Introduction

HP Prime is the latest advanced graphing calculator from Hewlett-Packard. It incorporates a full-color, multi-touch screen and comes pre-loaded with HP Apps. HP Prime has a Home view, with a history of your numerical calculations, as well as a CAS view, with a history of your symbolic computations.

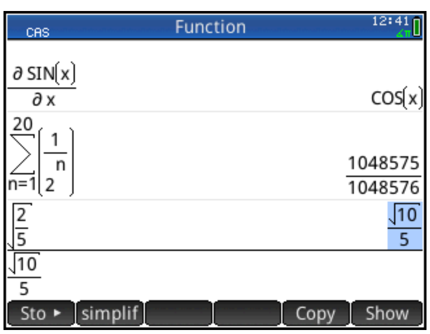
HP Prime has three design principles:

- Provide a high degree of mathematical fidelity across multiple mathematical representations
- Give students the touch-active and app-based experiences with mathematics that they have come to expect from mobile display technologies
- Deliver a simple and seamless experience for mathematical exploration and problem-solving

Home and CAS

With HP Prime, you can choose whether to operate numerically in the Home view or symbolically using the CAS in the CAS view. For example, press Settings and enter $\sqrt{8}$ in the Home view to see 2.828... or press CAS Settings and enter the same expression in the CAS view to see $2\sqrt{2}$.

CAS View



Calculation History

- Tap to select an entry
- Tap twice to copy it

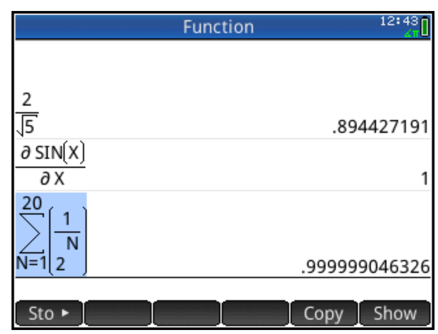
Command Line Editor

- 2D textbook format

Menu Buttons

- Tap to activate
- Context-Sensitive

Home View



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 once to activate

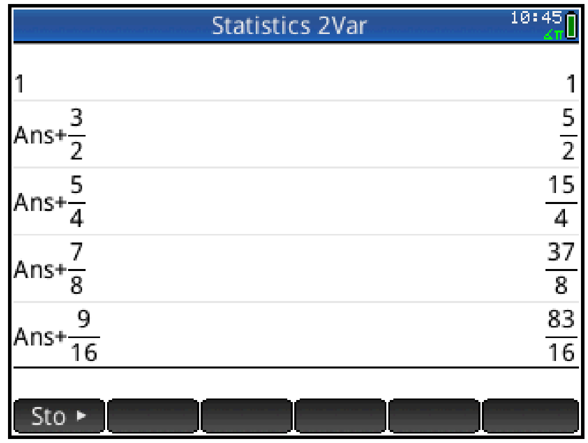
RPN Note: HP Prime supports RPN entry. In Home Settings (Shift Settings), navigate to **Entry** and select RPN. These workshop materials use the default Textbook setting.

Example: Infinite Series

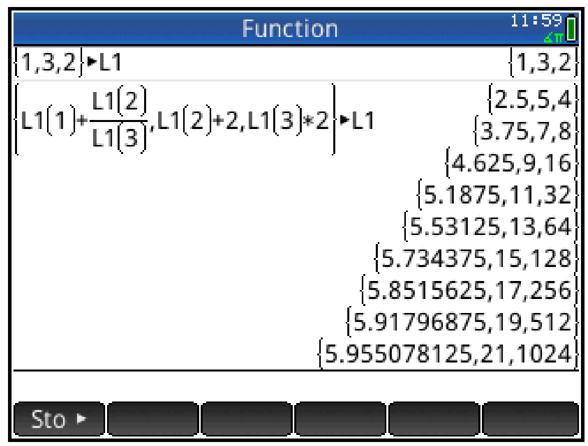
Suppose we wish to explore the series $1+\frac{3}{2}+\frac{5}{4}+\frac{7}{8}+\frac{9}{16}...$

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 + 3 ÷ 2 Enter
4. Press a b/c to cycle through its decimal, proper fraction, and improper fraction forms
5. Continue as shown to the right until you have the first 5 partial sums



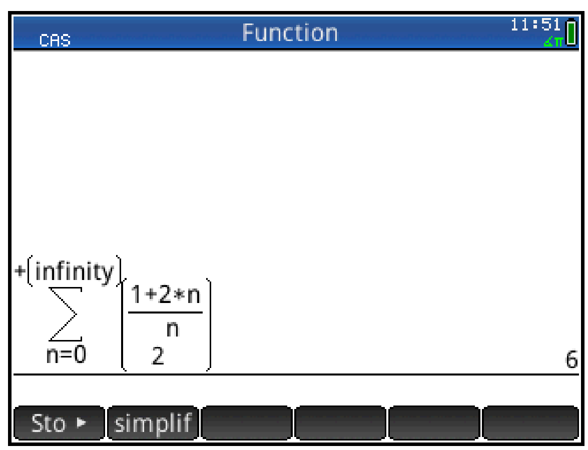
Another approach is to use lists. In the figure to the right, the List L1 is first defined to contain the 1st partial sum (1), followed by the numerator and denominator of the following term. The second line adds the next term to the sum, then adds 2 to the numerator and multiplies the denominator by 2, and stores the result back into list L1. From there, just pressing Enter generates the partial sums.



To use the CAS, we observe that the sum can be rewritten symbolically as

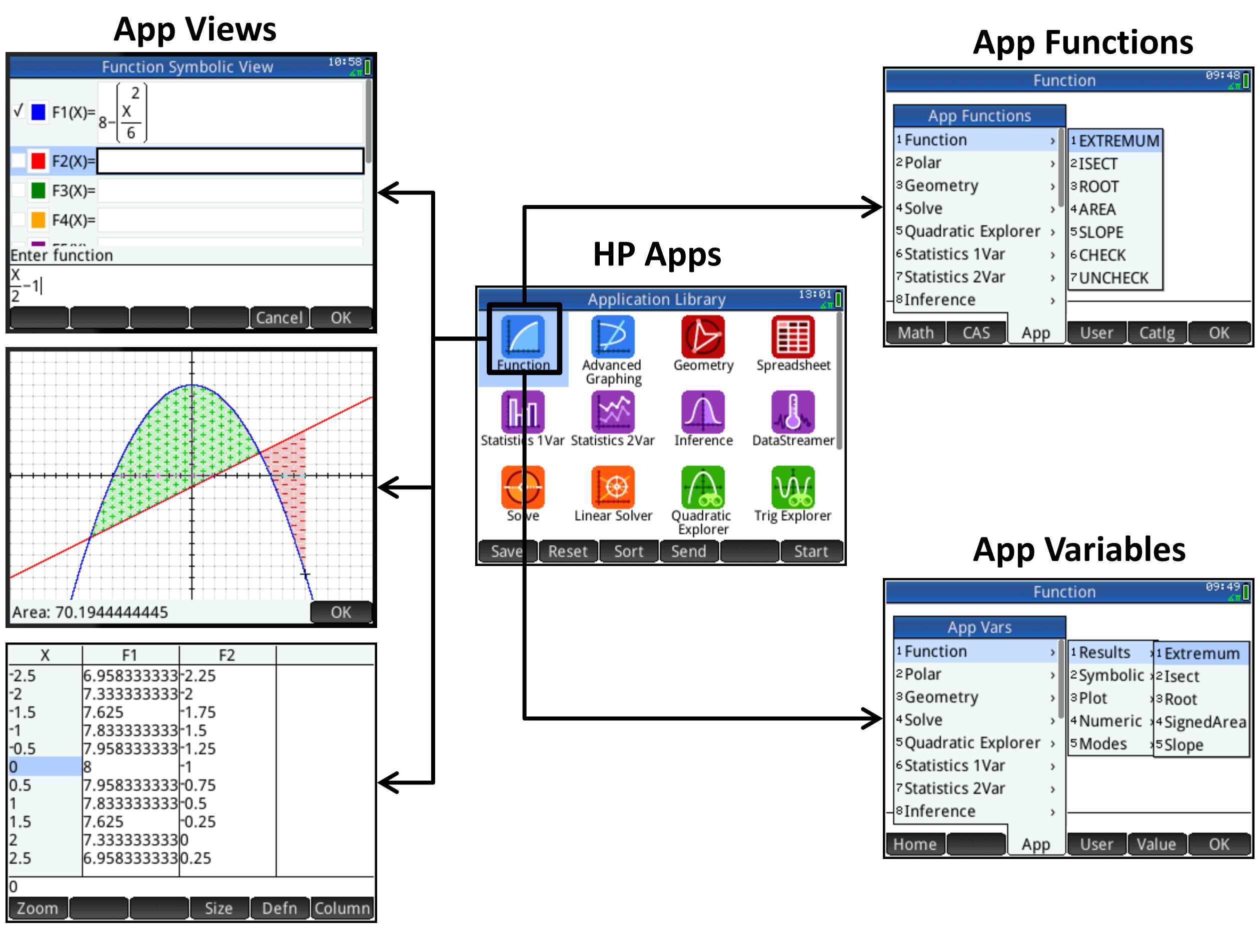
$$1+\frac{3}{2}+\frac{5}{4}+\frac{7}{8}+\frac{9}{16}...=\sum_{n=0}^{\infty}\frac{1+2n}{2^n}$$

1. Press CAS Settings to open the CAS view.
2. Press Units to open the template menu and select the summation template
3. To enter n=0, press ALPHA Shift ( ) ▶ 0
4. To enter +∞ at the top, tap on the top and press +, then Shift and tap on ∞
5. Tap on the right template box and enter the rational expression.
6. When you are done, press Enter



HP Apps

HP Apps are designed to explore mathematical topics or solve problems. All HP Apps have a similar structure, with numeric, graphic and symbolic views to make them easy to learn and easy to use. Fill the app with data while you work, and save it with a name you'll remember. Then reset the app and use it for something else. You can come back to your saved app anytime-even send it to your colleagues! 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.



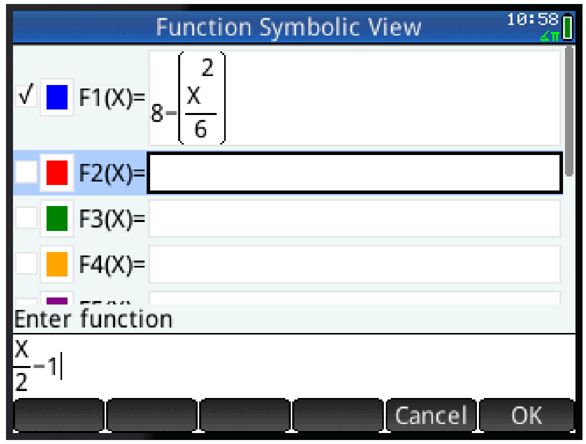
Press Apps Info to see the App Library. Drag with your finger to browse the library, then tap the icon of the app you want to use. The HP Apps are color-coded for easy identification:

- 5 graphing apps (blue) to explore graphs –including the new Advanced Graphing App!
- 2 Special apps (red): the Geometry app and the Spreadsheet app
- 4 Statistics Apps (purple) for descriptive and inferential statistics and data collection
- 4 Solver Apps (orange) for solving specific types of problems (triangles, finance, etc.)
- 3 Explorer Apps (green) for investigating a function's equation and its graph

The Function App

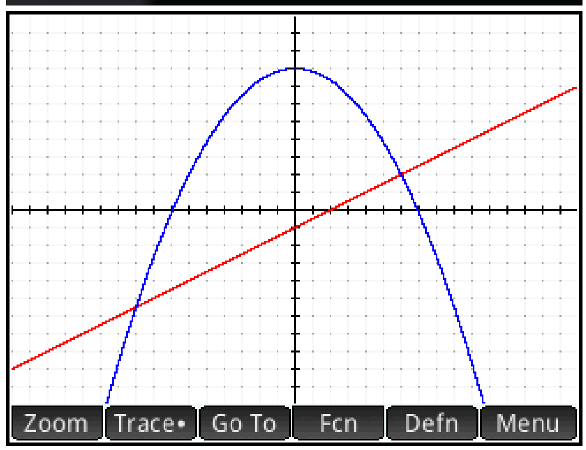
The Function App gives you all the tools you need to explore the properties of functions, including plotting their graphs, creating tables of values, and finding roots, critical points, etc.

1. Press Apps/Info and tap on the Function icon. The app opens in Symbolic view.
2. Enter $8-\frac{X^2}{6}$ in F1(X) and $\frac{X}{2}-1$ 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 Plot/Setup to see the graphs of your checked functions



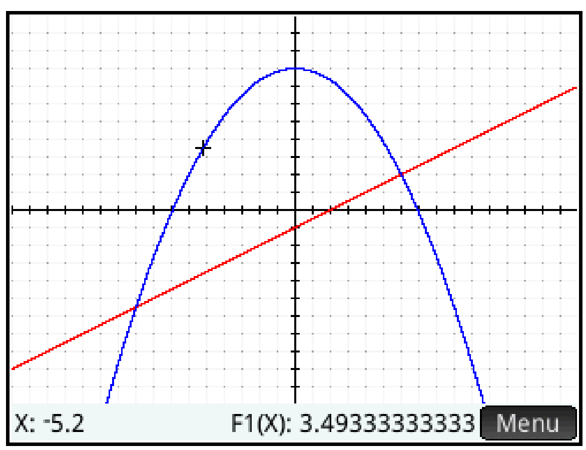
In Plot view, tap Menu to open the menu. The menu buttons are:

- **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
- **Fcn**: opens a menu of analytic functions
- **Defn**: displays the definition of a function
- **Menu**: opens and closes the menu



Things you can do:

- Press ◀ or ▶ to see that you are currently tracing on 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 ▼ or ▲ 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 + and – to zoom in and out on the cursor)



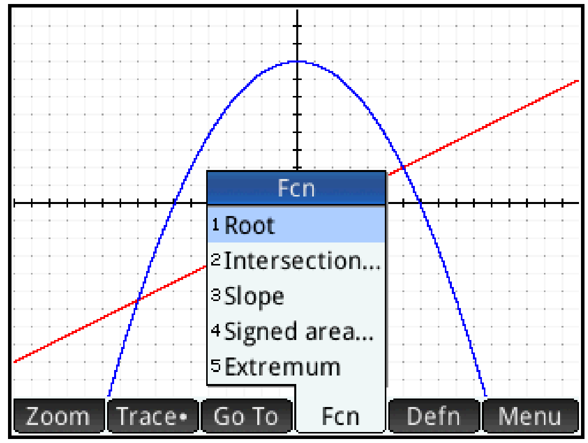
The **Fcn** Menu

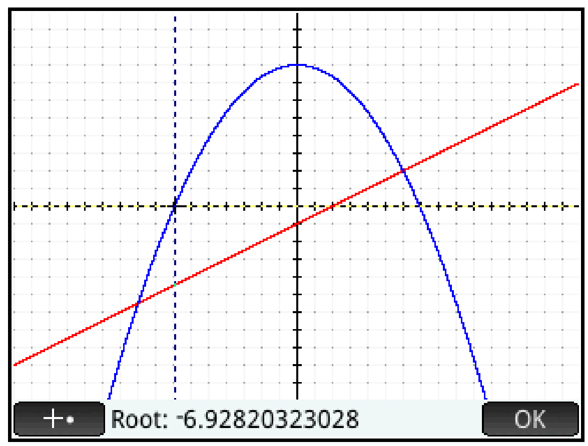
In the following examples, we will use the options in the **Fcn** menu to explore our two functions.

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 1 Program Y.
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

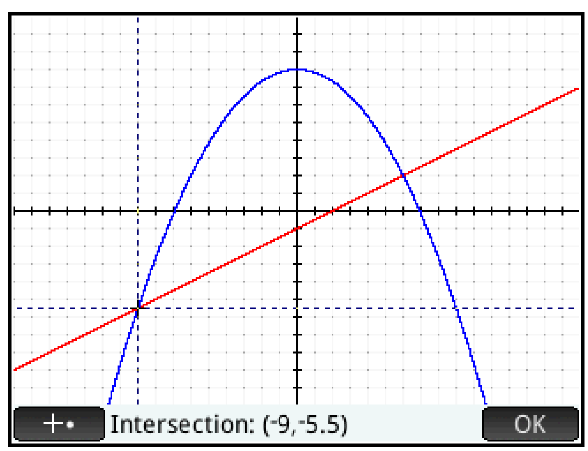




Intersection

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 that right



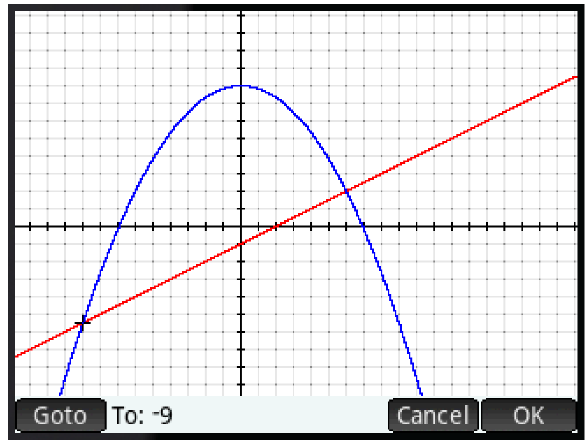
Slope

The Slope option in the **Fcn** menu works similarly to Root, except that the slope continues to be displayed as you trace the function, until Cancel is pressed.

Signed Area

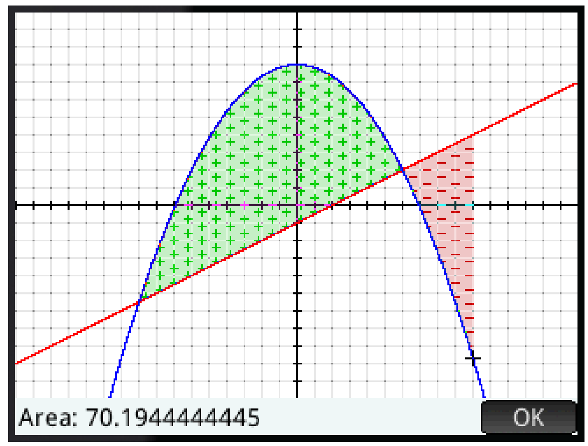
Suppose you wish to find the signed area between the curves, from *x*=-9 to *x*=10.

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



With the touch display, navigation is improved and the experience is more interactive.

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

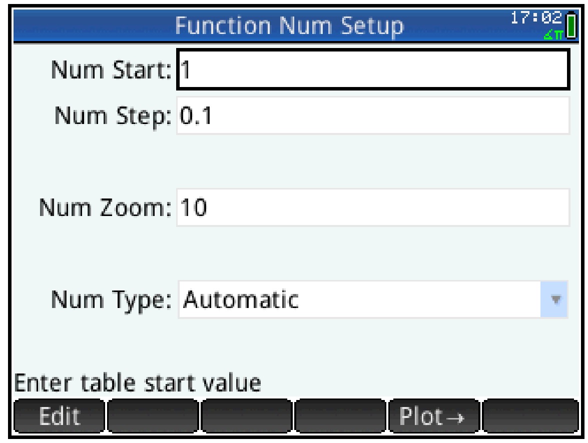
The `Extremum` option works in a manner similar to the way `Root` works.

The Function App: App Functions and App Variables

The five functions from the **Fcn** menu are available to you from the Home view and they store their last results in variables named after the functions. For example, in the Home view, ROOT(F1(X),-7) will now return -6.928… and that value will be stored in the app variable Root. The table below lists the most common app functions and app variables for the Function App.

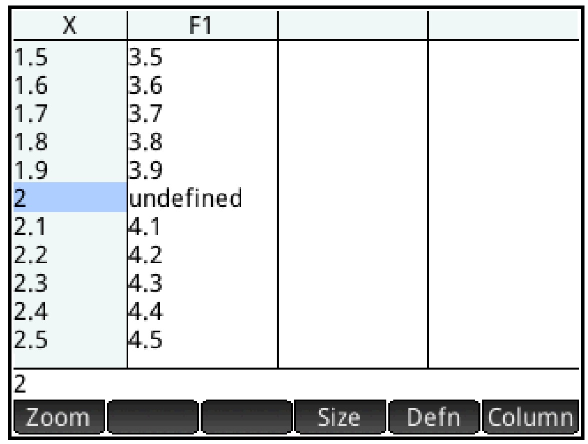
Function App: The App Functions and App Variables			
Fcn Option	App Function Name and Syntax	Example	Stores results in
Root	ROOT(Expr1,Value)	ROOT(X^2-1,0.5)	Root
Intersection	ISECT(Expr1, Expr2, Value)	ISECT(F1(X),3-X,2)	Isect
Slope	Slope(Expr1,Value)	SLOPE(X^2-6,3)	Slope
Signed Area…	AREA(Expr1[,Expr2],Val1, Val2)	AREA(F1(X),-6.9,6.9)	SignedArea
Extremum	EXTREMUM(Expr, Value)	EXTREMUM(F2(X),3)	Extremum

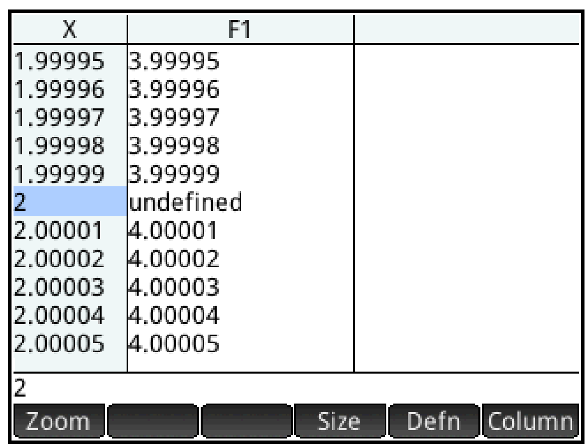
1. Press Symb (Setup) to return to Symbolic view. We will now look at some of the functionality in the Numeric view of the app.
2. Press Shift Esc (Clear) to delete all the function definitions. You will be asked to confirm this action. Tap OK .
3. In F1(X), enter $\frac{(X^2-4)}{X-2}$
4. Press Shift Num (Setup) to see the Numeric Setup view of the app. Change the options as shown in the figure to the right.



Note the new menu button: PLOT→. If pressed, this button changes the options in this view to match the settings in the Plot view. For example, with the default Plot view, Num Start would be set to -15.9 and Num Step would be set to 0.1. Tracing along the graph in plot view would then mirror navigating through the table: both would show the same (x,y) ordered pairs.

5. Press Num (Setup) to see the Numeric view. The menu buttons are:
   - **Zoom**: same as the Plot view menu
   - **Size**: chooses a font size
   - **Defn**: displays the column definition
   - **Column**: chooses 1-4 columns
6. With any value in the x-column selected, type 2 to jump to that value.
7. Now press + (Ans) and − (Base) to zoom in and out on that row of the table just as you did to zoom in and out on the cursor in the Plot view.





Example: Dividing Land Equally

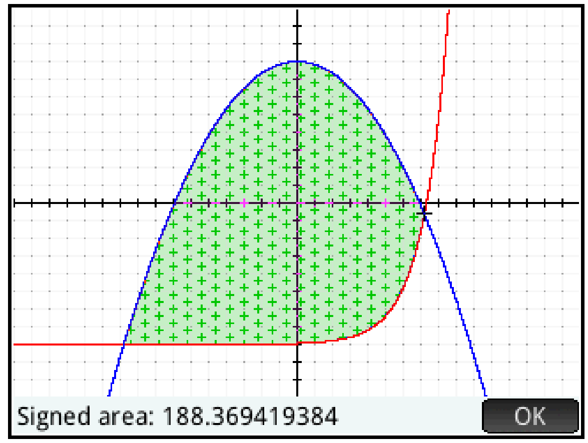
Two brothers inherit land that they want to divide equally between them. The local land records indicate that the land is bounded roughly by the two functions

$y = 8 - \frac{x^2}{6}$ and $y = \frac{2^{x-1}}{10} - 8$, where x and y are measured in kilometers. If they choose to put up a fence along a border running north and south, where should they put the fence?

1. Enter the functions in F1(X) and F2(X)
2. Use Plot or Numeric view to establish that the two boundaries intersect at x≈ -9.8 and x≈ 7.2
3. Use Signed Area to estimate the area of the land to be 188.37 km^2(18,837 hectares), so each brother should get approximately 94.185 km^2
4. Optional: use Signed Area to get a visual estimation of the boundary
5. Define F3(X) as follows:

$$F3(X) = \int_{-9.8}^{X} F1(T) - F2(T)\delta T$$

6. Use Plot view to get an estimate (x≈ -0.7) and then use Numeric View to zoom in on the solution: *x*≈ -0.644



X	F1	F2	F3
-1.3	7.718333333	-7.97969369	8.3804396E1
-1.2	7.76	-7.97823624	8.5376238E1
-1.1	7.798333333	-7.97667418	8.6951929E1
-1	7.833333333	-7.975	8.8531125E1
-0.9	7.865	-7.97320566	9.0113480E1
-0.8	7.893333333	-7.97128254	9.1698650E1
-0.7	7.918333333	-7.96922139	9.3286288E1
-0.6	7.94	-7.96701230	9.4876045E1
-0.5	7.958333333	-7.96464466	9.6467574E1
-0.4	7.973333333	-7.96210709	9.8060524E1
-0.3	7.985	-7.95938738	9.9654545E1

-0.7

Zoom | Size | Defn | Column

X	F1	F2	F3
-0.65	7.929583333	-7.96813598	9.4080923E1
-0.649	7.929799833	-7.96811389	9.4096821E1
-0.648	7.930016	-7.96809178	9.4112719E1
-0.647	7.930231833	-7.96806966	9.4128617E1
-0.646	7.930447333	-7.96804752	9.4144516E1
-0.645	7.9306625	-7.96802536	9.4160414E1
-0.644	7.930877333	-7.96800319	9.4176313E1
-0.643	7.931091833	-7.96798100	9.4192212E1
-0.642	7.931306	-7.96795880	9.4208111E1
-0.641	7.931519833	-7.96793658	9.4224011E1
-0.64	7.931733333	-7.96791435	9.4239910E1

94.1763131674

Zoom | Size | Defn | Column

Extensions:

- What if the brothers wanted an east-west boundary? Estimate the boundary location.
- The brothers want to divide the land into thirds; where do the north-south boundaries occur?

In this example, we used the Function app to easily visualize and estimate the solution to a typical classroom problem. In our next example (P. 11), we extend that power of visualization.

The Advanced Graphing App

The Advanced Graphing App is designed to plot graphs in the *x*/*y* plane. It can handle conic sections, polynomials, inequalities – virtually any mathematical open sentence in two variables or less.

1. Press Apps Info and tap on the `Advanced Graphing` icon

The app opens in Symbolic view. There are 10 fields (V1-V9 and V0) for defining the graphs you want plotted in the Plot view.

2. In V1, enter $X^2 + 3Y^2 + 2XY - 81 = 0$
3. Tap on the color picker to choose a color for the graph
4. Press Plot Setup to see the graph of V1
5. Tap Menu to open the menu

The menu is basically the same as the menu in the Plot view of the Function app, though without the **Fcn** menu.

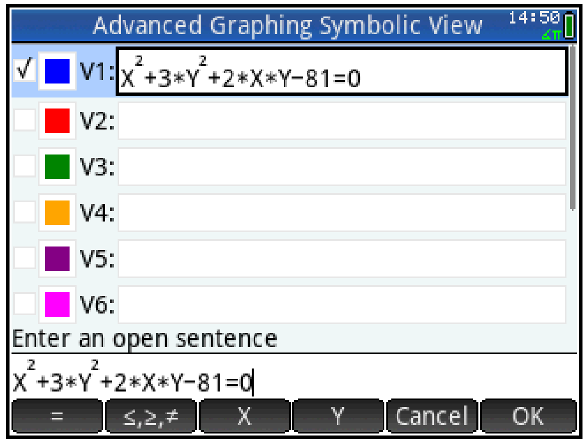
Things you can do:

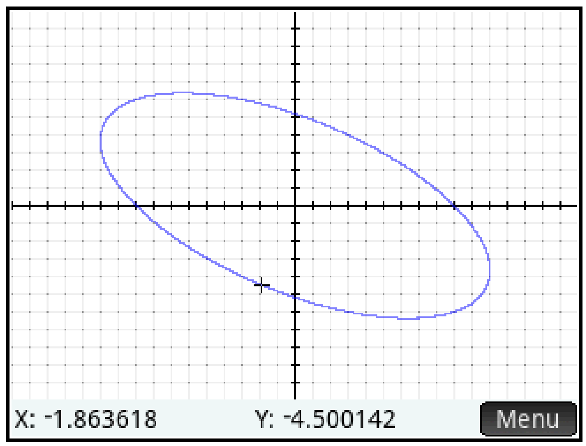
- Tap anywhere on the display to re-locate the cursor
- Pinch or un-pinch to zoom out or in, respectively (or press + and − to zoom in and out on the cursor)
- Tap and drag to scroll the window
- Trace the edge or jump between points of interest (x-intercepts, intersections, inflections points, etc.)

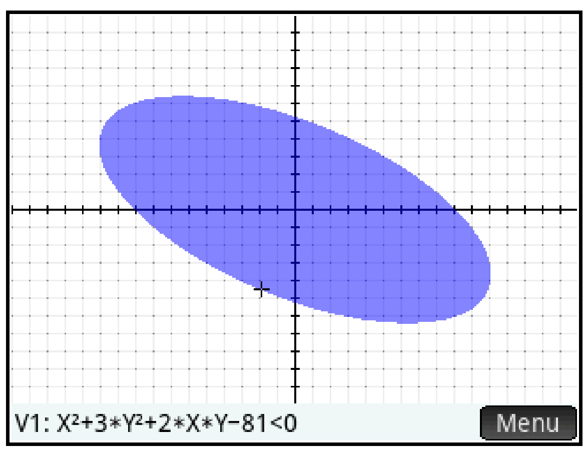
6. Tap Defn and an editor opens, showing you the current expression in textbook format. Tap Edit and change the = to <.

<u>Hint</u>: tap ≤,≥,≠ to open a menu of common relational operators and select <.

7. Tap OK to see the graph of the inequality; tap ↧ to exit the editor



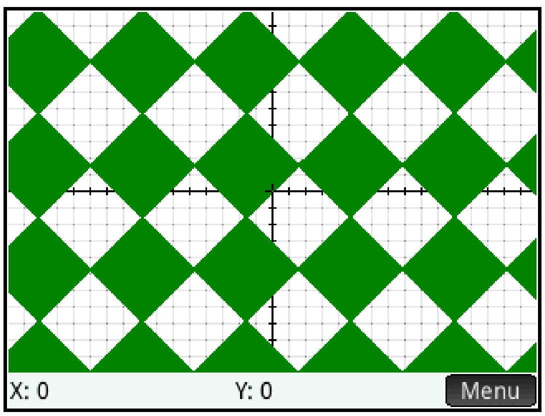




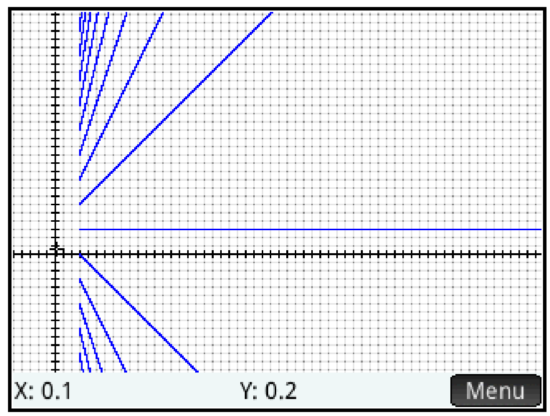
The Advanced Graphing App can plot the graphs of many types of relations. The table below lists just a few.

Relations	Examples	Notes
Polynomials in *x* and *y*	$x^2+3x^2+2xy-81=0$	a rotated ellipse
	$4y^4-5x^2y^2+x^4=0$	check out the factors
Linear Inequalities	$2x+3y<5$	
Non-Linear Inequalities	1>0	plots every pixel
	$\frac{\lvert x-3\rvert}{2}<4$	
	$Sin\left(\left(\sqrt{x^2+y^2}-5\right)^2\right)>Sin\left(8*Tan^{-1}\left(\frac{y}{x}\right)\right)$	see below

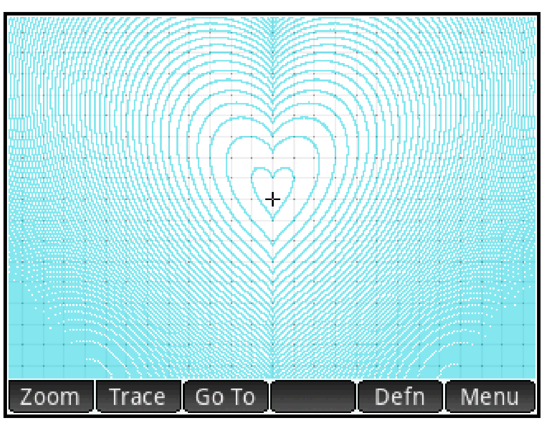
The gallery below shows some example graphs. There is also a gallery built-in to the app. From the Plot view of the app, press Menu and select **Visit Plot Gallery**. Swipe left and right to move between graphs.



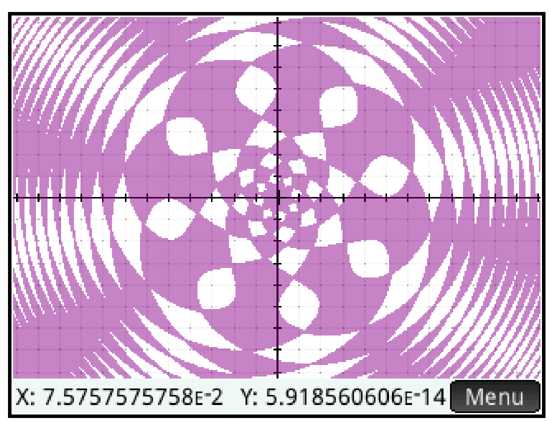
Sin(*x*)<Sin(*y*)



y Mod *x* = 3



(Sin((π/2)*(X^2+(Y-(((((3 NTHROOT (X²))))))²))=1)



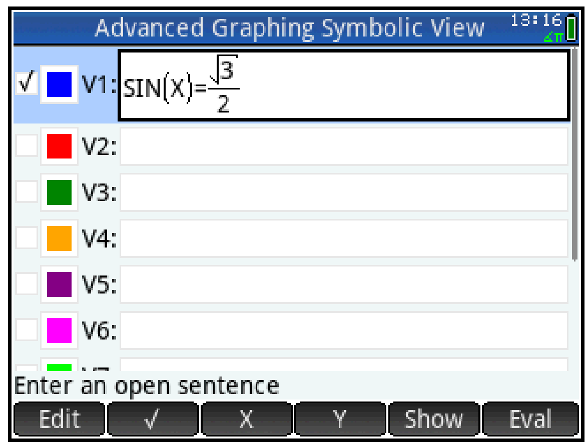
$Sin\left(\left(\sqrt{x^2+y^2}-5\right)^2\right)>Sin\left(8*Tan^{-1}\left(\frac{y}{x}\right)\right)$

Example: An Introduction to Solving Trigonometric Equations

In this activity, we look at introducing students to the topic of solving trigonometric equations.

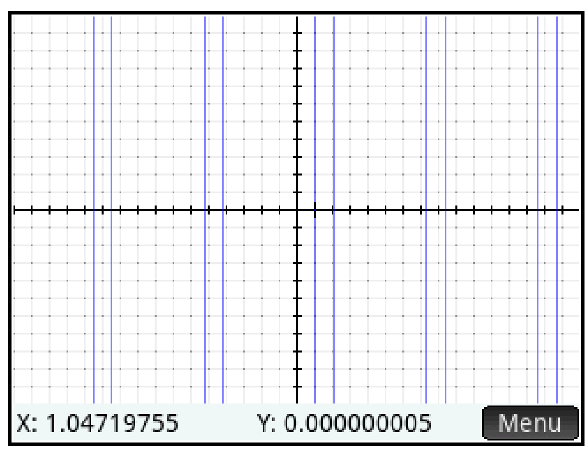
As an example, we take the equation $\sin(x) = \frac{\sqrt{3}}{2}$. If we use this equation as an example to introduce students to the notion of solving trigonometric equations, what do we want them to understand from the very outset? There are three things we want them to see first and foremost:

1. There are an infinite number of solutions
2. These solutions are composed of two branches
3. There is a conventional way of expressing these two branches of infinite solutions in a succinct way



1. Press Apps Info and tap on the Advanced Graphing app icon; the app opens in Symbolic view.
2. In V1, enter $\sin(x) = \frac{\sqrt{3}}{2}$

Tap on the colored square to the left of V1 to select a color for the graph, or just accept the default.

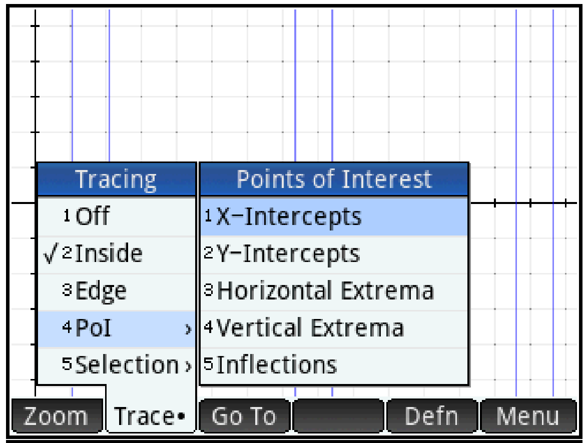


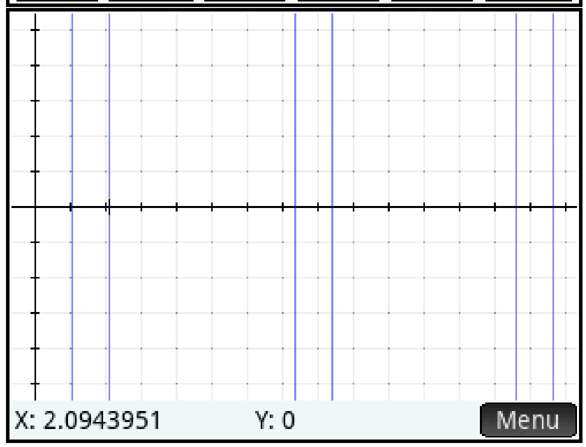
3. Press Plot Setup to see the graph.

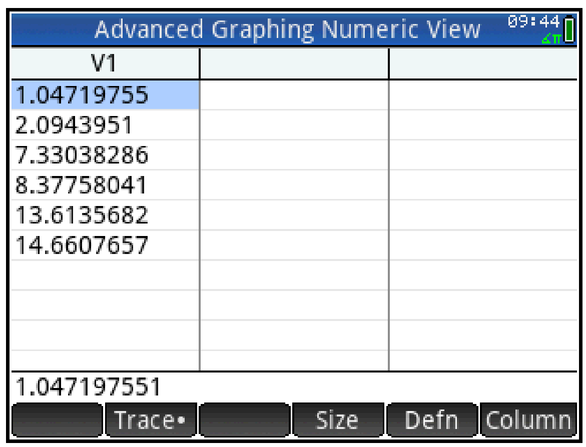
The graph appears to consist of a set of vertical lines. The vertical lines suggest solutions of the form *x=c*, where c is a real number. The lines are arranged in pairs, suggesting two sets of solutions. You can pinch with your fingers to zoom in or out. Zooming out shows more and more of these pairs of lines, suggesting there are an infinite number of solutions. So far, this graphical representation has done a good job of fulfilling our first two requirements.

The tracer is on the first vertical line to the right of the y-axis and reads x=1.047… or x=π/3. We will now train the tracer to jump from one x-intercept to the next.

x=2π/3x=π/3x=2π/3.



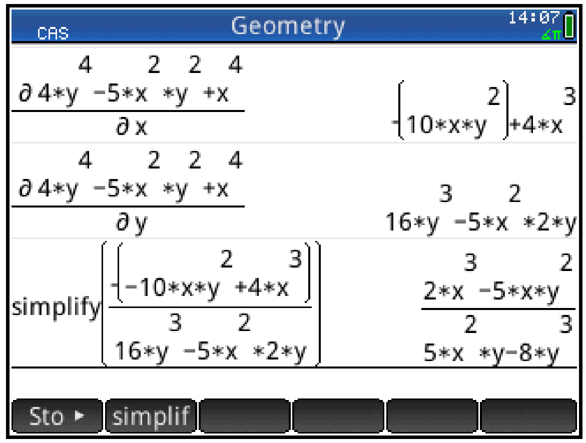




Example: Implicit Differentiation

If $4y^4 - 5x^2y^2 + x^4 = 0$, find $\frac{\delta y}{\delta x}$. This is a typical implicit differentiation problem. The solution shows that the derivative depends on the values of both *x* and *y*, but how do students understand this? In this example, we extend the power of visualization to problems of this sort.

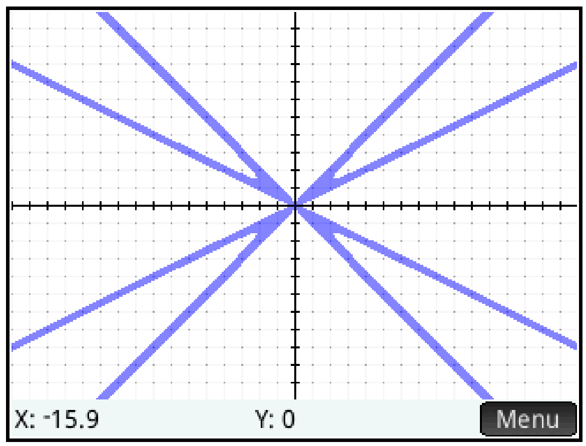
1. Though it will not perform implicit differentiation directly, the CAS does handle it in steps, as shown to the right



Hint: enter the expression first, to keep a copy handy. Use Copy to insert it in your subsequent work.

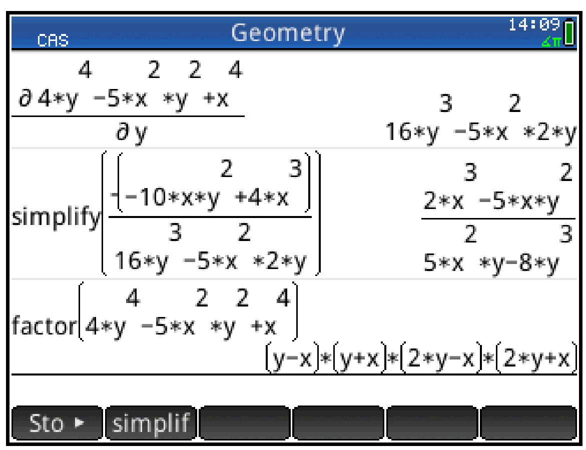
Now we turn to the Advanced Graphing App to explore further.

2. Press Apps Info and tap on the Advanced Graphing icon
3. Enter the equation in V1
4. Press Plot Setup to see the graph



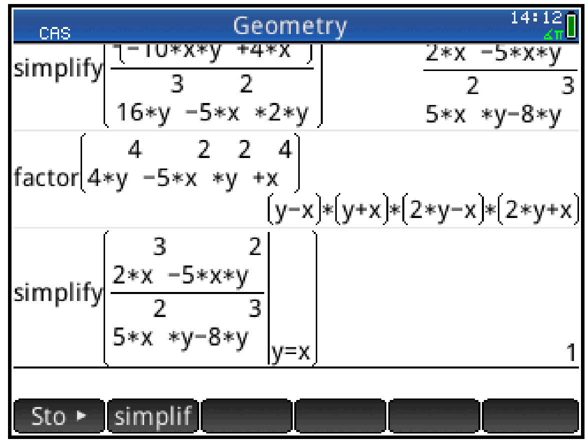
The graph appears to be the lines, *y*=*x*, *y*= -*x*, *y*=*x*/2, and *y*= -*x*/2. The CAS factor command gives us a way to verify this.

5. Press CAS Settings to return to the CAS view.
6. Press Mem B, Algebra, and select Factor. Then tap on the history and drag back up to your original expression. Tap on it to select it and then tap Copy. Press Enter ≈ to see the factors of our expression.



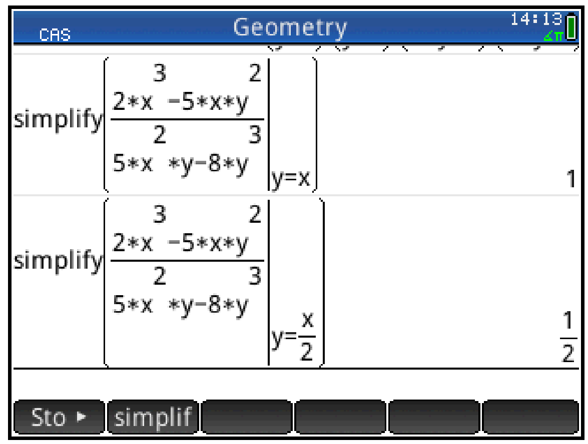
The factors agree with our understanding of the graph. But if the graph consists of those four lines, then the derivative is limited to the values -1, -1/2, 1/2, and 1. How do we reconcile this with the rational expression we have for our derivative?

7. Return to CAS view (CAS Settings) and tap simplif. Press F, and select □|□ (the Where command). This command is used to make substitutions.
8. Tap and drag the history until you see our derivative expression. Select it and tap Copy.
9. Move to the second box in the template and enter y=x



<u>Hint</u>: use lowercase variables in the CAS

10. Press Enter to see the result.
11. Simply copy the previous input and edit it for the other substitutions ($y= x/2$, etc.)



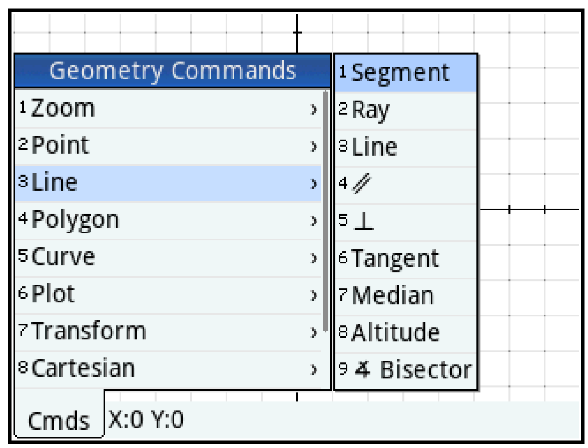
In this example, we extended the power of visualization to include a polynomial in *x* and *y*. The graph of the polynomial led to a better understanding of its derivative and to a conjecture regarding its properties, and the power of the CAS let us prove the conjecture. HP Prime, with its CAS and the Advanced Graphing app, represents a new standard in classroom tools to explore mathematics, make conjectures, and pursue proofs.

About the HP Prime Geometry App

The HP Prime Geometry app is a full-featured dynamic geometry application. Because of the unique structure of HP Prime apps, the Geometry app is very well suited for pedagogical purposes. The table below describes the major app views.

Symbolic View	Plot View	Numeric View
• See how a geometric construction was created, step by step • Edit the definition of any geometric object in the construction	• View a geometric construction and its associated measurements and calculations • Manipulate a construction, animate a point, etc. and watch the construction and its measurements change	• Create measurements and calculations to view in Plot view • Run tests on geometric objects, such as whether or not they are parallel, perpendicular, collinear, etc.

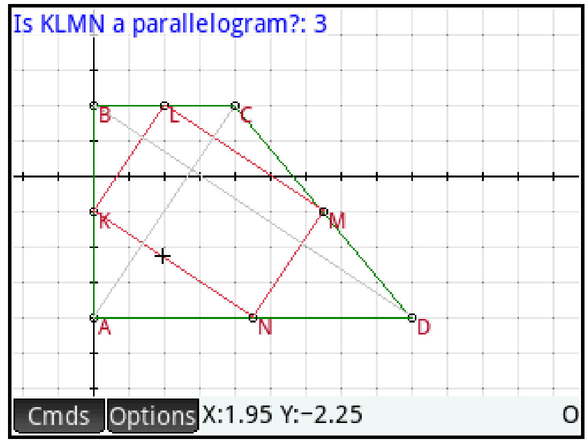
Press Apps Info and tap on the Geometry icon. The app opens in Plot view. The menu button Cmds opens the menu of the most common commands used in Plot view:



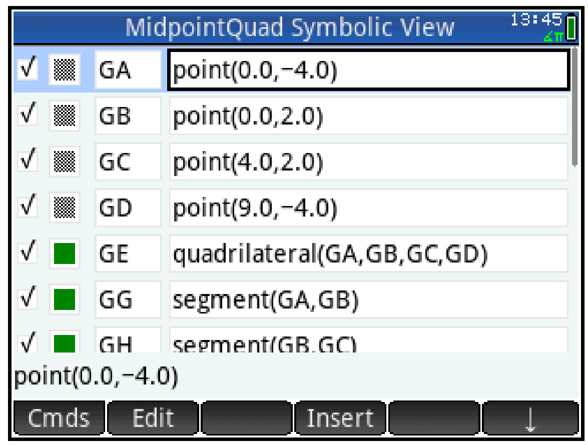
- **Zoom**: zoom in or out, etc.
- **Point**: points, points on objects, midpoints, intersections, etc.
- **Line**: segments, lines, tangents, perpendiculars, etc.
- **Polygon**: triangles, quadrilaterals, and special polygons
- **Curve**: circles and other conic sections, locus of points, graphs of functions, etc.
- **Plot**: slopefields, ODE's, and other plot types
- **Transform**: translation, reflection, dilation, etc.
- **Cartesian:** point coordinates and equations of some geometric objects
- **Measure**: slope, area, perimeters, etc.
- **Tests**: test for linearity, parallel or perpendicular lines, etc.

Things you can do:

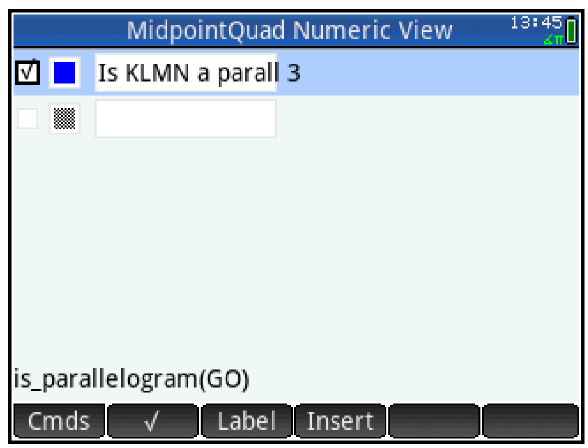
- Tap and drag to scroll the graphing window
- Pinch and un-pinch to zoom out or in
- Tap any object and press Enter to select it; then move it with your finger or the direction keys; press Esc to deselect it.
- Drag any selected point with your finger to move it without selecting it



- Press Symb to enter Symbolic view and see the symbolic definitions of objects in Plot view
- The Commands menu appears here as well. Press Cmds to open the menu. Here, the commands are limited to the six categories of geometric objects and their transformations.



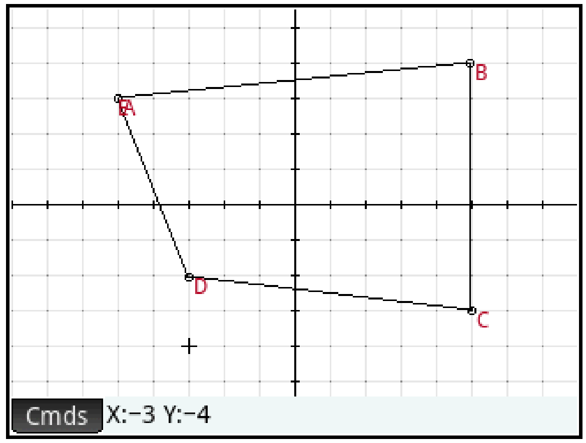
- Press Num to enter Numeric view and see, edit, or create measurements, tests, and calculations based on the objects in Symbolic view (and to show or hide them in Plot view)
- The Commands menu appears here as well. Press Cmds to open the menu. Here, the commands are limited to the three categories of measurements, Cartesian properties of geometric objects, and tests on them.



Example: Exploring Quadrilaterals

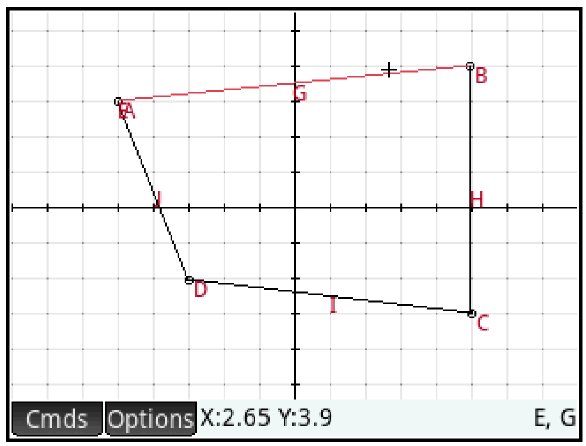
In this activity, we use the Geometry app to create a quadrilateral. We then create and connect the midpoints of consecutive sides of the quadrilateral to form another quadrilateral and explore the properties of the latter in terms of the former.

1. Press Apps Info and tap the `Geometry` icon. The app opens in its Plot view.
2. Tap Cmds, Polygon, and select `Quadrilateral`.
3. Tap a location and press Enter to select the first vertex of the quadrilateral. Continue to tap and press Enter to select the other three vertices. Press Esc Clear to deselect the quadrilateral command.



We will now create the segments whose midpoints we want.

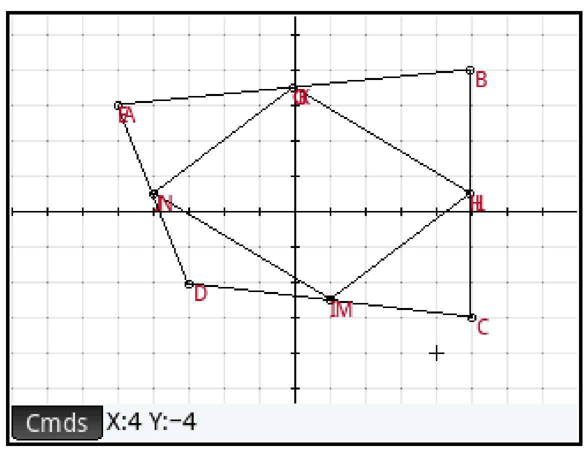
4. Press 9 to start the Segment tool (a shortcut). Tap on point A and press Enter. Then tap at point B and press Enter. Continue in this fashion to create segments BC, CD, and DA. Press Esc Clear to deselect the Segment tool. In the figure to the right, the segments are named G, H, I, and J.



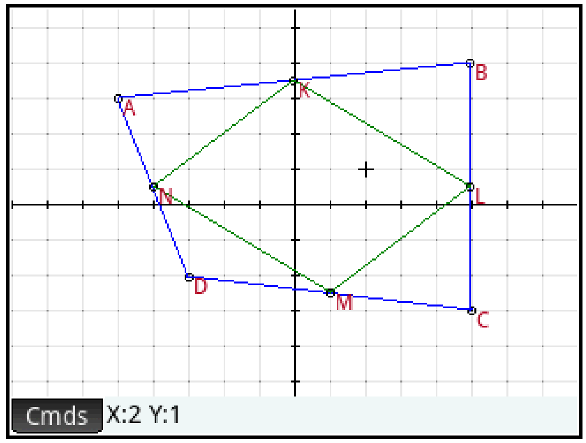
Now we want to create midpoints for the four sides.

5. Tap Cmds, Point and select `Midpoint`.

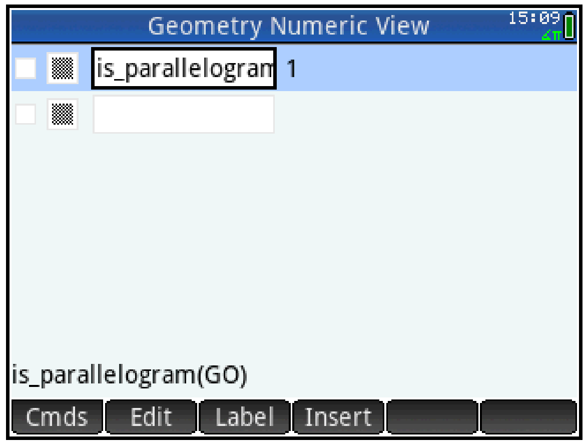
   Tap near the midpoint of $\overline{AB}$ and press Enter. Continue likewise to create the midpoints of the other segments. When you are done, press Esc Clear to deselect the midpoint command.
6. Repeat Steps 2 and 3 to create quadrilateral O from points K, L, M, and N.

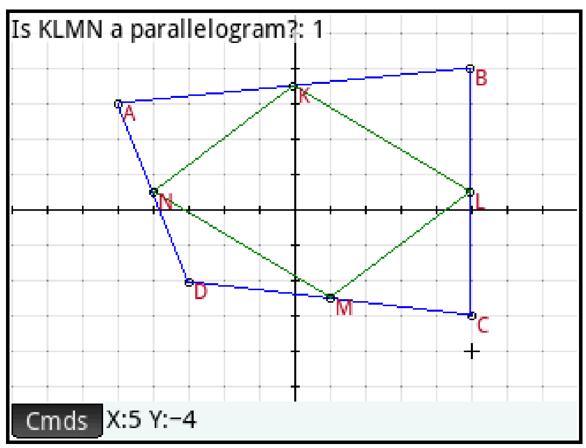


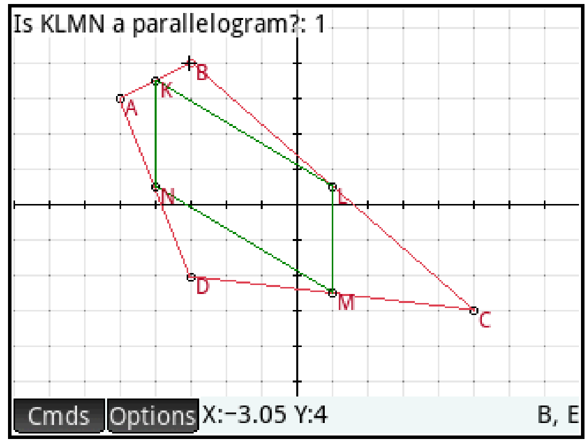
The display now shows both quadrilaterals. We will now tidy up our construction and making it colorful before beginning our explorations.

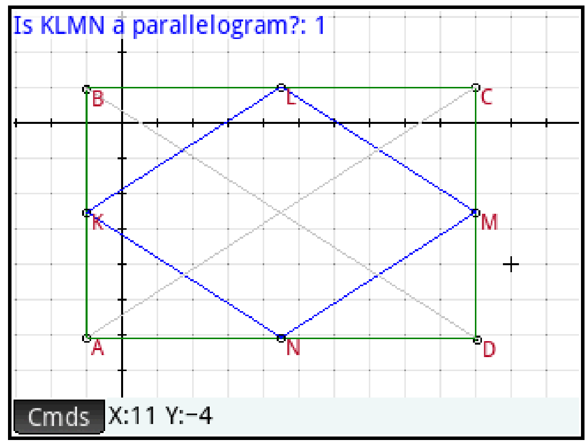


7. Press Symb to display the Symbolic view of the app. Here, each of the geometric objects is defined symbolically. Objects with checks besides them are displayed in the Plot view. Uncheck each segment by highlighting it and pressing √.
8. With the segments hidden, return to Plot view (press Plot) and give the quadrilaterals their own colors. Tap on the original quadrilateral to select it. Tap Options, Choose color, and tap on a color to select it. Or you can tap on the color picker at the bottom left and drag to get any color you like.
9. Repeat Step 8 to select to select a color for the inner quadrilateral.
10. Press M to open the Numeric view of the app. Here we define measurements and tests involving our geometric objects. Tap New to start a new measurement. In this case, it is a test. Tap Cmds, `Tests`, and select `Parallelogram`. The command is pasted into the command line. Remember that the name of our inner quadrilateral is GO. Tap Vars, select GO and press Enter. Tap √ to check this test for display in the Plot view.
11. Tap Label. An edit line opens for you to supply a label. Type "Is KLMN a parallelogram?" and press Enter.
12. Return to the Plot view to see our constructions and the test result.









We are now ready to explore our construction.

1. Select one of the vertices of the outer quadrilateral by tapping on it and pressing [Enter]. You can now drag it anywhere within the display with your finger. As you move a vertex, notice that the parallelogram test on KLMN maintains a value of 1, indicating it is always a parallelogram.
2. Press [Esc] to deselect the point.

The parallelogram test can return 5 values:

0. Not a parallelogram
1. A parallelogram only
2. A rhombus
3. A rectangle
4. A square

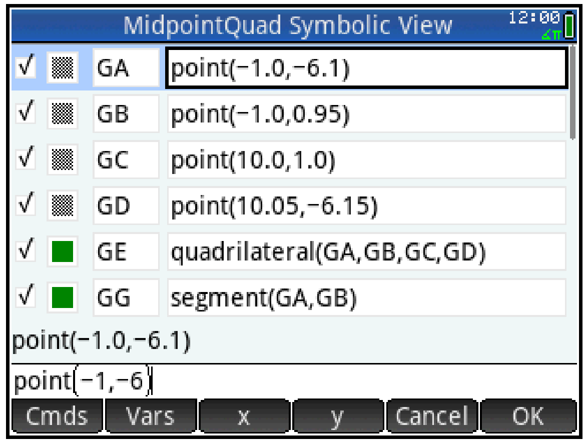
It seems that KLMN is always at least a parallelogram, no matter where we move the coordinates of points A, B, C, and D (as long as they are not collinear!).

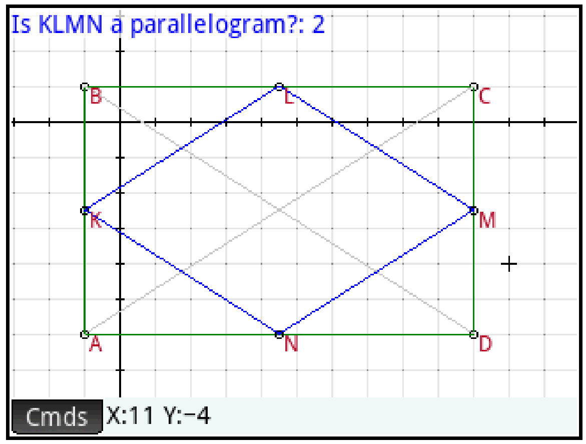
Let's make ABCD a rectangle.

3. Move points A, B, C, and D so that they appear to form something close to a rectangle. In the figure to the right, the opposite sides of ABCD appear to be roughly equal in length and consecutive sides appear perpendicular.
4. Press [Symb] to open the Symbolic view of the app and observe the definitions of points A, B, C, and D.

We shall edit the coordinates of these points so that they are more exactly the coordinates of a parallelogram. Specifically, in our case (but not necessarily yours), we will make the following changes:

- GA: point(-1, -6)
- GB: point(-1, 1)
- GC: point(10, 1)
- GD: point(10, -6)





5. Tap on the definition of GA to select it.
6. Tap Edit to edit the definition
7. Delete the current coordinates and enter your own. Press Enter or tap OK when you are done.

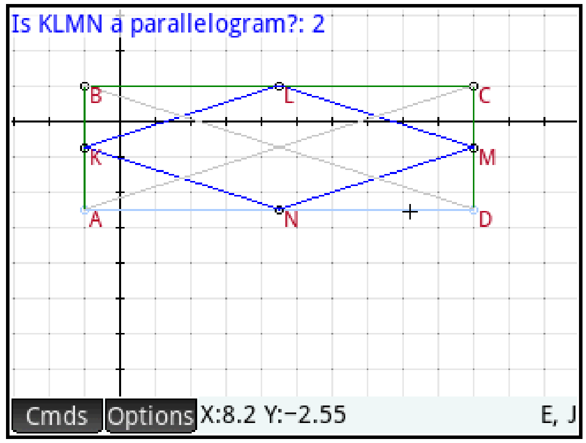
In the top figure to the right, the coordinates of point A are being changed to (-1, -6).

8. Repeat Steps 5-7 with points B, C, and D
9. Press Plot Setup to return to Plot view to see what has changed.

In this case, the test result has changed to 2, indicating that KLMN is a rhombus. Making ABCD a rectangle seems to make KLMN a rhombus. We will now change ABCD, but keep it a rectangle and see how the test behaves.

10. Tap on segment AD, between point N and point D, and press Enter to select it. A pop-up box will appear; make sure segment AD (object J) is selected and any others de-selected; then tap OK.

11. You can now use the up- or down-direction keys to move the segment, maintaining ABCD as a rectangle.



You will note that the test continues to return a value of 2, indicating that if ABCD is a rectangle, then KLMN is a rhombus.

This example was used to illustrate the technique involved:

- In Plot view, move A, B, C, or D to form what appears to be a special quadrilateral
- Go to Symbolic view and edit the definitions to make the coordinates exact
- Return to Plot view to see the effects on the test results
- Manipulate ABCD, keeping its properties intact and see if the test result changes

We can make ABCD a kite, a rhombus, a rectangle, a square, or a trapezoid. For each quadrilateral type, we can make a conjecture about KLMN. With the testing and symbolic abilities of the Geometry app, students can set about the proofs or refutations of conjectures such as these:

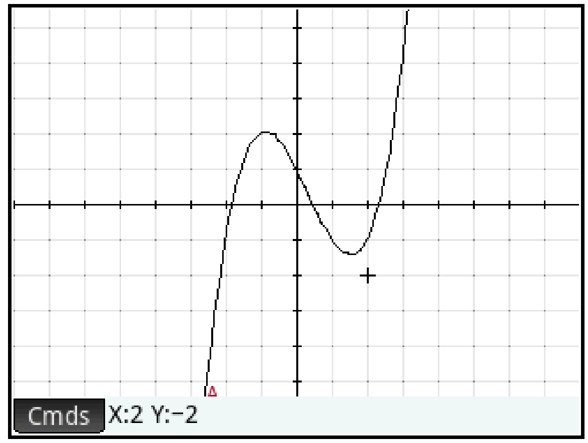
- If ABCD is a rhombus, then KLMN is a rectangle
- If ABCD is a rectangle, then KLMN is a rhombus
- If ABCD is an isosceles trapezoid, then KLMN is a rhombus
- If the diagonals of ABCD are perpendicular, then KLMN is a rectangle
- If the diagonals of ABCD are congruent, then KLMN is a rhombus

Example: Slope and Derivative of a Function

In this activity, we construct a visualization tool for the derivative of a function.

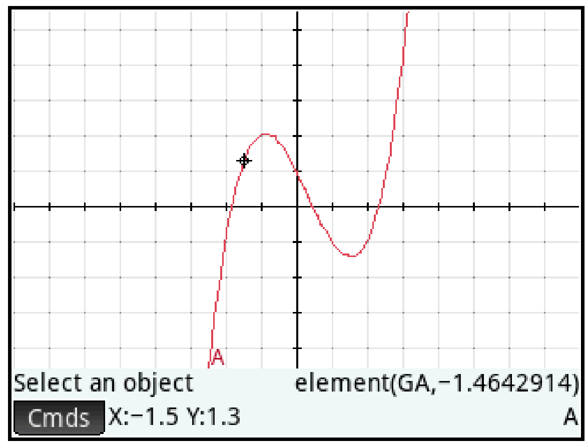
1. Press Apps Info, use the direction keys to select the Geometry icon, and tap Reset. You will be asked to confirm the reset; tap OK.
2. Tap Cmds, `Plot`, and select `Function`. An edit line opens with plotfunc() and new menu buttons appear with x and y.

   Enter the function $\frac{x^3}{2}-\frac{x^2}{2}-3x+1$ after the parenthesis and tap OK. The graph of the function is drawn. Press + Ans to zoom in.

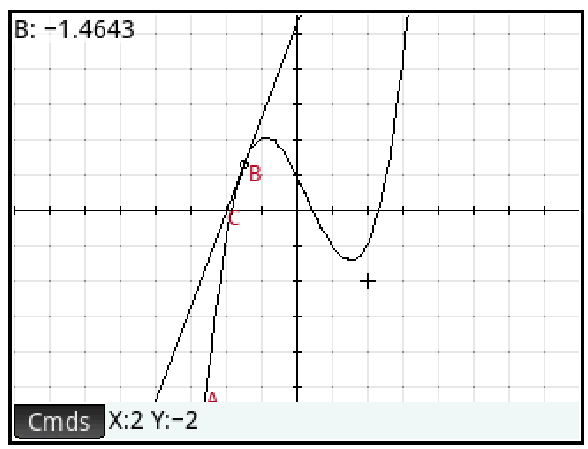


Note: the Geometry app uses lowercase x as the independent variable for functions.

3. Tap Cmds, `Point`, and select `Point On`. Tap on the graph (it will turn red when selected). In the figure to the right, the bottom of the display shows the help (Select an object) and the current command (element(GA, -1.46)). Press Enter ≈. Point B appears, defined as a point on the graph. Press Esc Clear to exit this command.

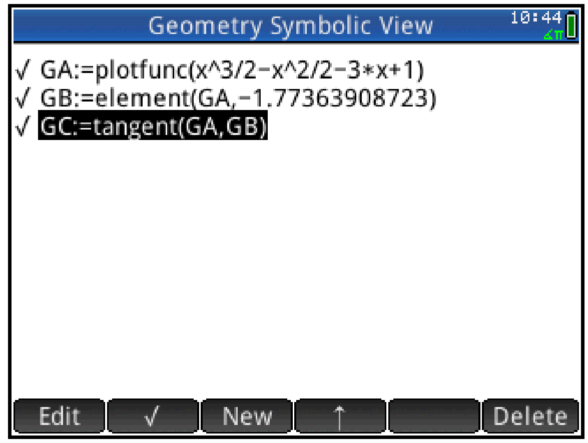


4. Tap Cmds, `Line`, and select `Tangent`. Tap on the curve and press Enter ≈. Then tap on point B and press Enter ≈. The tangent to the function through point B is drawn.



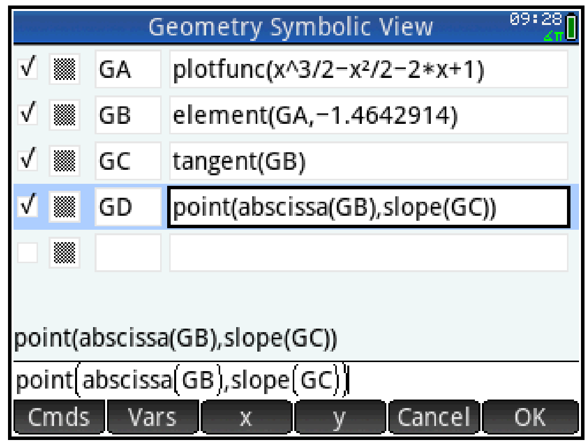
5. Tap point B and press Enter ≈ to select it. You can now drag point B along the curve with your finger or use the direction keys and the tangent line will follow.

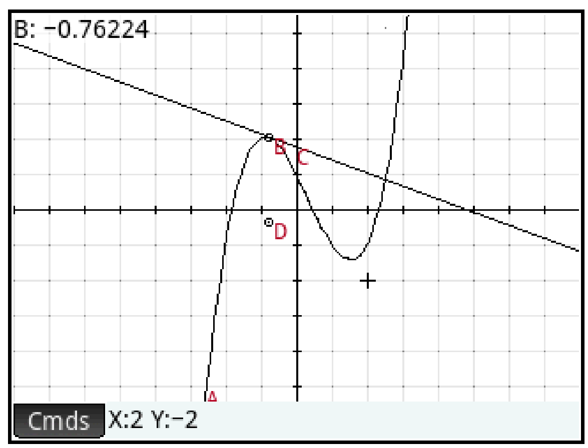
6. Press [Symb] to see the Symbolic view of the app. All objects created in the Plot view have their symbolic definitions here.



We will now define the a new point. The x-coordinate of this point will be the same as point B and the y-coordinate will be the same as the slope of the tangent. The new point D will be a point on the derivative of the function.

7. Tap on the new line at the bottom of Symbolic view.
8. Tap [New] to create new object. Tap [Cmds], `Point`, and select `Point`. The point() command appears in the edit line.
9. Press [Mem] and tap [Catlg] if needed. Press [Vars] [Mem] to access commands that begin with the letters AB and select `Abscissa`. Tap [Vars] and select GB. Move past the right parenthesis, press [,] and return to the Catalog for the slope command. The completed definition is shown to the right.
10. Press [Plot] to return to Plot view. As you move point B, you can see that point D moves along the derivative.

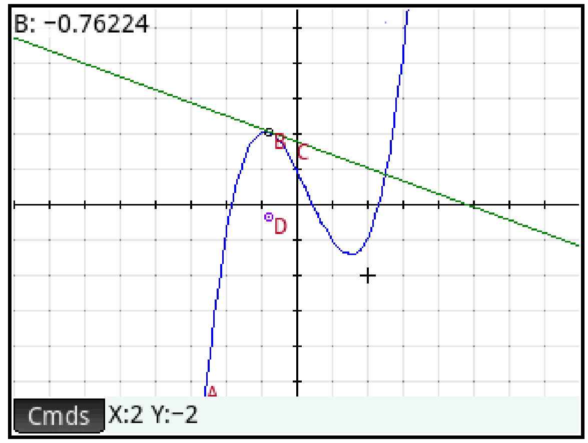


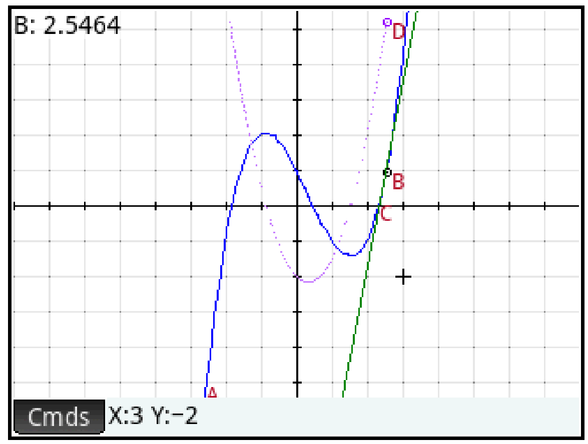


We are now ready to use our construction!

We will now give our geometric objects their own distinctive colors.

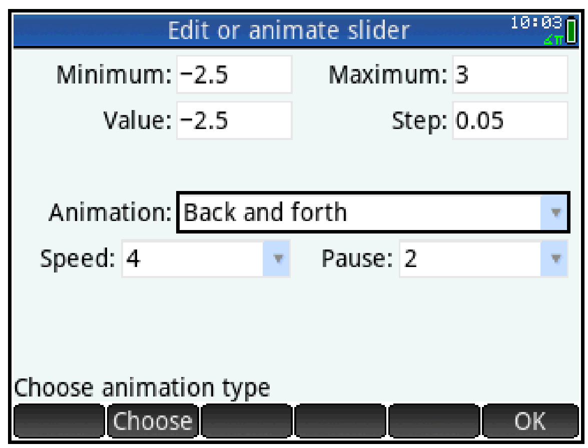
1. Return to Plot view and tap the function. Tap Options and select `Choose color>`. A color palette opens. Either tap a color or tap the color picker at the bottom left. Here you can drag to get the color you want and tap OK.
2. Repeat Step 1 to choose colors for the tangent and point D. In the figure at the top right, the function is in blue, the tangent is green, and point D is purple.



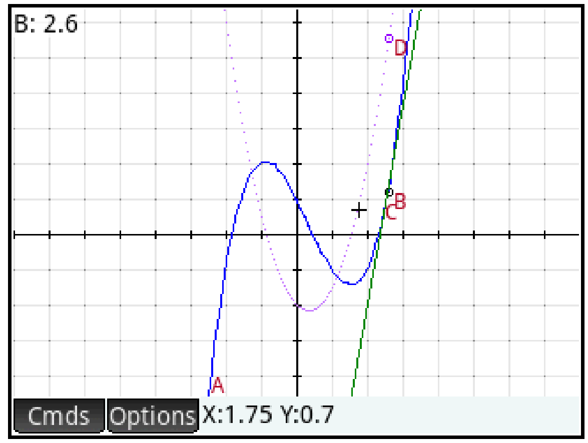


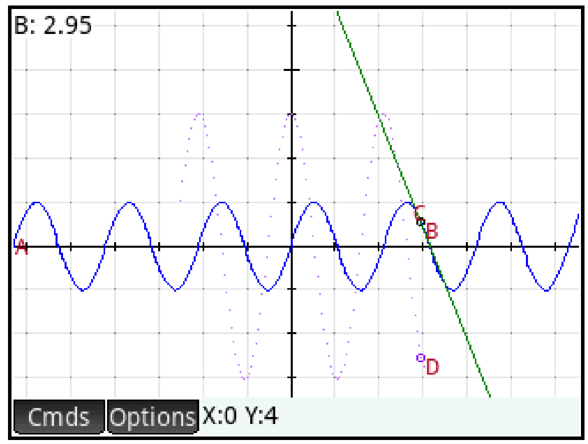
Point B, as a point on an object, automatically has its own slider bar. The slider bar can be used to manually move point B or to animate its movement. We will now activate the trace of point D and then animate point B to draw the slope function.

3. Tap point D. Tap Options and select `Trace`. Now as you move point B, a trail is drawn. As you continue to drag, the shape of the derivative function emerges, as shown to the right.
4. The top left of the screen shows the x-coordinate of point B. Tap and hold on this measurement. A slider bar will appear. You can move the slider left and right and point B will follow. Tap Edit . Here you can set the minimum, maximum, and step values for the movement of point B. You can also animate the movement of point B. Select `Back and forth` animation and press Enter.



5. Press Esc Clear to close the slider. The animation will commence. To start and stop an animation, tap Options and select `Animate` (it is a toggle, like `Trace`).
6. Tap Options and select `Trace` again to deselect it (it is a toggle). Now point D will no longer show its trail. You can erase the current trace by selecting `Clear trace` in the Options menu.
7. You can go to Symbolic view and edit the definition of GA to study the slope function of any function you wish. In the figure to the right, GA has been changed to the plot of sin(3*x).
8. Press Apps Info tap Save , and save your new SlopeFunction app.





You now have a construction that has a number of methods to visualize the derivative of a function:

- Move point B and see a single point on the derivative that has the same x-value as point B
- Move or animate point B and leave a trace of points on the derivative

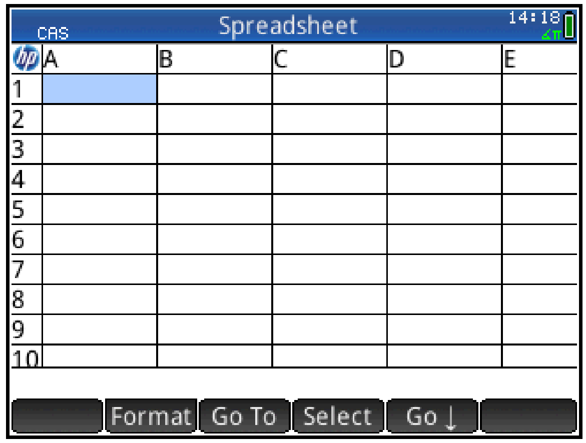
Your students can now visualize the graph of the derivative of any function using this one construction.

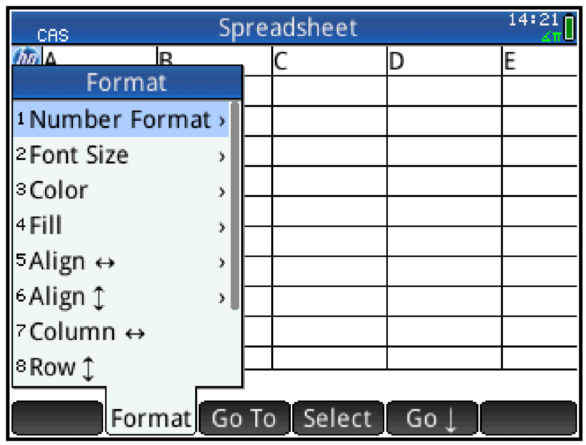
The Spreadsheet App

The Spreadsheet App gives you the most common features you expect in a spreadsheet. But with HP Prime, you also get the power of a CAS integrated with the spreadsheet.

Press I and tap the Spreadsheet icon. The app opens in Numeric view-its only view. The menu keys are:

- **Format**: opens the Format menu (see figure to the right and below)
- **Go To**: jumps to a specified cell
- **Select**: activates Selection mode
- **Go**: determines which cell is selected after you tap OK





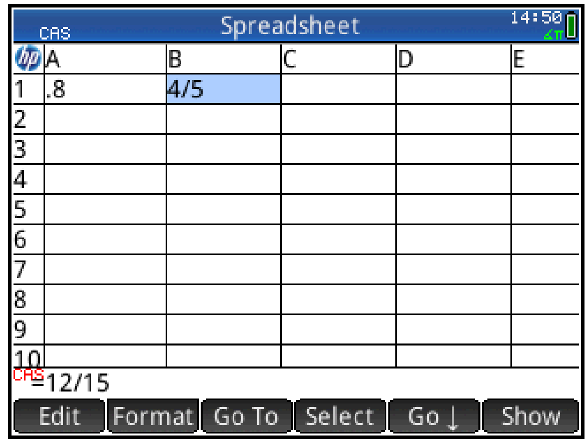
Things you can do:

- Tap and drag to scroll through the spreadsheet
- Tap and hold to invoke Selection mode; then drag to select a rectangular block of cells
- Pinch open or closed horizontally to change the width of a column
- Pinch open or closed vertically to change the height of a row
- Enter contents into a cell (number, matrix, expression
- Define a cell, row, column or sheet using a formula

The Spreadsheet app can return numerical approximations for a formula, or it can use the CAS to return exact numeric or symbolic results. The examples in this section will cover both uses.

To get started in the Spreadsheet app, here is a simple exercise that illustrates the CAS and non-CAS uses of the app.

1. Select cell A1, type 12/15, and press Enter.
2. Select cell A2 and type the same thing, but before you press Enter, tap CAS. The dot next to CAS shows the CAS is now active.

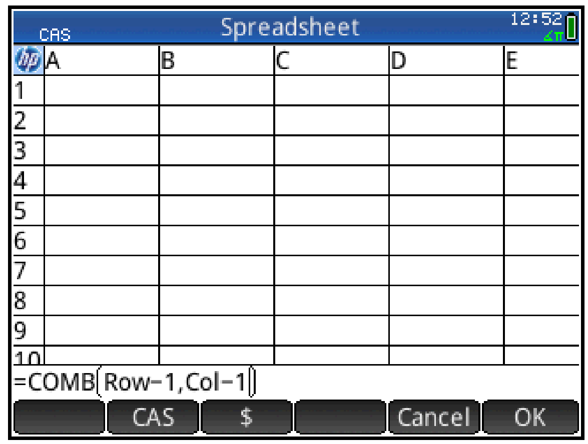


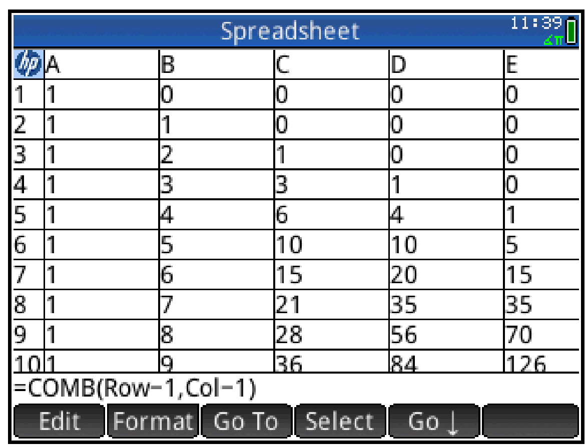
A1 is evaluated numerically, but A2 is simplified using the CAS. Select B1 to see the acronym CAS at the start of its formula.

Example: Pascal's Triangle

Next we define the entire spreadsheet with a single command.

1. Tap the upper-left corner to select the entire sheet. Press Shift = to start a new formula. Press Mem, tap Math, tap `Probability`, and select `Combinations`. Between the parentheses, enter Row-1,Col-1, as shown to the right.

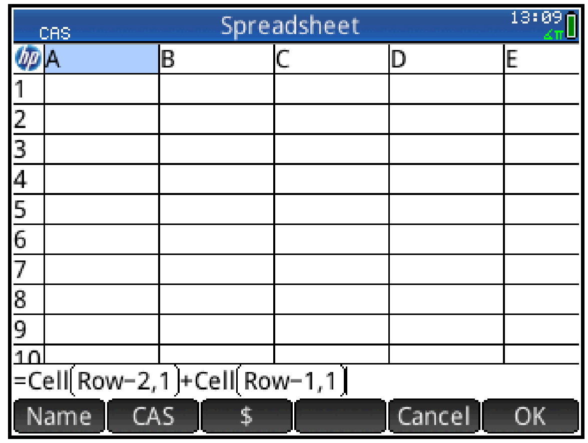




<u>Hint</u>: Row and Col are Spreadsheet app variables. To retrieve Row, press Vars, tap App, tap `Spreadsheet`, tap `Numeric`, and select `Row`. Select Col in a similar manner. You can always just type names in letter by letter, using ALPHA for uppercase and ALPHA Shift for lowercase letters.

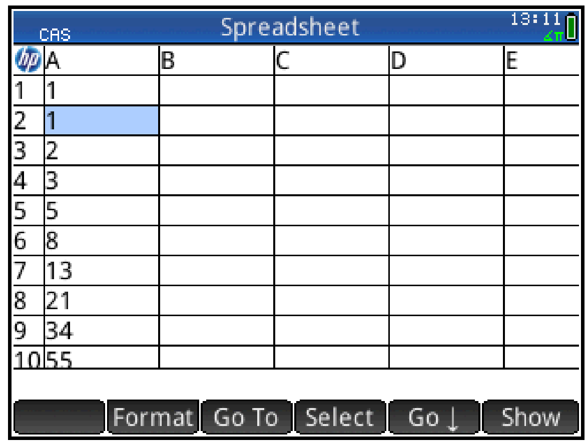
2. Tap OK to see the spreadsheet fill with Pascal's triangle! Use your finger to scroll through the spreadsheet.
3. To clear the entire spreadsheet, tap on the upper-left corner and press Shift Esc.

Example: The Fibonacci Sequence



Another important variable for the Spreadsheet app is Cell, as you will see in our next example.

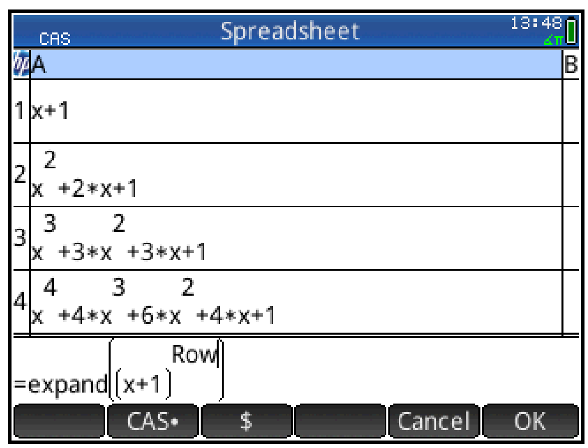
1. Tap on the column header for Column A to select it.
2. Press Shift   to start a new formula. Then enter Cell(Row-2,1)+Cell(Row-1,1) as shown to the right.
3. Tap OK to see Column A fill with zeroes.
4. But now enter 1 in cell A1 to see Column A fill with the Fibonacci sequence.



You can now appreciate the value of the app variables Cell, Col, and Row!

Example: Back to Pascal's Triangle

Here is another CAS example that involves symbolic results.



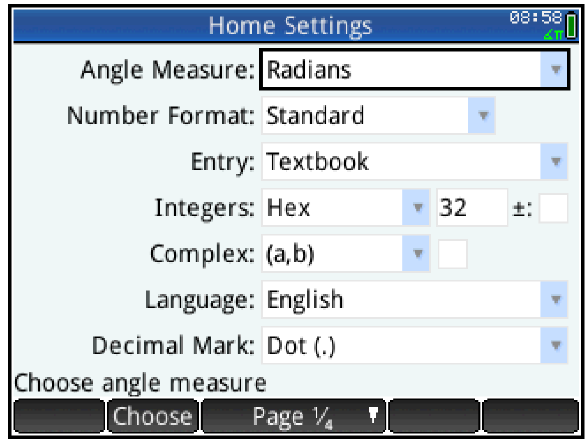
In the example to the right, we use the CAS to define one column of the spreadsheet to expand the binomial x+1 to various integer powers. Note the expression editor shows a CAS button: CAS. When active, the CAS is used to evaluate the formula. When it is not active, the formula is used to obtain numerical results.

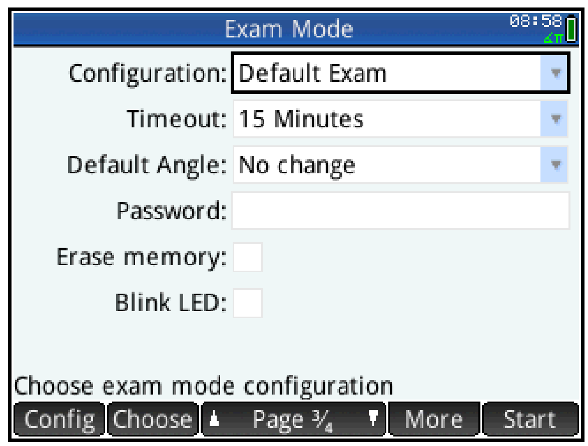
Imagine all the patterns you and your students can explore in symbolic expressions!

Examination Mode

HP Prime can be configured and locked for an examination. The machine will remain locked for a pre-set time period and secured with a password. LED lights at the top of the unit will flash to show that it is in examination mode.

1. Press Shift Settings to enter Home Settings
2. Swipe upwards to get to the third page; the header will say *Exam Mode*. Alternately, press the right halves of Page 1/3 and Page 2/3.





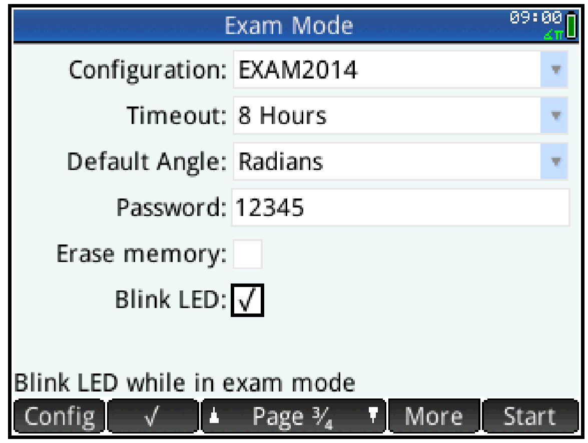
The menu keys are:

- **Config**: opens the Configuration page, where you can check which features you want disabled
- **Choose**: opens a choose box
- **Page**: tap the left help to go up a page and the right half to go down a page in the Home Settings
- **More**: opens a menu of options to copy or reset the current configuration
- **Start/Send**: starts Exam mode on the current HP Prime or send it to another HP Prime (**Start** changes to **Send** if Prime is connected via USB)

Things you can do:

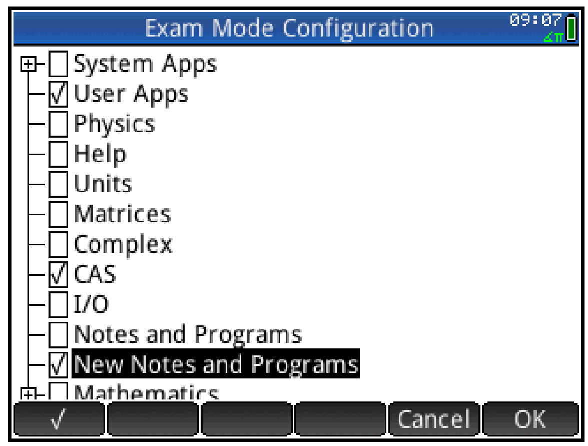
- Give your configuration a name
- Set a time period
- Set a password
- Check a box to erase memory when examination mode starts
- Check a box to make the LED lights blink while in examination mode.

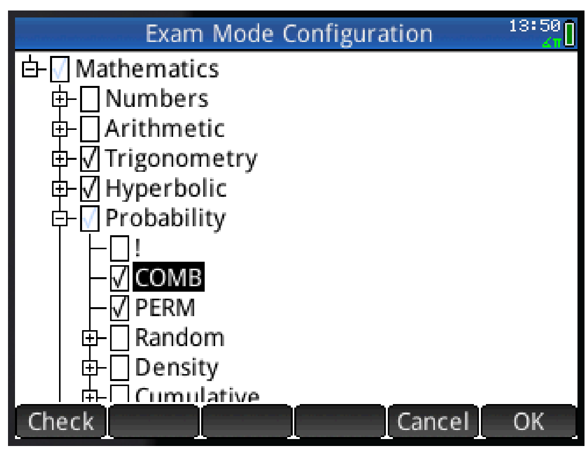
3. Tap More `Copy`, and enter a name for our new configuration: EXAM2014
4. Tap *Timeout*, then tap Choose and select a time period.
5. Tap *Default Angle*, then tap Choose and select a default angle measure
6. Tap *Blink LED* twice (to select it and check it)



We are now ready to define our EXAM2014 configuration.

7. Tap Config to enter the Configuration page
8. Tap *User Apps* to disable saved apps with their data
9. Tap *CAS* to disable the CAS
10. Tap *New Notes and Programs* to disable the Note and Program editors
11. Tap and drag to scroll down the tree until you see the entry *Mathematics*. Tap on the plus sign (+) next to *Mathematics* to expand the tree
12. Tap on *Hyperbolic* to disable all hyperbolic trigonometric functions
13. Tap on the plus sign next to *Probability* to expand the tree another level and tap *COMB* and *PERM* to disable the individual functions $_nC_r$ and $_nP_r$
14. Tap OK to save this configuration with your new name: EXAM2014
15. Press Start to start Exam Mode on the device, or if it is connected to another HP Prime, press Send to start Exam Mode on the attached HP Prime

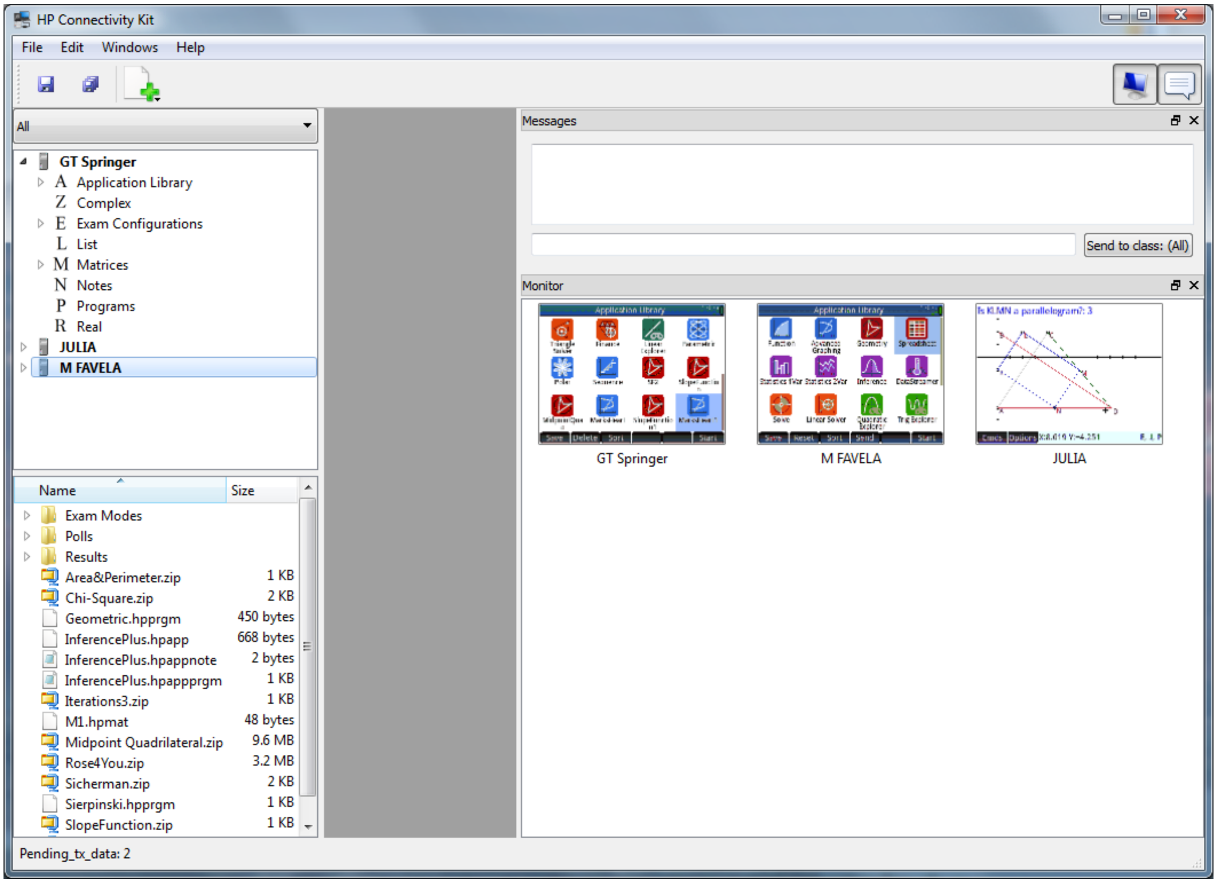




Once Exam Mode starts, the LED lights will blink to show that the configuration is in effect. All HP Prime calculators that were sent the same Exam Mode configuration from the same HP Prime will blink in unison using the same random pattern of the 3 color lights. You can also create and send exam mode configurations from the HP Connectivity Kit, discussed next.

The HP Prime Connectivity Kit

The HP Connectivity Kit allows you to connect to one or more HP Prime calculators via USB or wirelessly. With the HP Prime Wireless Kit, you can create an HP Prime Wireless Classroom Network. Within this wireless network, you can monitor student progress, poll the class, send HP Prime content (apps, programs, notes, etc.), and both send and receive short messages.



The Connectivity Kit has three main areas:

- **Calculator Pane**
    - See the list of connected HP Prime calculators by name
    - View data on a connected calculator, edit apps, write programs, etc.
    - Synchronize the new data with the connected HP Prime calculator
- **Content Pane**
    - Create and edit Exam Mode configurations, create polls and quizzes, store programs and apps you want to send to the class, etc.
    - Send content and exam mode configurations to the class or an individual
- **Work Area**
    - see all HP Prime displays, monitor students, etc. using the Monitor window
    - send and receive messages using the Messages window
    - share one student's display for discussion purposes