1+2n}{2^n}$$

1. Press [CAS Settings] to open the CAS view. Press [≣,√□,│□│ Units C] to open the Template menu and select the summation template
2. To enter n=0, press [ALPHA alpha] [( ) │□│ N] [▶] [0 Notes " "]
3. To enter ∞ at the top, tap on the top and press [Shift] [,∞,→ 9 S] and tap on ∞
4. Tap on the right template box and enter the rational expression. Hint: use the fraction from the Template menu.
5. When you are done, press [Enter ≈]
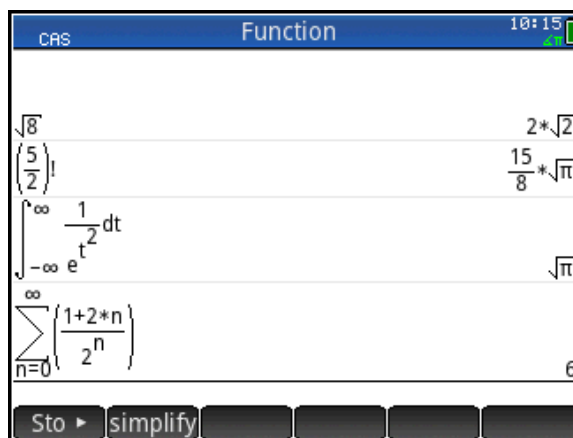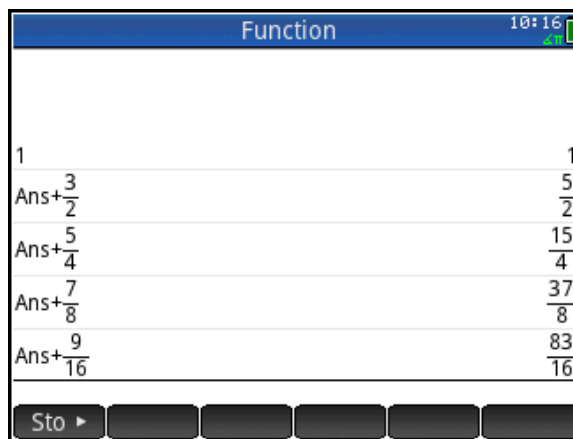
HP Prime Apps and Their Views

The HP Prime graphing calculator comes pre-loaded with a number of apps. Each app was designed to explore and area of mathematics or to solve problems of a specific type. Every Prime app is divided into one or more views. Most commonly, an app has a Symbolic view, a Plot (or Graphic) view, and a Numeric view. In this sense, the apps all have a common structure so they are easier to learn to use as a set of apps. The Prime app schema is shown in the figure below.

HP Apps and their Views

Symbolic   Graphic (Plot)   Numeric
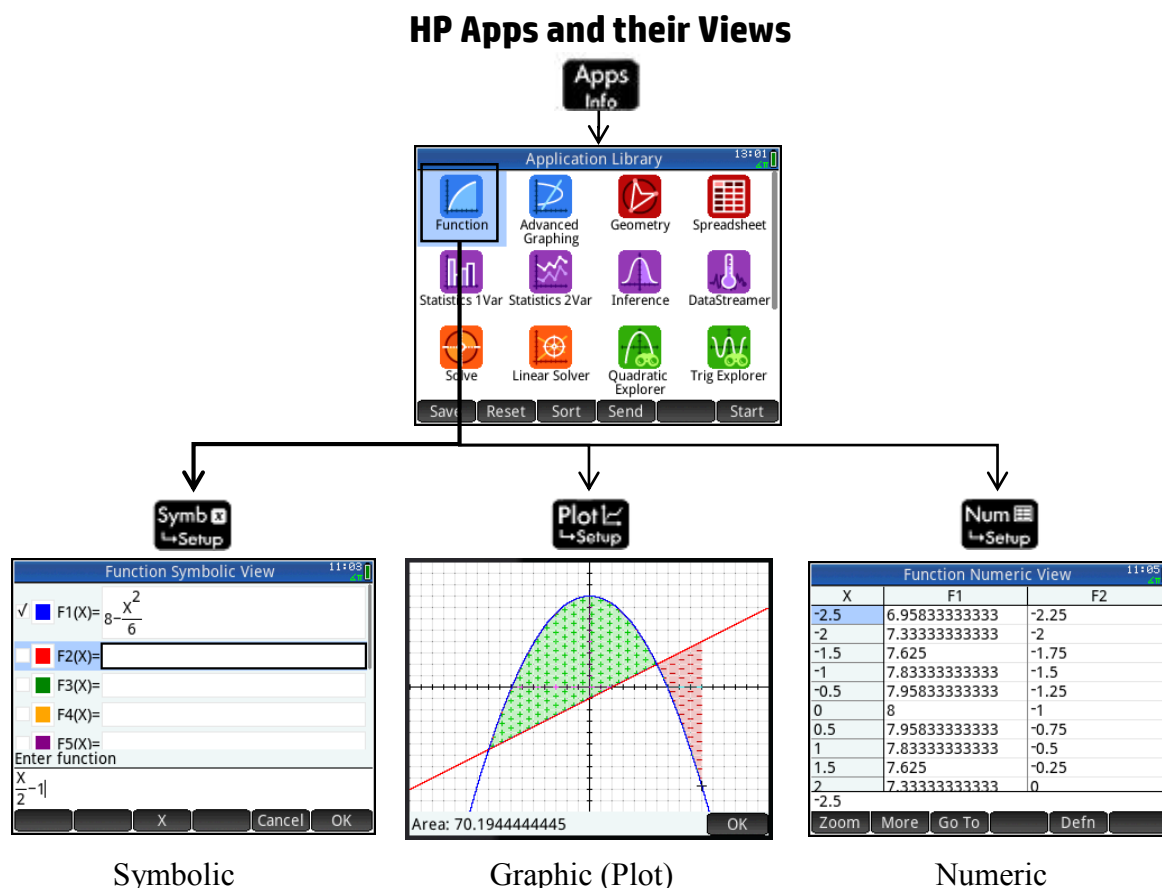
Press ![Apps Info] to open the App Library. Tap on an app to start it, or navigate the library using the cursor pad and tap ![Start] to launch the app.

Fill the app with data while you work; you can come back to this app anytime-all your data is automatically saved! You can save an app with a name you'll remember; then reset the original app and use it for something else. HP Apps have app functions as well as app variables; you can use them while in the app, or from the CAS view, Home view, or in programs.

The Function App

The Function App gives you all the tools you need to explore the properties of functions, including plotting their graphs, creating tables of values, and finding roots, critical points, etc.

1. Press $\boxed{\text{Apps}}$ and tap on the Function icon. The app opens in Symbolic view.

2. Enter $8 - \dfrac{X^2}{6}$ in F1(X) and $\dfrac{X}{2} - 1$ in F2(X)

3. For each function, tap on the color picker to choose a color and check/uncheck it to select/deselect it for graphing

4. Press $\boxed{\text{Plot}}$ to see the graphs of your checked functions

In Plot view, tap $\boxed{\text{Menu}}$ to open the menu. The menu buttons are:
- **Zoom**: opens the Zoom menu
- **Trace**: toggles tracing off and on
- **Go To**: enter a specific *x*-value and the tracer will jump to it
- **Sketch**: sketch a graph with your finger
- **Fcn**: opens a menu of analytic functions
- **Menu**: opens and closes the menu

Things you can do:

- Press $\textcircled{\triangleleft}$ or $\textcircled{\triangleright}$ to trace the current graph (F1(X))
- Tap anywhere on the display and the tracer will jump to the x-value indicated by your finger tap while still remaining on the function being traced.
- Press $\textcircled{\blacktriangle}$ or $\textcircled{\blacktriangledown}$ to jump from function to function for tracing
- Tap and drag to scroll the graphing window
- Pinch or un-pinch to zoom out or in, respectively (or press $\boxed{\text{Ans}^+}$ and $\boxed{\text{Base}^-}$ to zoom in and out on the cursor, respectively)
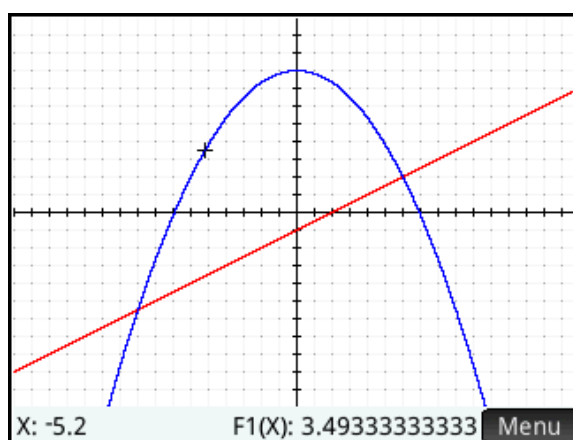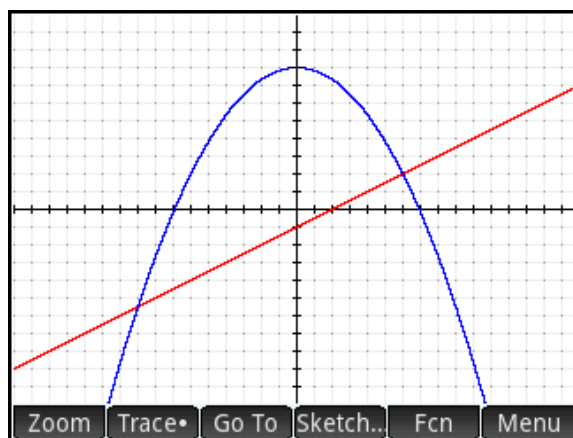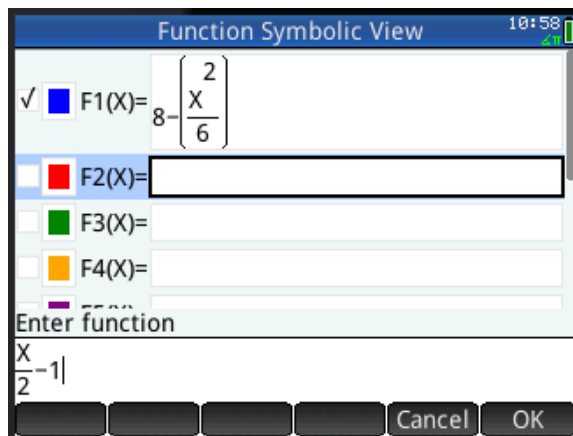
The **Fcn** Menu

The following examples use the options in the **Fcn** menu to explore our two functions.

Roots

First, we will find one of the roots of our quadratic function, F1(X).

1. Tap anywhere near the left-most root of the quadratic (around *x*=-7)
2. Tap ⎡Menu⎤ to open the menu (if necessary)
3. Tap ⎡Fcn⎤ to open the **Fcn** menu
4. From the list, select **Root**, either by tapping on it, using the direction keys, or pressing $\boxed{\underset{\text{Matrix}\ \ \ u}{4}}$.
5. The value of the root (*x*=-6.928…) is displayed
6. Press ⎡+⎤ to show the exact location of the cursor and ⎡OK⎤ to exit
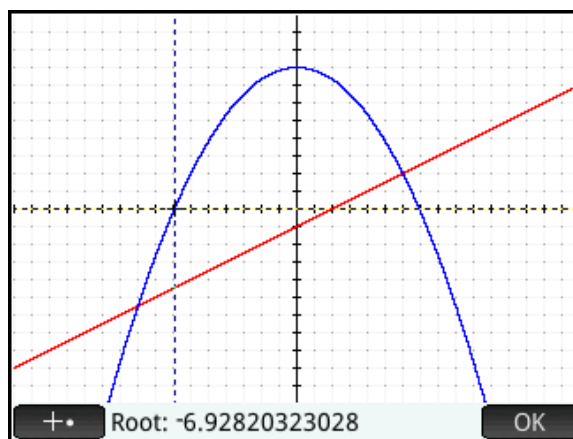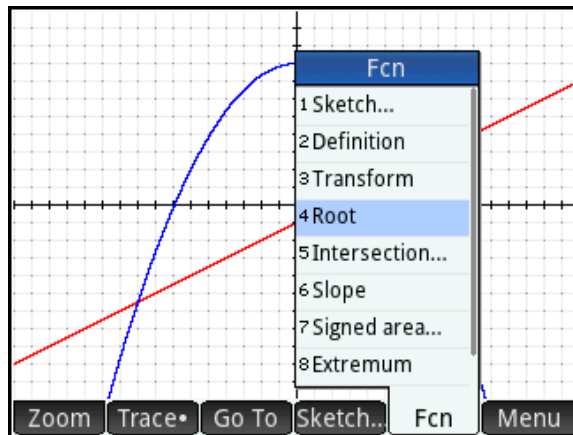
Intersections

We will now find the left-most point of intersection of the two graphs.

1. With the cursor still at the root from the previous example, tap ⎡Fcn⎤ to open the **Fcn** menu and select **Intersection**
2. A pop-up menu gives you the choice of finding the intersection with F2(X) or the *x*-axis. Press ⎡OK⎤ to select F2(X).
3. The intersection is displayed as shown to the right
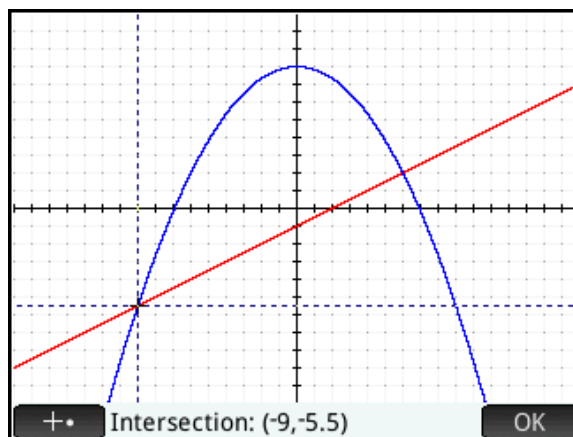
Slope and Tangent

The Tangent option draws the tangent to the current function through the trace point. Use it with the Slope option to see the slope of the tangent. Both the tangent and slope continue to update as you trace the function, until ⎡Cancel⎤ is pressed. Tangent is a toggle; tap it again to disable.

Signed Area

Suppose you wish to find the signed area between the curves, from x=-9 to x=10.

1. Tap Fcn to open the Functions menu and select Signed Area…
2. Tap near x=-9, use the direction keys to move the cursor to x=-9 exactly, and tap OK.
3. Now tap near x=10 and use the direction keys to move the cursor to x=10 exactly
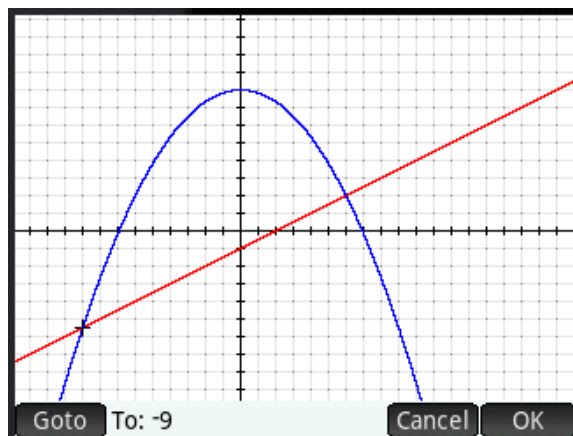
As you move the cursor, the area between the curves is filled in graphically. The color display shows you which regions have positive area and which have negative area. The fill patterns have "+" and "-" in them to remind the students that the area is signed.

4. Tap OK to see the area; tap OK again to exit.
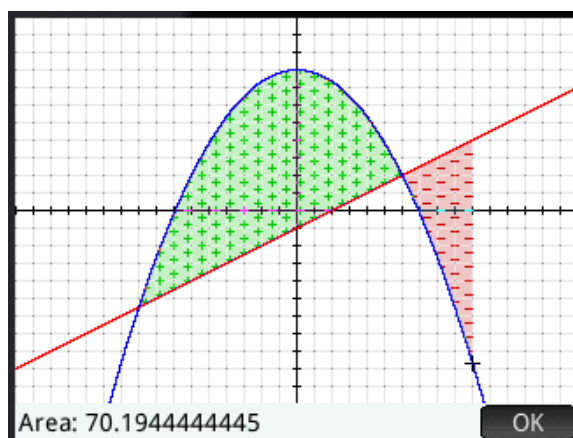
Extremum

The Extremum option finds either a maximum or a minimum, whichever is closest to the trace point.

Sketching a function

5. Return to Symbolic view and uncheck F1 and F2.
6. Return to Plot view and tap Menu and Sketch… Now you can sketch a graph with your finger. HP Prime will replace it with a function graph and show you its equation. Tap OK to accept the new graph or just draw another one with your finger. When you are done sketching, tap OK to exit Sketch mode. Your expressions are all saved in Symbolic view.
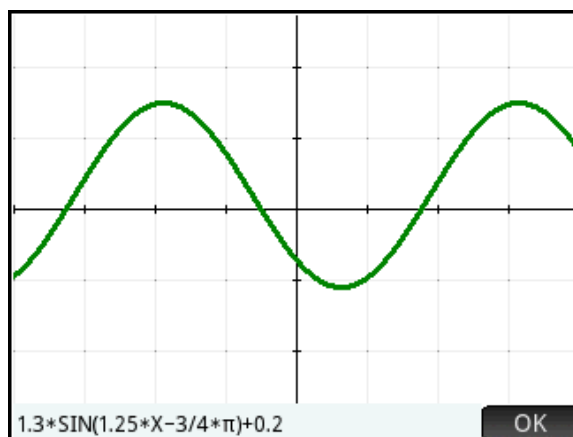
With the multi-touch display, working in Plot view is not only simpler, it is more interactive!

Example: Intersection of Two Curves

For our next example, we will draw a parabola and a line and find their intersections in three different ways.

1. Press ⬛ and tap on the Function App icon. The app will open in Symbolic view, where you can enter up to ten functions. Press ⬛ to enter Plot view.

You will see an error message saying that there are no functions to plot. Tap ⬛ OK ⬛ , because we are going to draw our own functions!

2. Tap ⬛ Menu ⬛ to open the Plot view menu, then tap ⬛ Fcn ⬛ and select **Sketch…**

3. Draw a parabola with your finger. The HP Prime will show the trail of your finger. If you like the sketch, tap ⬛ OK ⬛ ; otherwise, just draw again with your finger until you get the parabola you want. The equation is shown at the bottom. When you tap ⬛ OK ⬛ , the function is copied to Symbolic view and the graph of the function replaces your sketch.

4. Draw a line that intersects your parabola twice. Tap ⬛ OK ⬛ .

5. Tap ⬛ OK ⬛ to exit Sketch mode.

6. Tap at one of the intersections and the tracer will move there. In the figure to the right, there is an intersection in the neighborhood of (3.2, 3.04).

No functions checked.

OK

$-0.25*X^2+0.2*X+5$

OK

X: 3.2   F2(X): 3.04   Menu
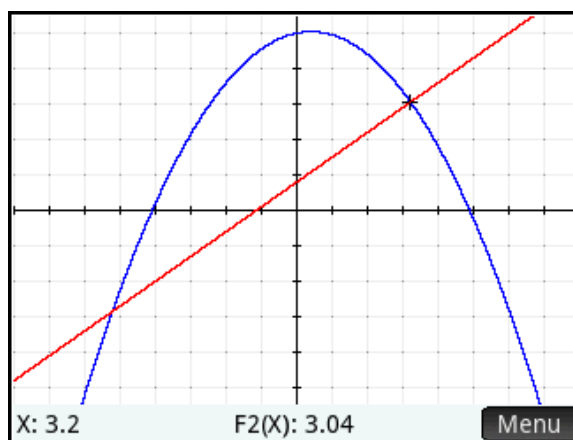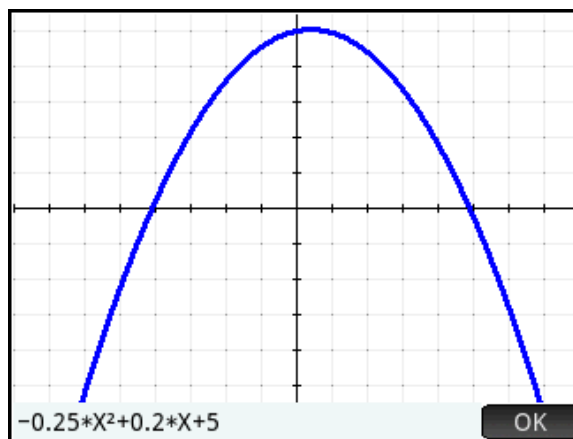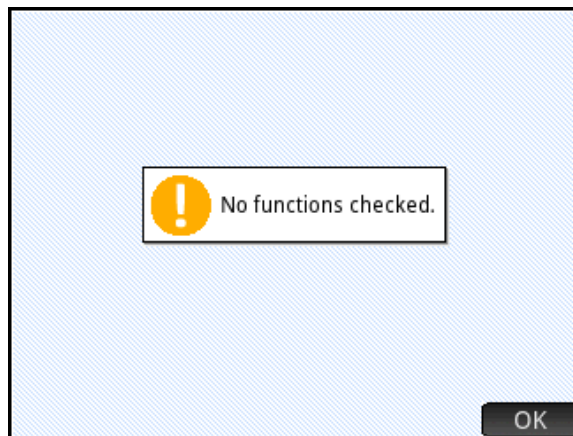
7. Drag the display to move the intersection to the middle of the display. Then pinch diagonally to zoom in on that intersection. After each zoom, tap to place the tracer as close to the intersection as possible. This is a dramatically different technological experience for finding the intersection of two curves- but it is one that is quite valuable and goes straight to the heart of the process. In the figure to the right, our new approximation for the intersection is (3.22, 3.053) after a few zooms.

8. Press $\boxed{-}$ to zoom out on the tracer back to the original window.

9. Press $\boxed{\text{Num}}$ to enter Numeric view. With the cursor in the x-column, enter 3 to see values near x=3. Tap on the x-value 3.2, which is closest to our intersection. Press $\boxed{+}$ (or pinch vertically) to zoom in on this value. After each zoom, tap the x-value that is closest to the intersection before zooming again.

In the figure to the right, we have zoomed in a number of times to estimate our intersection at (3.22, 3.053).

10. Return to Plot view (press $\boxed{\text{Plot}}$), tap $\boxed{\text{Menu}}$ to open the Plot view menu, then tap $\boxed{\text{Fcn}}$ and select **Intersection**. You will be prompted to select the other function. Tap $\boxed{\text{OK}}$ to see the intersection at (3.219, 3.0533).

Having a number of diverse technological experiences all focused on a key concept can help students develop a strong conceptual understanding of mathematics.

X: 3.21902   F2(X): 3.053314   Menu

Function Numeric View   11:54

X	F1	F2
3	3.35	2.9
3.1	3.2175	2.97
3.2	3.08	3.04
3.3	2.9375	3.11
3.4	2.79	3.18
3.5	2.6375	3.25
3.6	2.48	3.32
3.7	2.3175	3.39
3.8	2.15	3.46
3.9	1.9775	3.53
3.2		

Zoom | More | Go To | | Defn

Function Numeric View   12:05

X	F1	F2
3.215625	3.05806396485	3.0509375
3.216406	3.05696395875	3.051484375
3.217188	3.05586364745	3.05203125
3.217969	3.054763031	3.052578125
3.21875	3.05366210938	3.053125
3.219531	3.05256088258	3.053671875
3.220313	3.05145935058	3.05421875
3.221094	3.05035751342	3.054765625
3.221875	3.0492553711	3.0553125
3.222656	3.04815292358	3.055859375
3.21875		

Zoom | More | Go To | | Defn

Visualizing Identities and Conditions

Students usually just try to memorize basic identities. But HP Prime has an app that lets you test mathematical statements in 1 or 2 variables!

1. Press **[Apps Info]** to open the App Library and select the Advanced Graphing app. The app opens in Symbolic view, where you can enter up to ten mathematical statements. These can be equations or inequalities.

2. Enter $\sqrt{X^2} = X$. Tap **[=]** for the equal sign.

What do you expect to see for the graph of this equation?

3. Press **[Plot Setup]** to see the graph. The statement was an equation, but the graph looks like the graph of an inequality, specifically X≥0.

Once students put 2 and 2 together and realize that the graph means

$\sqrt{X^2} = X \ iff \ X \geq 0$, then they have a relatively easy way of testing most of the identities they will meet in high school mathematics.

4. For example, try $\sqrt{X^2} = |X|$. The graph is shown in red to the right. Now that is the graph of an identity!

Try any of the following:

- $\sin^2(x) + \cos^2(x) = 1$

- $\sin(x) = \cos\left(x - \dfrac{\pi}{2}\right)$

Statements in Two Variables

If $X^2 = Y^2$ does it follow that *X=Y?* That is, are $X^2 = Y^2$ and X=Y equivalent expressions?

1. Press **Apps Info** and select the Advanced Graphing app
2. Enter $X^2 = Y^2$ in V1
3. Press **Plot↔Setup**. The graph is shown to the right.
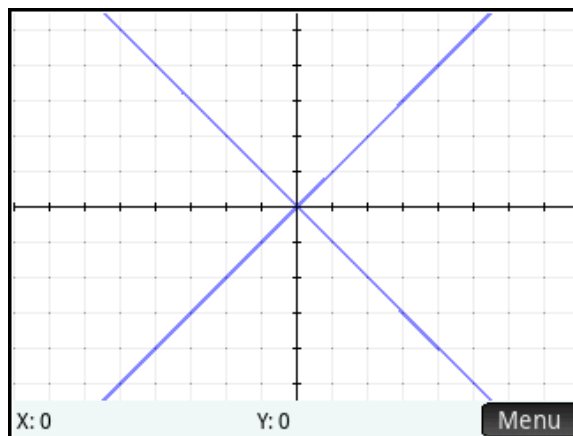
It seems there are 2 possibilities, and only one of them is that X=Y. Students must identify the other branch as X= -Y.

If $X^2 = Y^2$ then either *X=Y* or *X= -Y.*

Try the following:

- $\sqrt{x^2 + y^2} = x + y$

Graph it Your Way!

In the figure to the right, a single line has been represented in 4 symbolic forms students usually encounter in high school. With the Advanced Graphing app, all of these forms are considered valid.
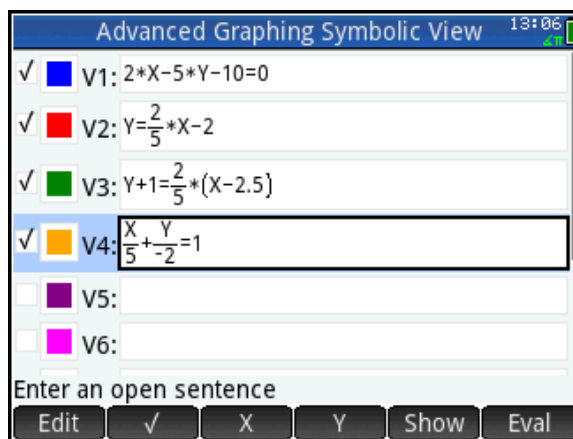
Press **Plot↔Setup** to see the graph of just the one line.
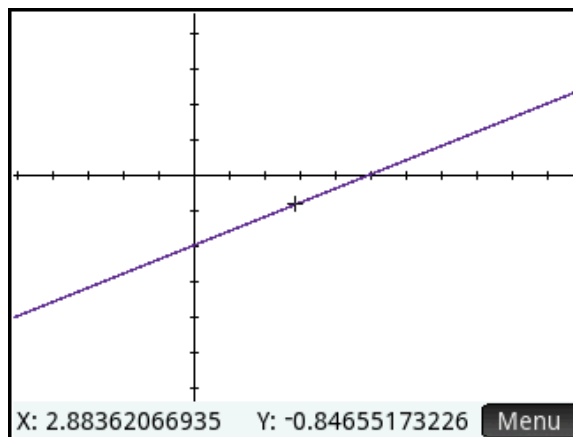
This unparalleled level of flexibility in the Advanced Graphing App allows students to test an identity or the equivalence of two different expressions. It also allows students to solve problems their own way, without having to conform to structures imposed by machines.

Example: A Special System of Linear Equations

Suppose you have a set of linear equations in Standard Form: Ax + By = C. Suppose further that the coefficients of each equation (A, B, and C) form an arithmetic sequence. What surprising property do they all have in common? This activity was featured at an NCTM National Conference lesson study presentation by Dan Kennedy.

1. Press `Apps Info` to open the App Library and select the `Advanced Graphing` app.

2. Create several linear equations, each of whose coefficients form an arithmetic sequence. The figure to the right shows a varied set of 7 such equations.

I like to challenge students to come up with their own outlandish examples and use them!

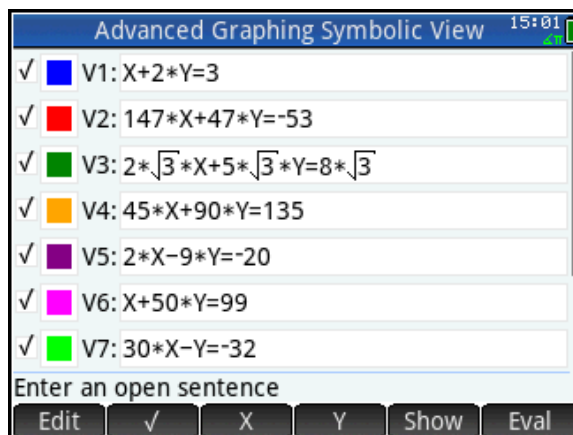3. Press `Plot Setup` to see the graphs.

It is surprising the first time one sees that these lines are all concurrent at the point whose coordinates are (-1, 2)! Students will be curious about the mathematics that shows why this must be true!

How do we re-write the equation AX+BY=C so that it reflects the fact that A, B, and C form an arithmetic sequence? Start with AX. Then B must be the sum of A and some value. Let's write AX + (A+B)Y. So the constant C must be B greater than this, or A+2B. So now we have AX + (A+B)Y = A+2B.

By inspection, Y=2 in order to have 2B on both sides. That leaves us:

AX+2(A+B)=A+2B or

AX + 2A + 2B = A + 2B

Now we have 2A on the left but only 1A on the right. So X= -1 is the only way to make the equation true. Thus any equation with this property contains the point (-1, 2).

Inverses and Transformations

The Advanced Graphing App supports transformations of graphs in a very logical way.

1. Open the Advanced Graphing App (or reset it) and enter Y=LN(X) for V1.
2. Enter Y=X for V2
3. The inverse of V1(X,Y) can be written as V1(Y,X). Enter this expression as V3.
4. Press ⬛ to see the graphs.
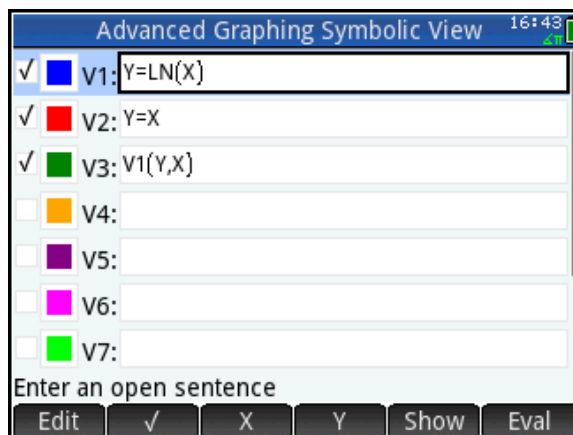
You can also do reflections, dilations and translations. In the figure below, we defined a unit disc in V1. The other entries are:

- V2, a translation of V1 3 units to the right and three units up
- V3, the reflection of V2 over the line Y=4
- V4, a horizontal dilation of V1 with a scale factor of 2
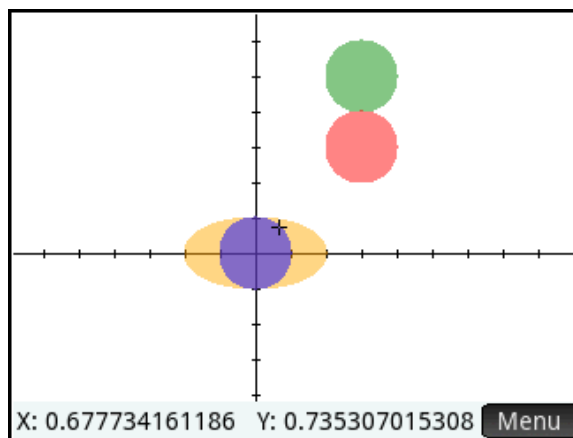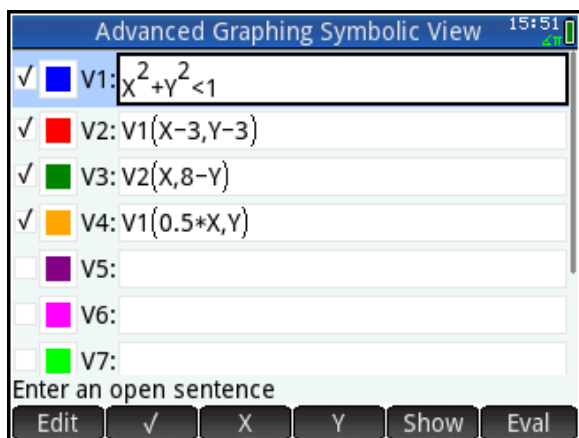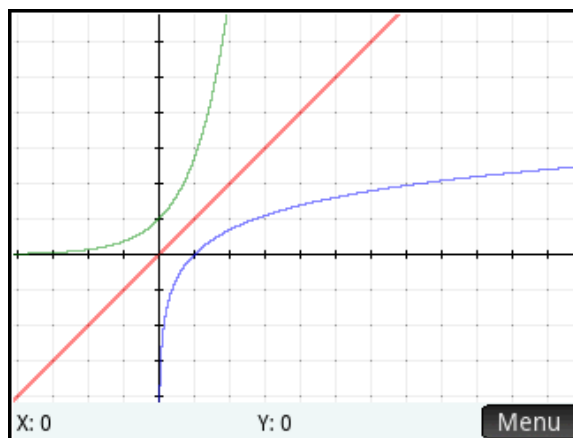
The Advanced Graphing App combines flexibility and power to bring an unprecedented level of visualization to your mathematics classroom!

Help is Always There!

HP Prime includes a Help key right on the keyboard: [?Help User] . Pressing this key displays helpful information about any app as well as its major views. You can also get help on any catalog/editor (program, matrix, etc.) and any command or function. This section introduces you to the Help System.

Help on Apps and their Views

1. Press [Apps Info] and use the cursor pad to select an app (eg. Function); then press [?Help User]. The help page for the app is displayed. Use your finger to scroll the help page. Tap [OK] when you are done.

2. Tap an app (eg. Function) to open it; then press [?Help User]. The help page for the current view (Symbolic, Plot, Numeric, etc.) is displayed. The purpose of the view is described and the various menu keys are listed. Tap [OK] when you are done.
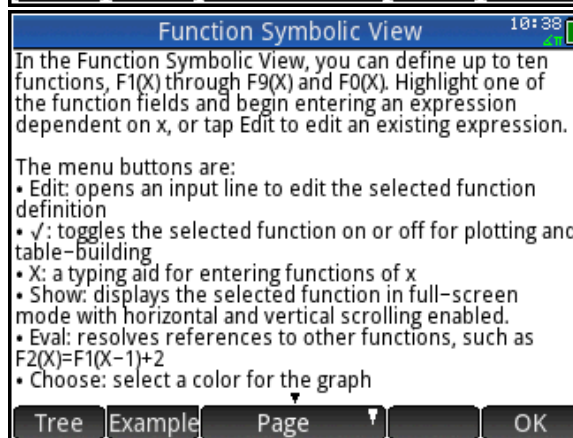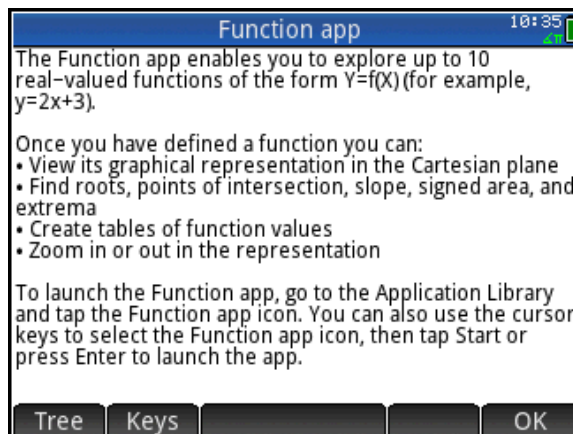
Help on Commands

1. Press [Mem B] to open the Toolbox menu. Tap [Math] to open the menu of common mathematical functions. Tap **List** to open the List submenu; the first entry is **Make List**. With **Make List** selected, press [?Help User].
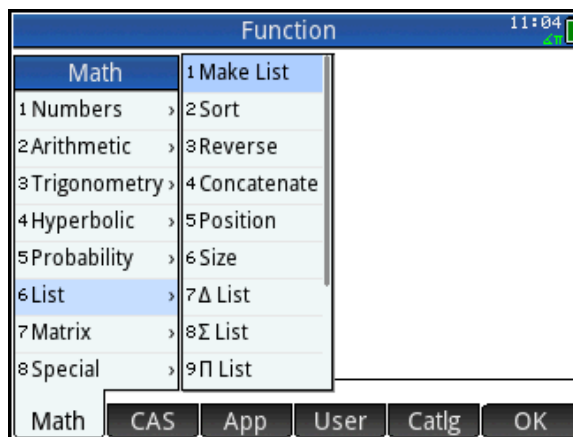
2. The help page for the MAKELIST command is displayed. The syntax is given, followed by a description of the purpose and use of the command. This is followed by one or more examples, as appropriate.
3. Tap `Exampl` and select an example to paste into the command line. In this case, the MAKELIST command will generate the list {1, 3, 5, 7, 9}.
4. Tap `Other` to see any related commands and open their help pages.
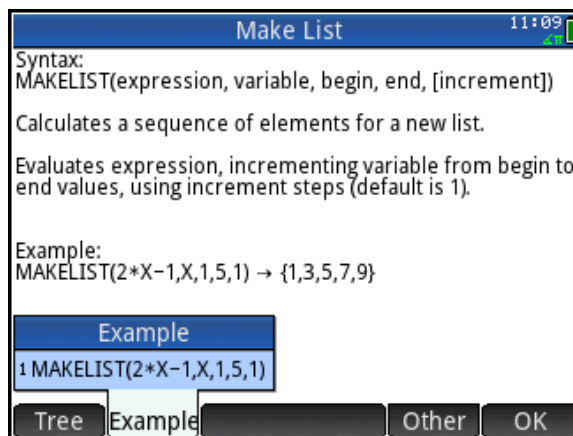
Exploring the Help Tree

5. Tap `Tree` to see the entire Help System topics tree. Click on the + box next to an item to expand it. Tap on an item to select it and then tap `OK` to view its page.
6. Tap `Keys` and then press one of the keyboard keys to get help on that key.
7. Tap `Search` and enter a keyword. HP Prime will take you to an item in the tree containing that keyword.
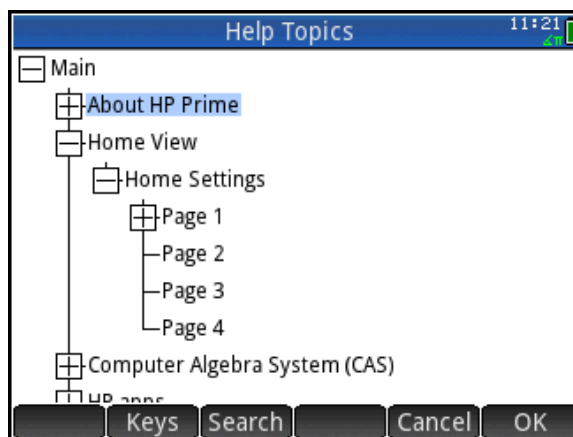
HP Prime has an extensive on-board help system to get you started and to support you as you explore mathematical concepts and solve problems.

The Statistics 1Var App

The Statistics 1Var app has Numeric, Symbolic, and Plot views similar to the Function and Advanced Graphing apps. In addition, you can use the app for calculating summary statistics for 1-variable data sets and constructing graphical displays of univariate data (stem plots, histograms, etc.).

Women in Computer Science

There is a concern that women are under-represented in the high-tech field of computer programming. In this activity, we explore the percentage of bachelor and advanced degrees in Computer Science awarded to women in various countries.

The table to the right shows the percentage of Computer Science degrees awarded to women in 22 countries in the year 2011.

2011 CS degrees awarded to women				
Country	Percent		Country	Percent
Austria	15.7		Israel	26.1
Belgium	9.8		Italy	25.5
Czech Rep.	12.2		Netherlands	12.8
Denmark	26.8		Norway	13.2
Estonia	23.1		Poland	15.6
Finland	23.9		Portugal	22.4
France	16.6		Spain	17.0
Germany	16.7		Sweden	29.4
Hungary	17.2		Switzerland	8.6
Iceland	13.1		UK	19.0
Ireland	42.3		USA	21.1

1. Press ![Apps Info] and select `Statistics 1Var`.

2. The app opens in Numeric view, where you ener columns of data. Enter the data manually in list D1 in Numeric view.

3. Tap [Sort] and then tap [OK] to sort the data in ascending order. The data set has 22 values; by inspection, what is the 5-number summary of the data set?

4. Press ⌨Symb to open Symbolic view.
    Set H1 to use D1 as its data and to
    draw a stem and leaf plot, as shown
    in the figure to the right. You can
    type in D1 or tap Column and select
    D1 from the list. Tap on the **Plot1**
    field to select it and then tap again
    to open the list of plot options and
    select **Stem and Leaf**.
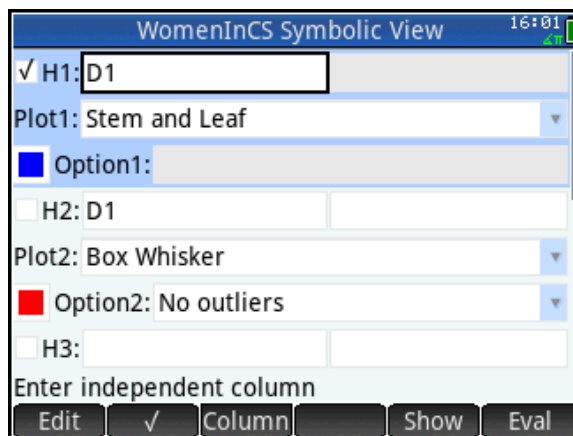
5. Press ⌨Num to return to Numeric view
    and tap Stats to calculate summary
    statistics for H1.
6. Does the 5-number summary agree
    with the values you gave in #2?
7. The mean is a bit larger than the
    median. What does this mean about
    any potential skew of the data?

8. Press ⌨View and select **Autoscale** to
    see the stem and leaf plot. Tap on a
    data point or use the cursor pad to
    navigate the data set.
9. From the 5-number summary and
    the stem plot, what do you conclude
    about the participation of women in
    Computer Science degree
    programs?
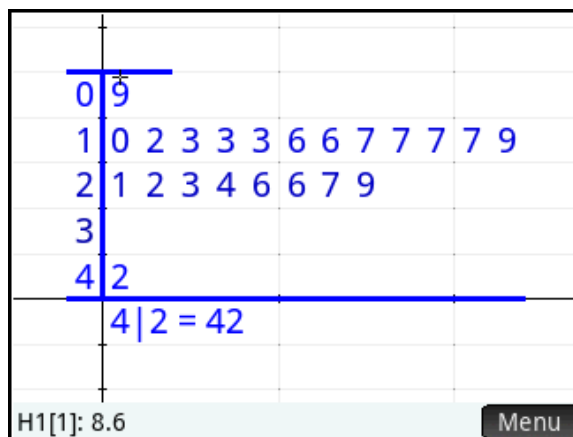
10. Return to Symbolic view and change the plot to a histogram.

11. Press ⬚ ⬚ to open Plot Setup view. Change the settings to agree with the figure shown to the right.
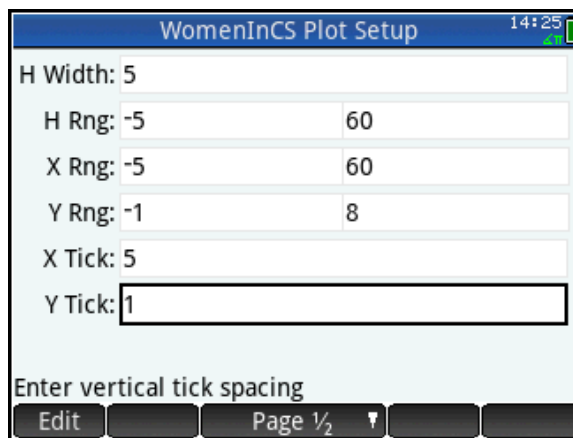
12. Press ⬚ to see the histogram. How would you describe this distribution?
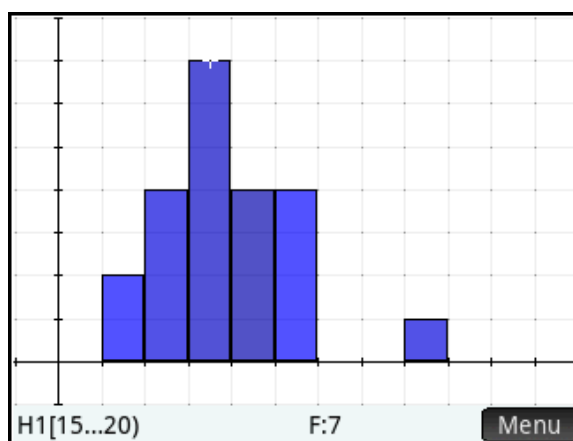
13. Is the maximum an outlier? Return to Symbolic view and change the **Plot1** field to **Box Whisker**. In the **Option** field, select **Show outliers**.

14. Press ⬚ and select **Autoscale** to see the plot.

15. The data point of 42.3 from Ireland is shown as an outlier. What can we learn about the participation of women in the field of computer programming from this outlier?
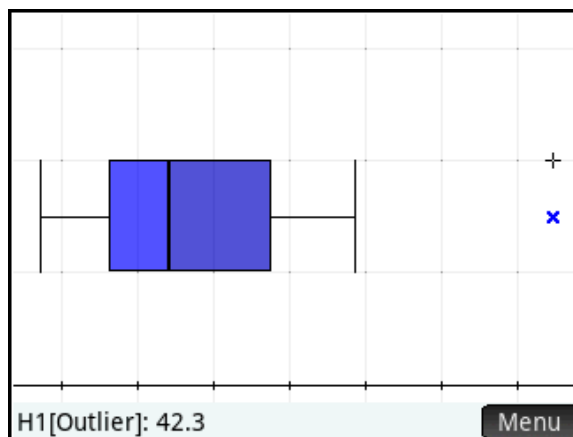
The Statistics 2Var pp

Use the Statistics 2Var app Numeric, Symbolic, and Plot views to enter bivariate data, compute functions of best fit, and predict y-values from x-values using the fit. You can also import the data into the Inference App to perform a linear t-test.

Cigarette Smoking in the United States

In this activity, we look at data from the Center for Disease Control on the number of daily smokers in the United States and the trend in that data. You can start with either the *Statistics 2Var* app or get the *Smokers* app from your instructor.

Part 1

The table to the right shows the percentage of people in the United States who smoke cigarettes daily, for each of the years from 2000 through 2010.

1. Press **Apps Info** to open the App Library and select the *Statistics 2Var* or *Smokers* app.

2. If you use the Statistics 2Var app, enter the data into C1 and C2 of Numeric view; if you got the Smokers app from your instructor, then the data is already entered for you. If you enter the data manually, consider using 0 for 2000, 1 for 2001, and so on, as was done in the figure to the right.

3. What is the average rate of decline in the percentage of daily smokers annually from 2000 through 2010? Is a linear model appropriate?

Percentage of daily smokers in the USA	
Year	% of daily smokers
2000	17.7
2001	17.4
2002	17.8
2003	16.9
2004	15.8
2005	15.3
2006	14.9
2007	14.5
2008	13.4
2009	12.8
2010	12.4

4. Press ⌨ to open Symbolic view. Set S1 to use C1 as the independent data and C2 as the dependent data, with a linear fit. You can also choose colors for the scatter plot and fit. In the figure to the right, the scatter plot will be drawn in red and the fit will be blue.
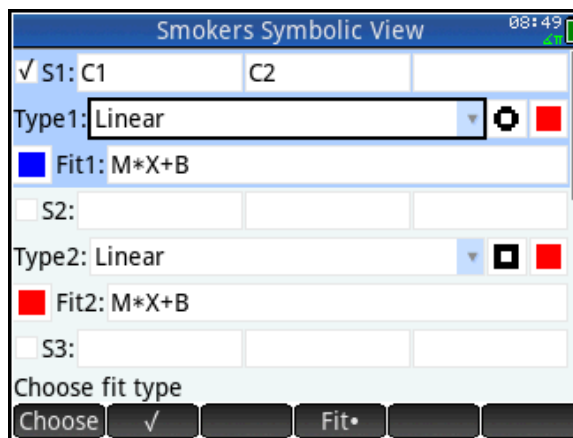
5. Press ⌨ and select Autoscale. Use your fingers to pinch and drag until you can see both axes and the x-intercept of the fit.

6. Tap [Menu] and [Defn] to see the linear fit expression in X: S1= -0.58*X+18.2545.

7. Explain what the parameters of this fit equation mean in terms of the percentage of daily smokers in the USA.

8. The PredX() command uses our fit to calculate the x-value for a given y-value. As you can see in the figure to the right, PredX(0)=31.4734. Explain what this means in terms of the percentage of daily smokers in the USA.

_____

_____
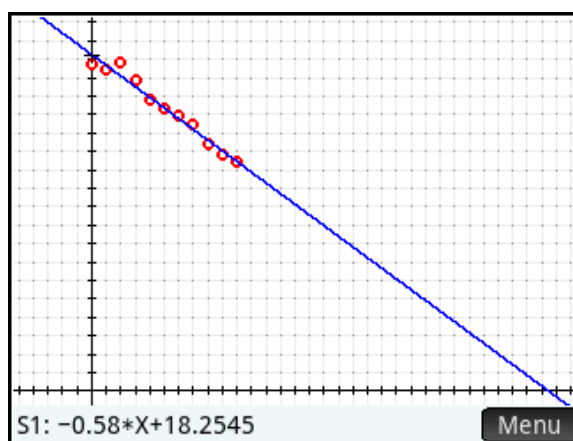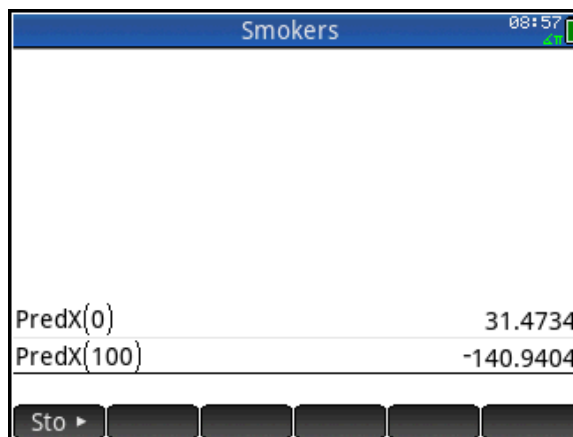
9. PredX(100)= -140.9404. Explain what this means and also express your confidence in this result.

Part 2

In this part of the activity, we perform a linear t-test and construct a 95% confidence interval for the slope of the line. First, let's suppose we want to perform a t-test on the slope at the $\alpha=0.05$ level.

1. Copy the data in Numeric view. To do this, tap and hold on the first data point in C1; then drag below and to the right to the last data point in C2. With all the data selected, press **Shift** **View Copy** (Copy).

2. We will now perform the linear t-test. Go to the App Library and select the Inference app. The app opens in Symbolic view. Tap the **Method** field and select **Regression**. In the **Type** field, select **Linear t test**.

3. The null hypothesis for the linear t-test is that the slope of the regression line is zero. Since the data indicate that the percentage of smokers is decreasing, our alternative hypothesis is that the slope of the regression line is negative. In Symbolic view, select $\beta_1<0$ in the **Alt Hypoth** field.

4. Press **Num Setup** to open Numeric view and paste your smokers data by pressing **Shift** **Menu Paste** (Paste). You will be prompted to paste your data as either grid data or text. Choose grid data and tap **OK**.

5. Tap **Calc** to view the results of the linear t test. Tap OK when you are done viewing the test results.

6. What does the p-value indicate about the null hypothesis vs. the alternative hypothesis?

1. Tap [OK] to return to Numeric view. Tap [Plot Setup] to open Plot view. You will see the scatterplot of the data, along with the linear fit.

2. Note that none of the residuals has an absolute value greater than 1. For the histogram of the residuals, a bin width of 0.25 is reasonable. Press [Shift] [Plot Setup] to open Plot Setup and change **Hwidth** to 0.25. Then press [View Copy] and select **Autoscale**.

3. Press ⊙ once or twice to see the scatterplot of the residuals. The scatterplot shows no discernable pattern.
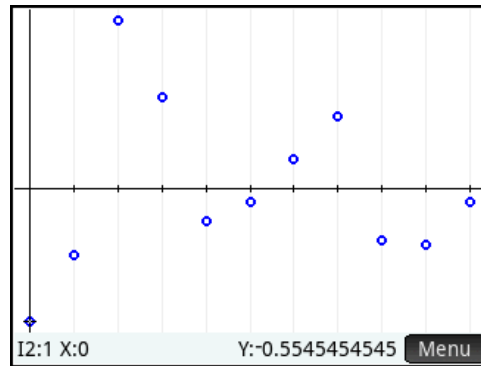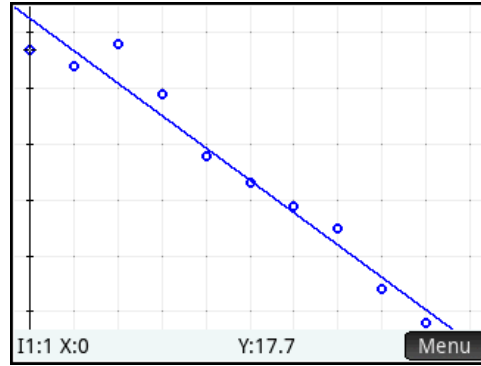
4. Press ⊙ once more to see the histogram of the residuals. Press ⊙ if you wish to return to the scatterplot of the residuals.
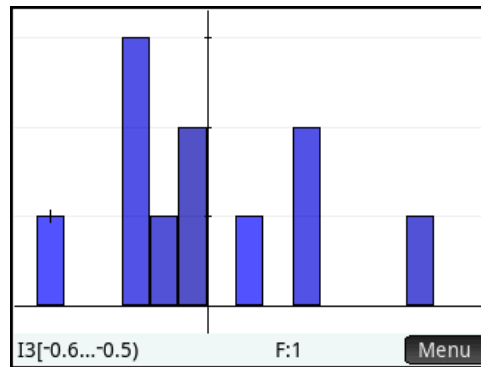
5. Finally, press ⊙ once more to see the normal probability plot of the residuals, which shows no alarming departure from linearity. Press ⊙ once more to return to the original scatterplot of the data and the fit line, or press ⊙ to return to the histogram of the residuals.
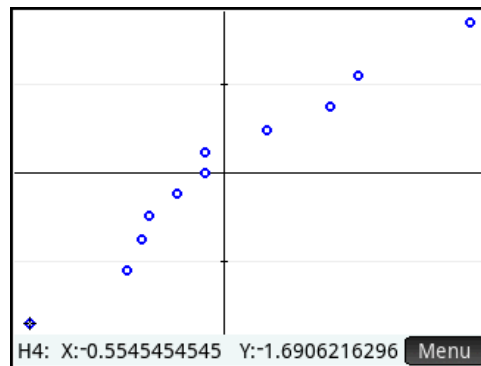
6. To construct a 95% confidence interval for the slope, return to Symbolic view and change the **Type** field to **Interval: Slope**.

7. Return to Numeric view and tap `Calc`. You will be prompted to enter a confidence level. Enter C=0.95 and tap `OK`.

8. The Results page for the confidence interval will be displayed, as shown in the figure to the right. What is the 95% confidence interval for the slope of the true regression line and what does it mean about the change in the percentage of daily smokers in the USA per year?

	Results	12:44
C	0.95	
Crit. T	2.2622	
DF	9	
β_1	-0.58	
serrSlope	0.0357	
Lower	-0.6608	
Upper	-0.4992	

0.95

| | More | | | | OK |

Exporting Data to a Spreadsheet

To export data from HP Prime to a spreadsheet, the data must be on the HP Prime Virtual Calculator. If your data is on a physical HP Prime, then you can use the Connectivity Kit to transfer the Statistics 2Var App that contains the data from the physical HP Prime to the Virtual HP Prime on your PC. The steps below begin with the data in the Statistics 2Var App on the HP Prime Virtual Calculator. We use data from a light intensity experiment to illustrate the process.

1. Open the Statistics 2Var App that contains your data. In the figure to the right, we see data from a light intensity experiment. Tap and hold on the cell C1(1), the cell that contains 0, until the cell is outlined in black (as shown).

	Statistics 2Var Numeric View		10:21
	C1	C2	C3	C4
1	0	128.4982		
2	0.0005	128.3516		
3	0.001	127.7656		
4	0.0015	127.326		
5	0.0023	127.326		
6	0.0028	126.1538		
7	0.0033	125.5678		
8	0.0038	125.2747		
9	0.0043	125.7143		
10	0.0048	126.3004		
11	0.0055	126.8864		
12	0.006	127.4725		
13	0.0065	128.0586		

0

| Edit | More | Go To | Sort | Make | Stats |

2. Drag down until the entire first column of data has been selected. Then drag to the right to select the entire second column as well.

3. In the HP Prime Virtual calculator menu, click on **Edit** and select **Copy**. The data is now on your PC clipboard.

4. Open your spreadsheet and select the starting cell for pasting your data.

5. Use the spreadsheet **Paste** command to paste the data, starting at the cell you selected.

You can easily copy data to and from the HP Prime Virtual calculator. Use the calculator's own copy and paste clipboard (Shift, View/Copy for Copy and Shift, Menu/Paste for Paste) to copy data anywhere within the HP Prime. In the next section, we copy data from the Internet to the HP Prime Virtual calculator. From there, it can be easily sent to the class, either wirelessly all at once, or via the unit-to-unit cable.

Importing Data to the HP Prime

Data can be easily imported from many sources into the HP Prime Virtual calculator. In this section, we import data from the Internet, first to MS Excel, and then to the HP Prime Virtual Calculator. David Keeling started taking CO_2 readings at the Mauna Loa Observatory in 1958. NOAA continued taking these reading from 1974. The data can be found at this URL:

http://www.esrl.noaa.gov/gmd/ccgg/trends/full.html

1. Click the **Data** tab and open the **annual mean data**. Select all of the data and copy it to the PC clipboard using Ctrl-C.

2. Open MS Excel. Select a cell and paste the data (Ctrl-V), starting at that cell. Usually, the paste command is sufficient and the data is separated correctly into columns. In some cases, you must take additional steps in Excel. In this example, the following additional step is needed.

3. Click the **Data** tab and click **Text to Columns**. Follow the wizard and the data will be separated into 3 columns: **Year**, **CO_2 annual mean**, and **unc**. Select all the data in the first two columns and copy them to your PC clipboard (Ctrl-C).
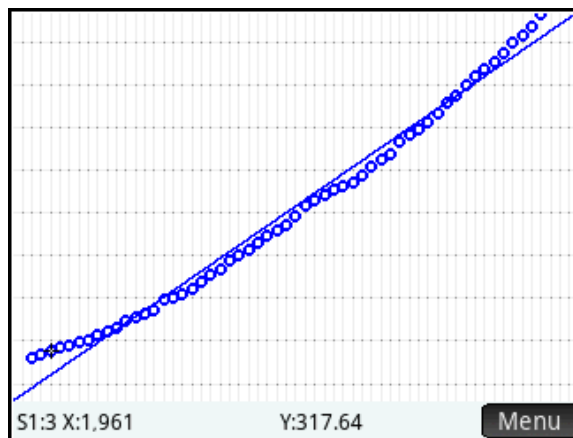
4. Launch the HP Prime Virtual calculator. Press [Apps Info] to open the App Library. Navigate to the Statistics 2Var app and tap [Reset] to delete all data currently in the app. Tap [Start] to open the app.

5. The app opens in Numeric view. With C1(1) selected, click **Edit** in the HP Prime Virtual calculator menu and select **Paste**. The year data is pasted into C1 and the CO_2 data is pasted into C2.

6. Press [Symb Setup] to open Symbolic view. By default, S1 is defined to use C1 as the independent data, C2 as the dependent data, and use a linear fit. Thus, there is nothing for us to do here. If you want a different fit type, select that field, tap [Choose] and select another type.

7. Press [View Copy] and select **Autoscale** to see the scatter plot. Tap [Menu] and then [Fit] to display the linear fit. Tap anywhere to move the tracer to the nearest data point, Press [▼] to move the tracer from the data to the fit.

8. Press ⬚ to return to Numeric view and tap ⬚ Stats ⬚ to see the *r* and R^2 values.

	S1
n	57
r	0.992905077529
R^2	0.985860492983
sCOV	419.23375
σCOV	411.87877193
ΣXY	39,849,553.93

Number of items

9. Press ⬚ to open the App Library and tap ⬚ Save ⬚. Enter a name for the app and tap ⬚ OK ⬚ twice. You now have a dedicated app that contains these data. In the figure to the right, the app named MaunaLoa contains the data. You can now reset the original Statistics 2Var app and use it for something else. The *MaunaLoa* app will always have your data, fit, etc. as you left it.
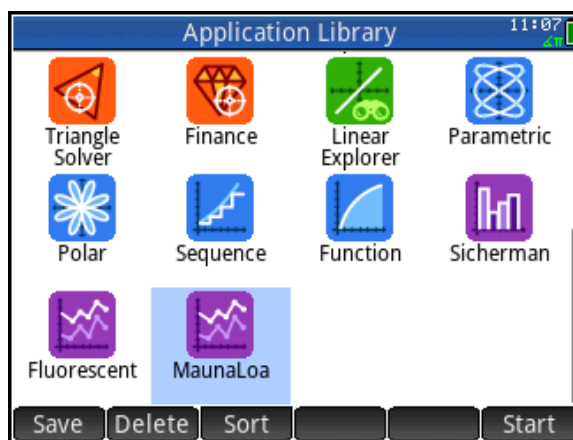
You can now send the *MaunaLoa* app to an entire class using the HP Prime Wireless Classroom Network. You can also send it to a single HP Prime via the USB cable. From there, students can pick it up one by one using the unit-to-unit cable. Again, the HP Prime is a highly portable and powerful laboratory system that can collect data from sensors, or import data from many sources for analysis, discovery, and to test conjectures.