

Calculators and AP Calculus: Update '98

by Mark Howell

A group of students take a math test. One has a graphing calculator; another has no calculator at all. Other students have other calculators—different models, different features. The teacher may have one of those models or another model altogether. And no two persons have equal training on their calculator(s).

How fair—how standardized—can such a test be? In the 1990's, the Advanced Placement Calculus program has squarely faced these challenges of technology-active assessment.

Embracing the Technology of the 90's

In 1990, graphing calculators were just coming onto the math education scene, and no standardized tests were yet allowing their use. But by 1991, the AP Calculus Test Development Committee (the group of teachers who write exams and help direct the program) recommended that teachers begin immediately to use graphing calculators to enhance teaching and that, as an intermediate step, scientific calculators be allowed—not required—on the 1993 and 1994 AP exams.

By 1995, graphing calculators had become required on the exams. Currently, the format of the AP Calculus Examinations is as follows:

- | | |
|------------------------------------|--|
| Section I – Multiple Choice | Part A: No calculators allowed;
28 questions, 55 minutes. |
| | Part B: Graphing calculators allowed (required
on about one-third of the questions);
17 questions, 50 minutes. |
| Section II – Free Response | Graphing calculators allowed (required on
some questions or parts of questions). |

In determining a student's grade, Sections I and II are given equal weight.

New Courses for the New Tests

(continued on page 2)

At the same time the AP testing program was incorporating the technology, the course description also underwent a major overhaul, with substantial shifts in emphasis (reflecting the calculus reform movement), plus other topic “tweaks.” Here are highlights of the description for 1998 (and the topical outline is posted at www.collegeboard.org/ap/math/html/index001.html):

(continued from page 1)

- Multiple representations of functions. (A cornerstone of the new course.)
- Tabular or graphical presentations of a function. (Now common.)
- Calculator-active questions about functions that don't yield to traditional analysis. (Now appearing.)
- More general applications of the definite integral, and (for BC students) slope fields and Euler's method. (New topics.)

The 1998 Results

Are the courses serving the students? The results for 1998 are in: The composite (i.e. multiple-choice and free-response combined) mean scores on both the AB and BC exams were the highest since at least 1994. (Beginning this year, BC students had both a BC grade and an AB subscore grade reported. Statistical analysis of the 1998 exam results showed the subscore grade to have high reliability.) Moreover, the group of students taking the AP exams appeared to be the strongest since graphing calculators were introduced.

(Teachers take note: A subtle change has occurred on the free-response portion of the exams. Whereas in the past, one or two questions were more difficult than the others, now the difficulty has been distributed over several questions. Students should therefore be encouraged to try every part of every free response question. Often, there are easy points to be earned on questions that have a difficult part.)

Good scores notwithstanding, the technology challenges facing the AP Calculus program continue. Although HP was the pioneer, now several calculator companies offer approved calculators that do symbolic algebra, and so the two big issues will continue to drive discussions about technology in the AP exams: equity and teacher training. In fact, equity concerns have prompted a proposal to split the exam's free-response portion into "open-calculator" and "closed-calculator" sections. (The earliest date for such a change would be 1999-2000 courses and the May 2000 exams.)

Mark Howell has been teaching mathematics and computer science at Gonzaga High School in Washington, DC, since 1977. Currently a member of the AP Calculus Test Development Committee, he is a longtime Reader, Table Leader, and Question Leader at the HP Calculus exam reading. Mark worked with the Hewlett-Packard software team during the development of the HP 38G. Mark and his lovely wife, Maureen, have a son Ryan, who is a budding computer science guru, age 3.

Fast New HP 38G ApLets: The “Wow!” Factor

by Colin Croft

Last March, I sat down with Gerald Squelart and Jean-Yves Avenard (both HP machine code programming gurus) to design a new set of HP 38G ApLets—ApLets that we hoped would cause math teachers to say “Wow!” Here are the first two: “Quadratic Explorer” and “Trig Explorer” (inspired by the often-used “Active Grapher” ApLet). I hope we succeed in “wowing” you!

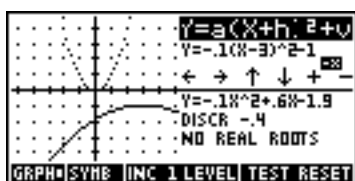
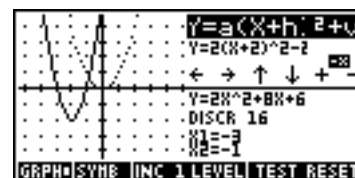
The Quadratic Explorer

To encourage students to take control of their own learning, this ApLet lets them investigate quadratic graphs by manipulating the graph and the equation. A worksheet supplied with the ApLet allows students to make observations about the behavior of the graph and to record their conclusions as they go.

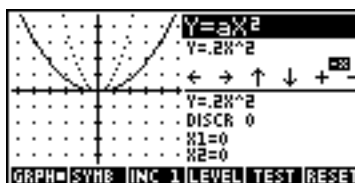


Written in fast machine code, the Quadratic Explorer ApLet is highly interactive and does not have the normal SYMB, PLOT and NUM views. When you **ENTER** it, you’ll immediately see a split screen showing the basic graph of $y = x^2$, along with information about its roots and discriminant.

As you modify the graph, the original remains (as a dotted line) for comparison. This is the GRPH view, since you control the graph (as shown in the menu line, where **GRAPH** has become **GRPH**).

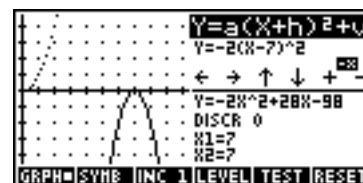


With the arrow keys, you can move the graph around on the screen, using **+**, **-** and **⊗** to dilate the graph by various factors. These changes happen very rapidly and are immediately reflected in the equation on the right-hand screen—given in both standard and vertex forms.



Notice, that for the vertex form (highlighted atop the right-hand screen), you’ll usually see $Y=a(X+h)^2+V$, the form involving all three parameters. But in case you want to investigate just one parameter at a time, **LEVEL** lets you set $Y=aX^2$ or $Y=(X+h)^2$ or $Y=X^2+V$, and then the ApLet varies only the parameter showing.

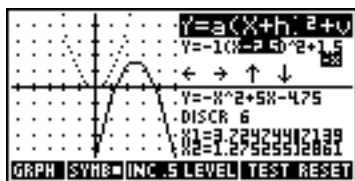
At first, the screen’s range is from -5 to 5 (for both axes), but this changes as you move off the initial screen. You control the movement increments via **INC**, which allows “jumps” of 0.5 , 1 or 2 .



(continued on page 4)

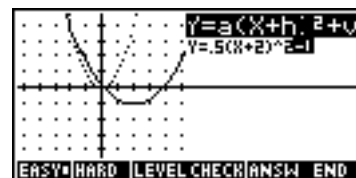
(continued from page 3)

Rather than investigating how the changes in the quadratic are reflected in the coefficients, you might choose instead to investigate how changes in the parameters a , h and v are reflected in the graph. Simply change from GRPH to SYMB mode via **SYMB** (or use the **PLOT** and **SYMB** keys).



In SYMB mode **◀** and **▶** move between parameters; **▲** and **▼** let you change them. The ranges of possible parameter values aren't infinite, but you can still fully explore a graph's behavior. For example, in both GRPH and SYMB modes, values of a are limited to ± 0.1 , ± 0.2 , ± 0.3 , ± 0.5 , ± 1 , ± 2 and ± 5 . (Such restrictions offer major speed advantages.)

After exploring, you can test your understanding of a quadratic's behavior via **TEST**. This draws a random quadratic graph whose equation you must find. **EASY** graphs fit on a display with centered axes (to allow easier comparison with the graph of $y=x^2$); **HARD** graphs use the full available axes.



Use the arrow keys to adjust parameters until you think the equation matches the graph, then **ANSW**. If you're incorrect, the display flashes between the target graph and yours. You can give up at any time via **QUIT**, but if you persevere, **ANSW** also reports how many attempts you needed to succeed.

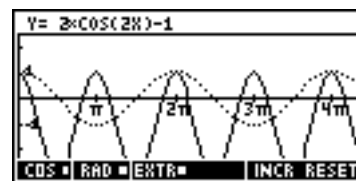


To fully appreciate how effective this animation is, download the ApLet and try it! A worksheet supplied with this ApLet guides students' independent explorations, asking them to record their observations and conjectures at each stage and then report their final conclusions in writing.

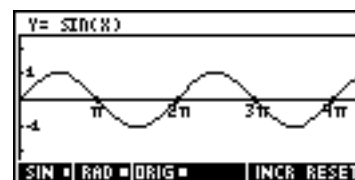
The Trig Explorer

The trig functions sine and cosine are among the most interesting to explore and graph, but often teachers do not enjoy teaching them because of the amount of time needed to draw the graphs. A common solution to this is to use a computer program, but unless you have a computer available for every student, the lesson becomes a teacher-driven lecture rather than a student-directed discovery.

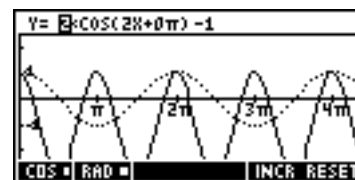
The Trig Explorer ApLet—very similar in behavior to the Quadratic Explorer—eliminates the need for such a compromise. It allows self-directed investigation of the various effects of parameters a , b , c and d on the graph of $Y=asin(bX+c)+d$. Again, the graph can control the equation (GRPH mode), or the equation can control the graph (SYMB mode). The original graph stays visible for comparison.



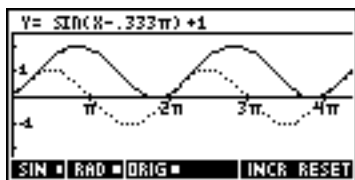
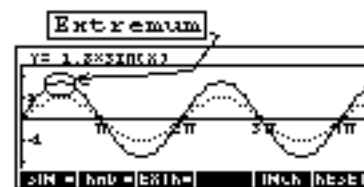
You can also swap from sine to cosine or radians to degrees via menu buttons. (The scale changes from degrees to radians as necessary.) In radian mode, the phase shift is given as a multiple of π . Again, as in the Quadratic Explorer, the **INC** (INCRement) button controls the size of the step used when moving horizontally.



Similarly, when you're in SYMB mode, **◀** and **▶** move from one parameter to the next; and **▲** and **▼** change the parameters.

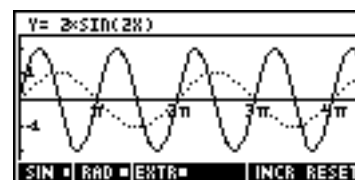


However, in GRPH mode, your control method is slightly different. There are two points of control, called the origin (ORIG) and the extremum (EXTR), shown here:



When the control point is on ORIG, the arrow keys affect the **phase shift** and the **vertical translation**.

When it is moved to EXTR, then the arrow keys affect the **amplitude** and the **frequency**.



Thanks to Jean-Yves' programming skills, holding down the arrow keys has an amazing effect: the graph re-draws so rapidly that it actually appears to crawl as the parameters change. Download the ApLet to see this in action! (We challenge you to watch this without a quiet "Wow!")

Like the Quadratic Explorer, the Trig Explorer ApLet comes with a student worksheet, but as it is for more advanced students, it is less guided, encouraging the students to make observations, form hypotheses, then to test and revise them.

To obtain these ApLets (or many others—see pages 20-21), or to get help in creating your own, visit Hewlett-Packard's Calculator web site at <http://www.hp.com/calculators>.

Gerald Squelart and Jean-Yves Avenard are HP 48 programmers employed by Hewlett-Packard in Melbourne, Australia. Originators of this ApLets project were HP's Charles Lim, also based in Melbourne, and Bob Parker, based in Perth.

Colin Croft is a mathematics teacher at St. Hilda's Anglican School for Girls in Perth, Western Australia. Teachers who attended the 1998 N.C.T.M. convention in Washington, D.C., may have met him at the HP booth. Colin has written other ApLets, which can be found at <http://www.sthildas.wa.edu.au/~ccroft>.

Earn Free Calculator Equipment: The New HP Calculator Redemption Program

An Announcement from
Hewlett-Packard Co.

When you and your students buy Hewlett-Packard calculators, you are on your way to earning free calculators and accessories through HP's new Calculator Redemption Program, now open to all educators throughout the U.S and Canada.

What Can You Get?

Announced just last month, the new program is based on a point system. When you buy 30, 60 or 90 HP graphic calculators, you earn points that you can redeem toward free calculator products and accessories.

For 25 Points	For 50 Points	For 100 Points
Connectivity Kit (for PC or Mac) or HP 38G or HP 48G	HP 48G+ or HP Infrared Printer (usable with the HP 38G, HP 48G Series, HP 17BII, and HP 19BII)	HP 48GX or HP Overhead Display Unit (usable with the HP 38G, HP 48SX and HP 48GX)

Notice that you can apply your redemption points flexibly—in whatever way works best for your program. For example, if you earn 100 points, you could apply it all to a single redemption from the 100-point column or, if you prefer, choose multiple redemptions from the 25- or 50-point columns.

How Do You Earn Points?

You can earn points whenever you or your students purchase HP graphic calculators, as follows:

Calculators Purchased	Calculator Type	
	HP 38 or HP 48G	HP 48G+ or HP 48GX
30	Earn 25 points	Earn 50 Points
60	Earn 50 points	Earn 100 Points
90	Earn 75 points	Earn 150 Points

What Documentation Do You Need?

If you are a **primary** or **secondary** educator, just send the proof-of-purchase (UPC) codes from the ends of the boxes, along with a letter on your school stationery detailing the product(s) you want to receive. (Your position as an educator will be verified prior to fulfillment.)

If you are a **college** or **university** educator, just send a letter on your school's stationery that includes these three items:

1. A statement that HP graphic calculators are required or strongly recommended for your class (please indicate models);
2. A description of the classes for which the HP calculator is required or recommended;
3. An estimate of the number of students purchasing HP graphic calculators per term or semester.

(Only one request per department is eligible for each term or semester. Your position as an educator will be verified prior to fulfillment.)

Where Do You Apply?

Send your request and documentation to:

The Math Learning Center
Hewlett-Packard Educator Program
P.O. Box 3226
Salem, OR 97302-0226

Note that Hewlett-Packard Company reserves the right to change this program or discontinue it at any time and without notice. If you have any questions about the program, feel free to contact The Math Learning Center:

Call: **1-800-750-8130**
E-mail: **hp@bbs.mlc.pdx.edu**

Cash Rebates and Sweepstakes Prizes: Now is the Time to Buy!

For a limited time you can get cash rebates of up to \$25 and be eligible for a \$20,000 Scholarship Sweepstakes drawing when you buy any of the following HP Calculators:

HP 48GX HP 48G+ HP 48G HP 38G HP 32SII HP 19BII HP 17BII HP 12C HP20S HP 10B

Coupons are available at all HP retail outlets. Just make your purchase and postmark your coupon, —along with a copy of the receipt and a UPC proof-of-purchase—no later than October 30, 1998. You'll get your rebate check in the mail and be automatically entered in the \$20,000 Sweepstakes (U.S. citizens only). See your HP retailer for more details. (HP retailers are listed on pages 31-35.)

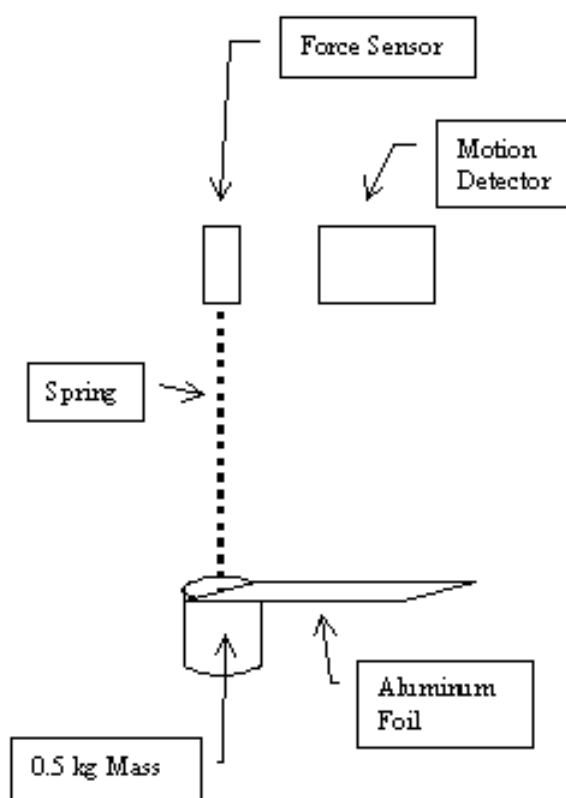
Classroom Lab Data Collection with the HP 48G Series

by G. T. Springer

A 0.5 kilogram mass is attached to the end of a long, vertical spring (over 50 cm) and then allowed to drop. The mass causes the spring to stretch (without distortion!) and then retract periodically. The force that the mass exerts on the spring also changes periodically. How does this force vary with the length of the spring?

To answer this, you need to collect force data on the spring-mass system. You can do this with a force sensor, a motion detector, and a PLDL 100 Datalogger from Firmware Systems, set up as shown in the diagram here.

The entire spring-mass system is suspended from the force sensor by clipping the top of the spring to the sensor. To measure the length of the spring, place a motion detector next to the force sensor and aim it face down. Then attach aluminum foil to the top of the mass so that the surface of the foil extends out from the mass perpendicular to the beam of the motion detector.



To control the PLDL 100, use the data collection program (free with the purchase of the Datalogger) on an HP 48G Series calculator. After you load and start the program (PRG), it will prompt you for the number of probes to be used. In this experiment, there are two probes.

Next, set up the ports on the Datalogger in ascending numerical order. Put the force sensor in Port 1 and the motion detector in Port 4 (where it always goes). The first time you see the **SELECT PORT** menu, choose Port 1. (The program will then return



to this menu after you've set up Port 1 with the force sensor.) There are default setup values for each of the listed probes, but you can also do a 2-point custom calibration on any probe whose readings are linear with respect to voltage.



Here is the setup menu as it would appear for the probe in Port 1. In this case, you would choose the force sensor and accept by default that the readings will be in Newtons. (Your 0.5 kg mass exerts a force of 4.9 Newtons on the spring when the system is stable.) Likewise, accept the defaults at the setup menu for the motion sensor in Port 4.

After you have set up the probes, continue to the **COLLECT DATA** menu, where you need to choose between collecting data in real time or setting up the sampling frequency and experiment duration. With the **IN REAL TIME** option, the data are not stored—only displayed in graphic form—whereas **MY WAY** collects and stores the data first. Choose **MY WAY**, as shown here.



In the next menu, you'll be asked for the sampling frequency and duration of the experiment. Shown here are the default settings, which allow you to collect data every 0.1 second (i.e. 10 samples per second) for 5 seconds. Press **ENTER** to accept these default settings.

Now the program will prompt you to start the experiment. First, lift the mass so that the spring is fully retracted and let it go, then press **ENTER** and the Data-logger will start collecting force and distance data simultaneously. (The red LED on the Datalogger will begin to blink more rapidly to indicate that it is busy.)

After a few seconds, if the beeper on your calculator is enabled, it will beep once when the experiment is over. Then the calculator will automatically collect the data from the PLDL 100 and beep again (at a higher frequency) to tell you that it's ready for you to examine the data.



At this point, the program will ask you which list to use as the independent variable data for graphing purposes. Choose the spring length data (i.e. the **MOTION**), as shown here.

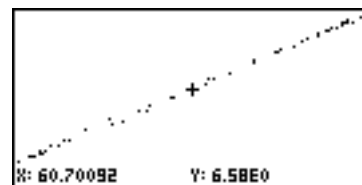
Similarly, choose the **FORCE** data as the dependent variable data. (Note that the program automatically collects elapsed time data, too. And as you'll see, you can always come back and plot time vs. force or time vs. length.)



(continued on page 10)

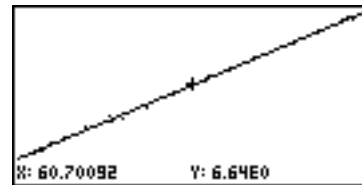
(continued from page 9)

The program automatically chooses an appropriate window and displays the data. Not surprising to those familiar with Hooke's Law, the data is quite linear. (On the other hand, this may surprise students who expected a different type of periodicity.)



Now press **ON**, which will take you to a menu that lets you generate a mathematical model to compare to your data. Shown here is the menu with the rather obvious choice.

Once you make your selection, you'll see both the data and the model displayed, with the Tracer on and coordinates displayed. Clearly these data show a very good fit to the linear model—again, no surprise.



The final menu gives you four options. At this point, you're finished and can choose to quit the program. But notice that you could just as easily repeat the same experiment, conduct a new experiment, or simply go back and examine different relationships in the data you have already collected. (For example, you could plot the motion versus the elapsed time to see the periodicity of the weight bobbing on the spring.)

Note, too, that the data you have collected and the fitting model are still available to you even after you quit the program. The data is in a variable called **DAT**; the model is in a variable called **EQ**.

The program used in this experiment is available from Firmware Systems and is free with the purchase of any PLDL 100 Datalogger. They also have a similar program for the HP 38G and a Windows-based program for the PC. You can contact Firmware by phone at 541-753-3617.

G.T. Springer teaches high school math in San Antonio, TX, and he is the driving force behind Los Gatos Matematicos, a math educator support and curriculum development group. A veteran trainer on the HP calculator workshop scene, he is also a steady contributor to this publication. G.T. lives with his wife, Michelle, on their ranch outside San Antonio, where they enjoy gourmet cooking, fine wines and caring for their many pets. Currently they are in Melbourne, Australia, where G.T. has taken a year's leave from teaching to act as an educator consultant for Hewlett-Packard.

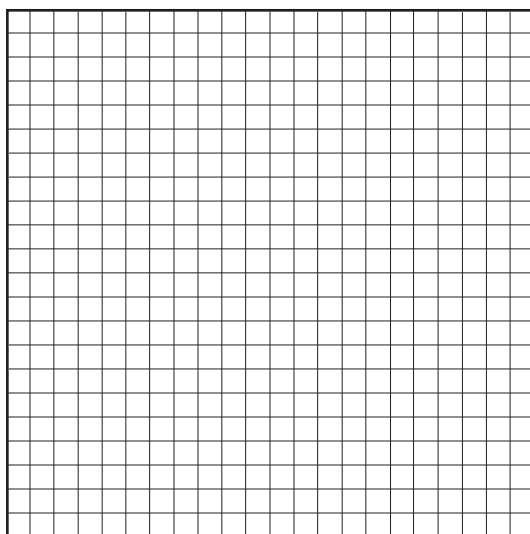
Which Cars Do You Like —and Why?

by Wade White

The December 1988 issue of *Car and Driver* magazine reported that after a test drive of eight cars (all under \$10,000), eight staff members rated the cars in each of 11 categories on a scale of 1 to 5, with 5 being the best. The ratings, summed in each category (40 was the maximum possible category rating), were as follows:

Car	Engine	Transmission	Brakes	Handling	Ergonomics	Comfort	Ride	Utility	Styling	Value	Fun
A. Ford Festiva LX	22	28	27	22	29	27	22	27	25	35	23
B. Honda Civic DX	38	38	30	37	33	26	28	33	37	32	35
C. Mazda 323SE	28	26	22	26	30	28	30	29	23	26	24
D. Mercury Tracer	27	29	25	25	32	36	35	33	28	33	25
E. Mitsubishi Mirage	27	33	25	20	30	27	29	31	29	23	23
F. Subaru Justy RS 4WD	13	21	21	17	23	18	16	26	18	21	11
G. Volkswagen Fox GL	26	33	29	34	31	31	31	31	21	28	29
H. Volkswagen Golf	35	29	32	38	37	34	32	37	26	35	36

Judging from the given data, which of these cars is best for you? How would you judge? How would you go about ranking all the cars based on the data alone? Hard to say? Here's one scientific method:



First, choose two categories that are important to you. For example, if you like cars that look good and are fun to drive, look at the categories of **Styling** and **Fun**. Then, on this grid, make a scatter plot of the data. Label axes with the **Styling** ratings along the horizontal axis and the **Fun** ratings along the vertical axis. Put a scale on each. (40 is the highest possible rating.) Label each dot with the car's letter (A-H).

Now make the scatter plot on your HP 38G. Press **(LIB)**, choose **Statistics** and press **(RESET VIEW)**, then **(EDIT)** or **(ENTER)**. Input the **Styling** data into **C1** and the **Fun** data into **C2**. On the menu line, set **EWV1X**. In the symbolic view (press **(SYMB)**), enter **C1** as the independent variable and **C2** as the dependent variable. Be sure **S1** has a \surd beside it.

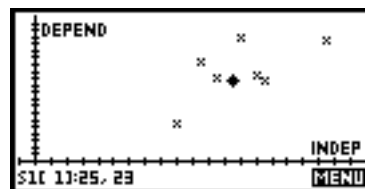
Set up the plot to show the same view as above, by pressing **(SETUP PLOT)** and using these settings:



(continued on page 12)

(continued from page 11)

Press **PLOT** to draw the graph. You should have a scatterplot that looks a lot like the one you made on the grid. You can't label each dot on the calculator, but you can use a split screen and trace through the data. Press **VIEWS** and choose **Plot-Table**. Use **◀** and **▶** to trace through the points. Which car seems to be best when **Styling** and **Fun** are your only considerations? Explain why.



Since 40 is the highest possible rating for each category, one approach is to choose the point closest to the point (40,40). Place a dot of a different shape or color at the point (40,40) on your graph on the grid. Also, add 40 to the bottom of each of the columns **C1** and **C2** in the **NUM** view on your calculator.

Now which car seems to be the best with regard to the styling and fun categories? Rate the cars where 1 is the best and 8 is the worst. Which cars were most difficult to rate? Why?

You can take the guesswork out of it by calculating the distance from each data point to the optimum point (40,40). The distance formula is

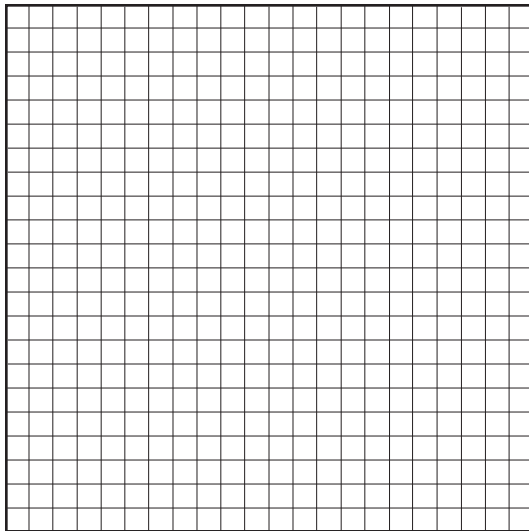
$$D = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2},$$

where (x_1, y_1) is one of the data points and $(x_2, y_2) = (40, 40)$. To do this on your HP 38G calculator and then store the results in **C3**, press **HOME** $\sqrt{((C1-40)^2 + (C2-40)^2)}$ **ENTER**, then **STO** **C3** **ENTER**.

Now rank the eight cars in the study, judging the best car as that whose data point is closest to (40,40).

Answer:	1. (B) Honda Civic DX	5.8
	2. (H) Volkswagen Golf	14.6
	3. (D) Mercury Tracer	19.2
	4. (E) Mitsubishi Mirage	20.2
	5. (G) Volkswagen Fox GL	22.0
	6. (A) Ford Festiva LX	22.7
	7. (C) Mazda 323SE	23.3
	8. (F) Subaru Justy RS 4WD	36.4

Now you're going to need all of the data in your calculator, so take a moment to enter it. (Hmm.... There are 11 categories and only 10 columns in the Statistics **NUM** view. Problem? No—store the last data column in a list, **L1**. This data, the **Fun** category, is currently in **C2**, so press **HOME** **C2** **STO** **L1** **ENTER**. (To see if you have stored the data into **L1** properly, press **LIST**, highlight **L1**, and press **ENTER**.) Input all the data values in columns **C1** through **C9** in the order listed in the table. For reference, input 40 at the end of each column.



You've calculated how the cars would stack up if you were to judge them only on **Styling** and **Fun**. But now you choose: What two categories would *you* pick to rate these cars?

Graph a scatterplot of the data in those two categories on this grid.

Now use the distance formula to help you rank the cars as you did above. (Remember to replace **C1** and **C2** with the columns of data you have chosen.)

What if you were interested in more than two categories? You wouldn't be able to graph a scatter plot, but you could still create an overall rating system by using the distance formula.

On your calculator, for example, the distance formula for five categories (**C1**, **C3**, **C8**, **C9** and **L1**) might look like this:

$$\sqrt{((C1-40)^2+(C3-40)^2+(C8-40)^2+(C9-40)^2+(L1-40)^2)}$$

Choose the five categories that are most important to you, and rate the cars according to those five categories, using this distance formula.

Now rate the cars using **all 11 categories**. (What distance formula do you use?)

Answers:	1. (H) Volkswagen Golf	23.9
	2. (B) Honda Civic DX	25.6
	3. (D) Mercury Tracer	36.2
	4. (G) Volkswagen Fox GL	36.8
	5. (E) Mitsubishi Mirage	44.9
	6. (C) Mazda 323SE	45.5
	7. (A) Ford Festiva LX	47.8
	8. (F) Subaru Justy RS 4WD	72.2

$$\sqrt{((C1-40)^2+(C2-40)^2+(C3-40)^2+(C4-40)^2+(C5-40)^2+(C6-40)^2+(C7-40)^2+(C8-40)^2+(C9-40)^2+(C0-40)^2+(L1-40)^2)}$$

Resource: Curriculum and Evaluation Standards for School Mathematics, Addenda Series, Grades 9 - 12, "Making Sense of Data," National Council of Teachers of Mathematics, 1992.

Wade White wrote this statistics activity for the HP 38G in 1995. At the time, he was on leave from teaching math at Central High School in Independence, OR, in order to be a full-time home parent for his two boys. Since that time, his interests evolved to elementary-age students, and beginning this Fall, he will be teaching first grade at Lyle Elementary School in Dallas, OR.

More Better Music

by Brady Brady

My first experience with music on HP calculators took place a little over ten years ago. I was in high school, and one of my friends had an HP 28C. Unbeknownst to him, I programmed a short sequence of notes, set a “trap” for him, and turned off the calculator. Soon, physics class was interrupted by Brady’s Calculator Concerto No 1. The calculator was confiscated for the remainder of the period, and I’ve been having fun ever since.

After reading the article on creating musical tones and songs on HP calculators [“Name That Tune,” by Bob Firman and Tom Dick, *hpC* 4/98], you may have wondered (as I did) if there wasn’t some way to avoid the tedium of entering every note’s frequency (in hertz) and duration (in seconds). Well, there is. The following program for the HP 48G Series calculators lets you do just that. With this program, to play a song containing “ n ” notes, all you need is an $n \times 2$ matrix (at level 2 of the stack) and a “speed” factor (at level 1 of the stack).

The first matrix column holds index **numbers** for the notes in the song—integers ranging from 0-87, corresponding to a piano’s 88 keys. (Any value greater than 90 is a rest.) For example, here’s a matrix whose first column denotes the C-major scale starting at middle C. This notation eases both entry and transposing (playing the song in other keys). For example, to transpose this scale up by 5 half-tones, to F-major, you just increase every note number by 5. An octave increase is 12.

39	4
41	4
43	4
44	4
46	4
48	4
50	4
51	4

The second column in the matrix contains the note **types**. A 1 denotes a whole note; 2 is a half note; 4 is a quarter note, etc. (The matrix shown is all quarter notes.) To represent a dotted note—held 1.5 times as long as the undotted version—use a negative value. For example, a dotted 16th note is -16.

The **speed factor** is the duration of a whole note (note type 1), in seconds. To convert a metronomic tempo (beats/minute) to a speed factor, multiply the note type by 60, then divide by the desired tempo. Thus, if a tempo specifies half notes at 80/minute, the speed factor is $[(2)(60)]/80 = 1.5$.

Here are notes along with their corresponding numbers (and frequencies), followed by the program itself, with comments. Note that A_0 is the lowest note on a piano keyboard, C_8 is the highest, and “Middle A” (A_4) is defined as 440 Hz.

No.	Note	(Freq.)	No.	Note	(Freq.)	No.	Note	(Freq.)	No.	Note	(Freq.)
-	C ₀	16.35	15	C ₂	65.41	39	C ₄	261.63	63	C ₆	1046.50
-	C ₀ [#]	17.32	16	C ₂ [#]	69.30	40	C ₄ [#]	277.18	64	C ₆ [#]	1108.73
-	D ₀	18.35	17	D ₂	73.42	41	D ₄	293.66	65	D ₆	1174.66
-	D ₀ [#]	19.45	18	D ₂ [#]	77.78	42	D ₄ [#]	311.13	66	D ₆ [#]	1244.51
-	E ₀	20.60	19	E ₂	82.41	43	E ₄	329.63	67	E ₆	1318.51
-	F ₀	21.83	20	F ₂	87.31	44	F ₄	349.23	68	F ₆	1396.91
-	F ₀ [#]	23.12	21	F ₂ [#]	92.50	45	F ₄ [#]	369.99	69	F ₆ [#]	1479.98
-	G ₀	24.50	22	G ₂	98.00	46	G ₄	392.00	70	G ₆	1567.98
-	G ₀ [#]	25.96	23	G ₂ [#]	103.83	47	G ₄ [#]	415.30	71	G ₆ [#]	1661.22
0	A ₀	27.50	24	A ₂	110.00	48	A ₄	440.00	72	A ₆	1760.00
1	A ₀ [#]	29.14	25	A ₂ [#]	116.54	49	A ₄ [#]	466.16	73	A ₆ [#]	1864.66
2	B ₀	30.87	26	B ₂	123.47	50	B ₄	493.88	74	B ₆	1975.53
3	C ₁	32.70	27	C ₃	130.81	51	C ₅	523.25	75	C ₇	2093.00
4	C ₁ [#]	34.65	28	C ₃ [#]	138.59	52	C ₅ [#]	554.37	76	C ₇ [#]	2217.46
5	D ₁	36.71	29	D ₃	146.83	53	D ₅	587.33	77	D ₇	2349.32
6	D ₁ [#]	38.89	30	D ₃ [#]	155.56	54	D ₅ [#]	622.25	78	D ₇ [#]	2489.02
7	E ₁	41.20	31	E ₃	164.81	55	E ₅	659.26	79	E ₇	2637.02
8	F ₁	43.65	32	F ₃	174.61	56	F ₅	698.46	80	F ₇	2793.83
9	F ₁ [#]	46.25	33	F ₃ [#]	185.00	57	F ₅ [#]	739.99	81	F ₇ [#]	2959.96
10	G ₁	49.00	34	G ₃	196.00	58	G ₅	783.99	82	G ₇	3135.96
11	G ₁ [#]	51.91	35	G ₃ [#]	207.65	59	G ₅ [#]	830.61	83	G ₇ [#]	3322.44
12	A ₁	55.00	36	A ₃	220.00	60	A ₅	880.00	84	A ₇	3520.00
13	A ₁ [#]	58.27	37	A ₃ [#]	233.08	61	A ₅ [#]	932.33	85	A ₇ [#]	3729.31
14	B ₁	61.74	38	B ₃	246.94	62	B ₅	987.77	86	B ₇	3951.07
									87	C ₈	4186.01

Program Code	Comments
« 0 0 → SONG SPD I NMBR	Initialize variables
« SONG 1 COL- OBJ→ HEAD →LIST	Get vector of note numbers; convert it to list
REVLIST	Order notes correctly
2 LN 12 / EXP SWAP ^ 27.5 *	Compute frequencies
OBJ→ { } + 1 + →ARRY	Convert list back to vector
SWAP OBJ→ HEAD →LIST	Get note type vector; covert it to list
INV	Take reciprocals of note types
DUP SIZE DUP 'NMBR' STO	NMBR = number of notes in song
1 SWAP	
FOR I	Perform loop for each note
IF DUP I GET 0 <	If duration < 0, note is dotted, so
THEN	
DUP I GET - 1.5 * I SWAP PUT	Get duration, multiply by 1.5, and replace
END	
NEXT	
SPD *	Multiply by speed factor
REVLIST	Order durations correctly
OBJ→ { } + →ARRY 2 COL+ OBJ→	Reassemble song matrix; place onto stack
HEAD 1	
FOR I	Count down from last to first note
I 2 * PICK	Examine note frequency
IF 5000 <	If < 5000, it is a note (not a rest)
THEN	
« BEEP » I 2 * 1 - ROLLD	So insert "BEEP" into stack
ELSE	Otherwise, there is a rest
I 2 * ROLL DROP	Therefore, remove frequency, and
« WAIT » I 2 * 1 - ROLLD	Insert "WAIT" command into stack
END	
-1 STEP	Continue countdown
1 NMBR	
FOR I	For each note or rest
EVAL	Play it!
NEXT	
»	
»	

LT Brady A. Brady teaches math at the Naval Academy Preparatory School in Newport, RI. He will be leaving the Navy soon to pursue a doctorate in mathematics. He likes to camp, play the piano, and "anything that includes meat and charcoal." Next spring, Brady will begin a hike of the Appalachian Trail. ("I need some time to unwind.... Where else can you eat all day and still lose weight?")

Understanding the Formal Definition of a Limit Using the HP 48G Series

by Michael Grasse

The purpose of this lab is to help you visualize the so-called “ δ and ϵ definition of limit.” This definition was never put forth to aid in the computation of limits. In fact, people were merrily computing limits for almost 200 years before this definition was invented. The purpose of the definition was to quiet the critics who said that calculus was based on faith and shallow reasoning—phrases such as “really, really close” are irksome to mathematicians—and to place the foundations of calculus on solid ground. You may initially think that the purpose of this definition is to make things confusing.

The Formal Definition of a Limit

The limit of $f(x)$ as x approaches a is equal to L if and only if the following is true:

Given any $\epsilon > 0$, there exists a $\delta > 0$ such that $0 < |x - a| < \delta$ implies $|f(x) - L| < \epsilon$.

Several things make this definition difficult, not the least of which are the absolute value inequalities. Stripping these away, the last part to the definition says that there must exist a small, positive number δ such that if we pick inputs that are at most δ away from a , we will be assured that the function values will be between $L - \epsilon$ and $L + \epsilon$ for some positive ϵ .

A few other things to keep in mind:

- Your job is to find an input error tolerance, δ that defines an interval that will always yield outputs within the given output tolerance, ϵ .
- After a working δ is found, any smaller δ will also work.
- What the function does at a is immaterial. In fact, the function can be undefined at a . All that matters is what happens near a .

To investigate limits with δ 's and ϵ 's on the HP 48, you'll be given an ϵ and set up the vertical view to be $[L - \epsilon, L + \epsilon]$, where L is the suspected limit. Next, you'll play around with the horizontal view until you see the graph enter and leave from the sides of the display. This will be $[a - \delta, a + \delta]$. The largest δ is when the graph enters and leaves from one or both corners of the display.

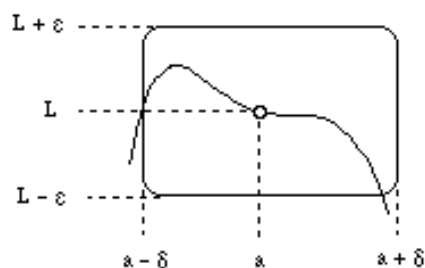


Figure 1

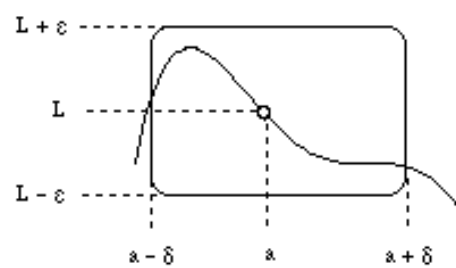
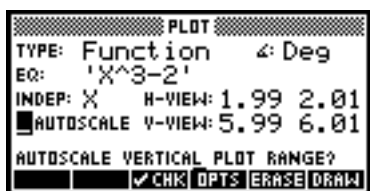


Figure 2

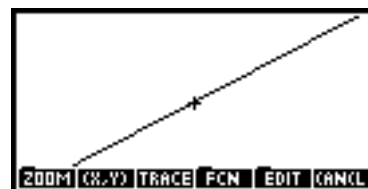
- Figure 1 shows a δ that is not small enough. Draw a point (on figure 1) that is on the graph, inside of $[a - \delta, a + \delta]$ and outside of $[L - \epsilon, L + \epsilon]$.
- Figure 2 shows a δ that “works.” Can you find a point in this view like the point described in question 1? Is this the best (largest) possible δ ?
- a. Assume that $\lim_{x \rightarrow 2} x^3 - 2 = 6$. Find the largest δ for an $\epsilon = 0.01$.



Store X^3-2 in EQ, and then set up the PLOT parameters as shown here.

Now plot...

That didn't work, so try $\delta = 0.001$ Not quite, but better. You'll find that $\delta = 0.0001$ works, as does $\delta = 0.0008$, but $\delta = 0.0009$ does not.



- Find the largest δ for an $\epsilon = 0.001$.
 - Does this function exist at $x = 2$?
- Assume that $\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1$.
 - Find the largest δ for an $\epsilon = 0.01$.
 - Find the largest δ for an $\epsilon = 0.001$.
 - Does this function exist at $x = 0$?
 - Assume that $\lim_{x \rightarrow 0} x \sin \frac{1}{x} = 0$.
 - Find the largest δ for an $\epsilon = 0.01$.
 - Find the largest δ for an $\epsilon = 0.001$.
 - Does this function exist at $x = 0$?

Michael Grasse teaches AP Calculus and is the Computer Co-coordinator at Elk Grove High School in Elk Grove Village, IL. A 1993 grant awardee in the Calculus Connections Project, he has taught HP graphing calculator workshops across the U.S. and in Singapore. Michael enjoys camping, photography and beer making. He lives with his wife, Nicolle, and dog, Scout, in Des Plaines, IL.

Educator Resources

The easy way to integrate Hewlett-Packard calculators into the learning process? Try them for yourself! That's what the HP Educator Support Program is all about. Through HP's partnership with **The Math Learning Center (MLC)**, you have a wide variety of ways to learn about and get HP products into your classroom.



Evaluating HP Calculators

To evaluate an HP calculator for use in your classroom, just contact **MLC** and they will send you an evaluation request form.

Training Workshops

HP is committed to helping you get the most out of HP graphic calculators through its ongoing training program. For an up-to-date list of scheduled workshops on HP graphic calculators, contact **MLC** by phone, mail, e-mail or fax. Or, if the already-scheduled workshops don't fit into your calendar, schedule your own! **MLC** has a list of instructors who are available to conduct workshops on HP graphic calculators—and they also will help you publicize it. (Just send information on your workshop to **MLC** after you have finalized the schedule.)

Free Classroom Materials

Then, to help you successfully integrate HP calculators into your classroom, Hewlett-Packard offers a wide assortment of materials and aids:

- Classroom posters for HP 38G or HP 48G series
- Overhead transparencies of all HP calculator keyboards
- Training guides/examples for the HP 38G and HP 48G series
- Additional copies of any issue of this newsletter—or a free subscription

To request any of these materials, contact **MLC**.

The Math Learning Center (MLC)
Hewlett-Packard Educator Program
P.O. Box 3226
Salem, OR 97302-0226
Phone: **800-750-8130** (8-5 PT M-F)
Fax: 503-370-7961
E-mail: hp@bbs.mlc.pdx.edu

Other Resources:

Books and Software

The following books address the use of HP Graphic calculators. (HP does not represent or endorse these books.)

Algebra & Pre-Calculus on the HP 48G/GX; Dan Coffin; Grapevine Publications; ISBN 0-931011-43-4

Calculator Enhancement for Differential Equations; T.G. Proctor;
Harcourt Brace Jovanovich; ISBN 0-155056-73-5

Calculator Enhancement for Linear Algebra; D.R. LaTorre;
Harcourt Brace Jovanovich; ISBN 0-155056-74-3

Calculator Enhancement for Multivariable Calculus; J.A. Reneke;
Harcourt Brace Jovanovich; ISBN 0-155056-78-1

Calculator Enhancement for Single-Variable Calculus; James Nicholson;
Harcourt Brace Jovanovich; ISBN 0-155056-76-X

Calculus Activities for Graphic Calculators; Dennis Pence; PWS Publishing Co.; ISBN 0-534924-31-X

Calculus Concepts: Graphing Calculator Instruction Guide; Iris B. Fetta;
DC Heath and Co.; ISBN 0-669398-69-1

Calculus Concepts: An Informal Approach to the Mathematics of Change; D.R. LaTorre, John W. Kenelly, Iris B. Fetta, Cynthia R. Harris, Laurel L. Carpenter; DC Heath and Co.; ISBN 0-669398-65-9

Calculus Investigations with the HP 48G/GX; D.R. LaTorre;
Charles River Media, Inc.; ISBN 1-886801-18-5

Calculus of a Single Variable; Thomas P. Dick, Charles M. Patton; PWS Publ. Co.; ISBN 0-534939-36-8

Calculus on the HP 48G/GX; Dan Coffin; Grapevine Publications, Inc.; ISBN 0-931011-44-2

Differential Equations using the HP 48G/GX; T.G. Proctor; Charles River Media.; ISBN 1-886801-19-3

An Easy Course in Using and Programming the HP 48G/GX; Chris Coffin;
Grapevine Publications, Inc.; ISBN 0-931011-41-8

Experiments in Computational Matrix Algebra; David Hill;
Random House/Birkhauser; ISBN 0-394356-78-0

Exploring Calculus with a Graphing Calculator; Charlene E. Beckman, Ted Sundstrom;
Addison-Wesley Publishing Company; ISBN 0-201555-74-3

Graphing Calculator Laboratory Manual for Calculus; Charlene E. Beckman, Ted Sundstrom;
Addison-Wesley Publishing Company; ISBN 0-201549-71-8

HP 48G/GX Investigations in Mathematics; D.R. LaTorre, Donald Krieder, T.G. Proctor;
Charles River Media, Inc.; ISBN 1-886801-23-1

Linear Algebra Investigations with the HP 48G/GX; D.R. LaTorre;
Charles River Media, Inc.; ISBN 1-886801-20-7

Mastering the HP 38G Graphics Calculator – A Guide for Students and Teachers; Colin Croft;
Applications in Mathematics; ISBN 0-958691-72-X

Technology in Calculus; Thomas P. Dick, Charles M. Patton; PWS Publishing Co.; ISBN 0-534930-81-6

For these and other books, see your local bookseller or visit amazon.com online. (Suggestion: search with keyword “HP 48G” or “HP 38G.”) Public-domain software is also available via links from HP’s web site at www.hp.com/calculators.

ApLets Now Available from the HP 38G ApLet Library

•	1-VAR INEQUALITIES	Solve inequalities using a number line.
•	2 x 2 SYSTEMS	Solve 2 x 2 systems of linear equations, using substitution, linear combination, and Cramer's Rule.
•	ACTIVE GRAPHER	Investigate rigid transformations of seven basic functions: $y = x$, $y = x^2$, $y = x^3$, $y = x $, $y = \sqrt{x}$, $y = 1/x$, $y = 1/x^2$.
•	AMPLITUDE/PERIOD	Investigate the effects of parameters A and B on the functions $y = \text{Asin}(Bx)$, $y = \text{Acos}(Bx)$, $y = \text{Atan}(Bx)$, $y = \text{Asec}(Bx)$, $y = \text{Acsc}(Bx)$, $y = \text{Acot}(Bx)$.
•	ANGLES	Solve for the missing angle, given a pair of complementary angles, a pair of supplementary angles, or a triangle.
•	ARCHIMEDES	Explore Archimedes' method for approximating the value of π by comparing the area of a regular polygon to that of the corresponding circumscribed circle.
•	AREA MODEL	Multiply first-degree monomials and binomials.
•	BASIC FUNCTIONS	Explore stretches, shrinks, and translations of seven basic graphs.
•	CARS 1993	Explore relationships among data to investigate various cars, their cost, mpg, etc.
•	CONIC PLOTTER	Investigate conic sections in general and standard forms.
•	CONICS – POLAR FORM	Investigate polar graphs of conics—how changing the eccentricity and distance from focus to directrix affects these graphs.
•	COORDINATE GEOMETRY	Find the midpoint, distance, and slope of a line segment.
•	DECIMALS	Explore patterns and symmetry by ordering pairs of digits from the decimal expansion of certain fractions that have periodic decimals.
•	DERIVATIVES	Graphically explore the first and second derivatives of functions.
•	DISTANCE	Determine lengths of line segments to the nearest hundredth.
•	DOT-TO-DOT	Explore points, slopes and equations of lines that enclose figures; investigate the piecewise functions that would create the exact drawing.
•	DRILL CORE	Explore relationships among data to predict the percentage of iron in a sample.
•	EFFECTS ON F(X)	Graph functions where negations and absolute values are applied to the function and its inputs.
•	FACTORING	Symbolically factor second-degree trinomials in the form $Ax^2 + Bx + C$.
•	FIBONACCI	Determine an approximation for the golden mean, using the ratio of width to length of the sides of the golden rectangles.
•	GUESS THE LINE	Write the equation of a line in slope-intercept form, given two points.
•	GUESS RATIONAL	Write the equation of a rational function, given horizontal and vertical asymptotes and a root.
•	INEQUALITIES	Graphically solve a system of linear inequalities.
•	INVERSES	Explore inverse relations and functions; analyze relations and functions graphically, numerically, and symbolically.
•	LAWS OF EXPONENTS	Apply the laws of exponents to multiply and divide monomials and to raise a monomial to a power.

algebra
geometry
trig
pre-calc
data/stats
physics
calculus

The HP 38G

Graphic Calculator

In Detail

Easy, Powerful, and Built for Math Class

The HP 38G has all the functionality and features of other graphic calculators, plus a lot more. Designed with the secondary school math classroom in mind, no other calculator makes learning and teaching math so exciting.

The HP 38G is the first calculator with interactive, electronic lessons, called ApLets, that help students learn faster and get more from classroom and home-work sessions. It's the future of calculator-based instruction: powerful, flexible, easy. And the HP 38G can connect to an overhead display unit, so students can see your keystrokes or share their own work!



Understanding comes more naturally to students, too, as the HP 38G lets them view expressions numerically, graphically and symbolically. The new split-screen view lets them compare two views at once, helping them to build a stronger conceptual base; the HP 38G makes math make sense.

Easy Menus and Commands

The HP 38G is the first graphic calculator from HP to use standard algebraic notation for its operations—no need to learn new methods to do the same old calculations. And the HP 38G remembers your calculations for future use. Simply move up the list and copy the information you want—point and shoot!

With easy-to-use menus, you get results fast. Pop-up menus offer commands with just a few keystrokes, and input forms offer easy screens to set up problems. Students just fill in the blanks, and the SHOW equation feature lets them be sure they've entered expressions correctly. There's even a fraction display mode!

Built-in Tools, Lots of Power

The HP 38G offers over 200 easy-to-find commands in clear, organized menus. Evaluate expressions symbolically, isolate variables, solve quadratic equations, and use HP Solve to conduct “What if...” investigations. Other features include:

- Taylor series approximations
- List-based, 1- and 2-variable statistics; regression models and plot types
- Complex numbers
- Real and complex matrices
- Programming to create your own Views, ApLets, and automatic calculations

ApLets Make Teaching Easier for You

ApLets combine variables, pictures, graphs and custom-designed views into one complete package. With ApLets, students can explore the problems without your guidance—and without fear of losing their work or the original lesson. They can save their work or start over if necessary. ApLets are easy and natural to use: students will even begin to create their own to share with you and others.



It's easy to create ApLets! Once you set up a problem for use in the classroom, just save it. All of the configuration information is saved, along with any notes and sketches you've created—together in a package easily transferred to your students via simple, wireless infrared. (Just point two calculators at each other and beam it across—and the same infrared beam also operates the I/R printer!) In very little time, everyone in class is working with the same information and problems—a complete lesson that you prepared.

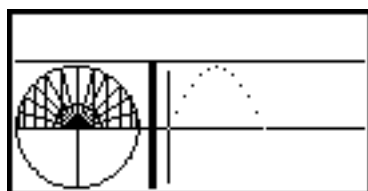
An ApLet (such as this one, written by G.T. Springer, of San Antonio, TX) is stored in the ApLet Library. It can begin with a note....



Students can then see a sketch of the problem and even customized views....



They can compare graphical and numeric views as they are generated. And if they goof, they just start over—the original ApLet isn't changed until it is saved.



ApLets are being created by teachers, publishers, and HP. They are available on bulletin boards and on the Internet. (Please see pages 20-21 and page 38 for more information.)

(Please see page 27 for Bid Specifications for the HP 38G Graphic Calculator.)

THE HP 48G Series Graphic Calculators in Detail

The State of the Art

The HP 48G Series of graphic calculators represent the best of the best—a new level of capability and convenience. They offer more memory, more functionality, and more graphics, including input forms, dialog boxes, enhancements to plotting, 3-D graphics, and built-in equations.

The HP 48G Series of calculators is truly at the head of its class, offering you and your students a wide range of choices in power, ease of use and expandability for the future.



The HP 48G Graphic Calculator has 32 KB RAM built-in and includes all HP 48GX features except the plug-in option—an excellent choice when plug-in expandability is not a requirement.

The new HP 48G+ Advanced Graphic Calculator opens up new horizons. With a full 128 KB of RAM built-in—four times the memory of the HP 48G—think how many more equations, programs, notes and formulas your students could have at their fingertips!

The HP 48GX Graphic Expandable is the finest calculator for your education and your career—period. With 128 KB of RAM built-in, plus the expandability of two plug-in ports for application cards or up to 1.25 MB of RAM, it's the most power you'll find in a calculator anywhere.

Power with No Equal

The power packed by the HP 48G Series is staggering. Graphics and calculus combine as in no other calculator. While you view the graph, the HP 48 finds roots, intersections, local extrema, derivatives, slopes, and areas under curves. You also get hundreds of built-in equations for geometry, stress analysis, electrical engineering, fluid flow, heat transfer, and more—all with HP Solve that lets you play “What if...” by varying your known values and solving for the unknown values—even with multiple equations!

And if all this isn't already precisely what you need, the HP 48G Series also offers powerful, structured, object-based programming. Write quick, simple utility programs, and then combine them into sophisticated applications—with totally custom menus and key assignments to make their use even faster.

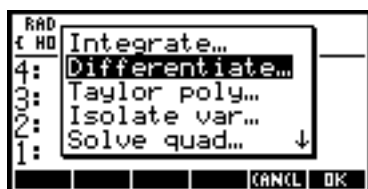
Built to Make Sense

But is all this power only for the technically gifted? Not at all! The HP 48G Series is easy to use, even for beginners.

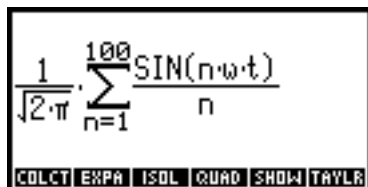


Look at the easy-to-use forms that speed up learning: each built-in application tool has an input form you just fill in.

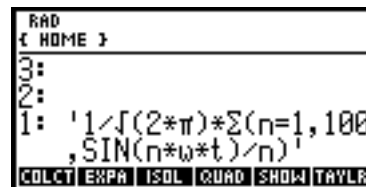
With clear prompts and menus organized for easy access, you and your students get satisfying results quickly. From unit management to matrices, the HP 48G Series is first-class in friendliness, too.



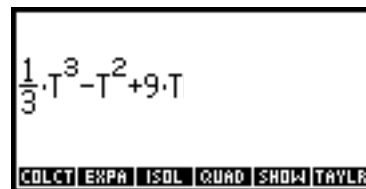
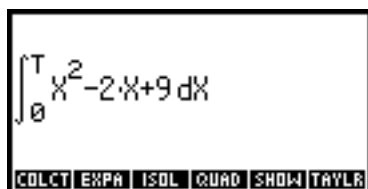
With the EquationWriter, you see this...



...instead of this.



And its symbolic math capabilities open new possibilities for your students. They can create expressions on the calculator, then evaluate them symbolically....



Calculators to Expand with Your Horizons

You can add up to 1.125 MB of RAM to the HP 48GX—or customize it with plug-in application cards. It can grow with you—you'll never need another calculator! And even the HP 48G and HP 48G+ offer expandability via data transfer—and you don't even need cables with the built-in infrared I/O! Just send and receive files via the HP 48 infrared port—to another HP 48 or to the optional HP infrared printer. And for longer-term storage and exchange, the built-in serial port makes sharing just as easy: with the Connectivity Kit accessories, you can link your HP 48 to your Macintosh or DOS computer via RS-232 for file exchange, program storage, and program development.



(Please see page 27 for Bid Specifications for HP 48G Series Graphic Calculators.)

HP Graphic Calculators

Features Summary

Product Name	HP 38G	HP 48G Series
Display	8 line × 22 char. LCD	8 line × 22 char. LCD
Entry system logic	Algebraic	RPN
Menus and softkeys	Yes	Yes
Prompts and alpha messages	Yes	Yes
Built-in RAM	32 KB	32 or 128 KB
Variables or registers	Unlimited within available memory	Unlimited within available memory
Built-in functions	Over 600	Over 2300
Re-definable keyboard and menu keys	Yes	Yes
$+$, $-$, \times , \div , $+/-$, $\ln(x)$, e^x , y^x , $\log(x)$, 10^x	Yes	Yes
Square root, $1/x$, $n!$, x^2 , $\%$, π	Yes	Yes
Fractions format	Yes	No
Trig., Hyperbolics, HP Solve (root finder)	Yes	Yes
Numeric integration	Yes	Yes
Complex numbers and functions	Yes	Yes
Statistical analysis	Multivariate/stat.	Multivariate/stat.
Σx , Σx^2 , Σy , Σy^2 , Σxy	Yes	Yes
Sample stand. dev./mean/weighted mean	Yes + population stand. dev.	Yes
Linear regression, comb./permutations	Yes	Yes
Curve fit (LIN, LOG, EXP, POW)	Yes	Yes
Normal, X, t, F distribution	No	Yes
Decimal hrs./hrs.min.sec. conversions	No	Yes
Polar/rectangular and angle conversions	Yes	Yes
Base conversions and arithmetic	No	Yes
Unit conversions	No	Yes
Bit/Boolean operations	No	Yes
Matrix operations, rectangular and polar	Yes	Yes
Matrix operations, cylindrical/spherical	No	Yes
HP MatrixWriter, row/column operations	Yes	Yes
ApLets	Yes	No
Notepad	Yes (built-in)	Yes (via variables)
Graphic functions/interactive graphics	2D	2D, 3D
Programming	Yes	Yes (RPL)
Number of formulas/programs	Unlimited within available memory	Unlimited within available memory
Optional infrared printer (HP 82240B)	Yes	Yes
Computer link	Yes	Yes
Two-way infrared I/O	Yes	Yes
Batteries	3 x AAA	3 x AAA
Warranty	One-year warranty	One-year warranty

In addition, all HP 48G Series calculators offer symbolic algebra (quadratic and polynomial); symbolic calculus (integration and differentiation); symbolic constants; business features; and a built-in Solve Equation Library. The HP 48GX also has expansion capabilities of two slots for multiple applications or up to 1.25 MB of memory.

HP Graphic Calculators

Bid Specifications

HP 38G



- 8-line x 22-character display
- Advanced functions access via pop-up display windows
- 15-digit calculation accuracy, displayed with up to 12 digits plus a 3-digit exponent
- Graph rectangular functions, parametric and polar expressions, recursively-defined sequences
- Up to 10 graphing functions defined, saved, graphed and analyzed simultaneously
- Up to 10 functions traceable on a single graph
- ApLets (small electronic lesson packets); ApLets limited only by available memory
- 15 interactive zoom features accessible from the display
- Sequence graphing mode shows both time series and cobweb/stairstep plot
- Numeric evaluation of functions in table format
- Interactive function analysis: values, roots, maxima and minima, integrals, derivatives
- Presents mathematical solutions in multiple views
- Split-screen capability displays 2 screens side-by-side for dynamic comparison
- HP Equation Solver
- Notes and pictures feature
- Matrix operations: inverse, determinant, transpose, augment, eigenvectors, and elementary row operations
- 10 matrices; sizes limited only to available memory
- List-based 1- and 2- variable statistics; regression models: linear, log, power, exponential, quadratic, cubic, logistic
- Box and whisker plots
- Histograms, scatter plots, regression equation graphs
- Programs; quantities limited only by available memory
- Dynamic results history stack at HOME screen
- Symbolic tools: variable isolation, substitution, quadratic solving, Taylor series
- Polynomial root finding
- Complex numbers
- 32 KB memory
- Data transfer with built-in IR (infrared) and serial port
- Connects to overhead projector accessory
- IR printer accessory
- Connectivity accessory kits for IBM-PC or Macintosh
- Powered by 3 AAA batteries
- Sturdy sliding hard case
- 1-year warranty



HP 48G Series



- Built-in RAM: 32KB on 48G; 128KB on 48G+ and 48GX
- 131 x 64 dot display
- 12-digit values, with 3-digit exponents
- HP EquationWriter for formatted equation entry
- Multiple plots on single graph; limited only by available memory
- Quadratic and polynomial root finder
- Symbolic and numeric integration and differentiation
- Differential equation solver
- Real and complex matrices; sizes and numbers limited only by available memory
- Object-based programming language; structures include CASE, DO, FOR, IF, UNTIL, and WHILE; program sizes and numbers limited only by available memory
- Infrared I/O; wireless transfer of instructor data to students
- Dialog-box function access
- Graphing: function, conic, polar, parametric, truth, differential equation, bar, histogram, scatter plots
- Graphic controls: zoom, box Z, tracing, shading, spacing, axis tick marks, scrolling
- Matrix operations: inverse, transpose, determinant, row operations, row-to-column conversions
- Statistical capabilities: standard deviation, mean, linear regression, combinations, permutations, weighted means
- Keys can be assigned new functions or programs
- Serial-wired Mac/PC interface
- Size: 8.1 x 18.0 x 2.9 cm (3.2 x 7.1 x 1.2 inches)
- Weight: 264 g (0.58 lb)
- 1-year warranty
- HP 48GX has two expansion ports, allowing plug-in applications or RAM memory accessory cards



Accessories for HP Graphic Calculators

Connectivity

Share your computer's peripherals with your HP 38G and HP 48G Series—and protect your calculator data and programs by storing them to your computer's disk drive! The HP Connectivity Kit provides desktop computer cables and utilities (including Windows-compatible programs) to capture HP 38G or HP 48G Series screen images, and to remotely control the HP 38G or HP 48G Series.

F1207C Serial Interface Kit, HP 38G/48G Series to DOS/Windows-compatible PC's.

Program transfers files between calculator and PC: libraries, programs, grobs, data sets, or ApLets. Includes utility to capture/save calculator screen images.

On the HP 48G Series, controls calculator memory remotely from a PC. (Has a simple file editor and an archive command to back up memory in a compressed file.) On the HP 38G, controls file storage remotely, from the calculator.

Includes 1.5-meter serial cable, 4-pin to 10-pin connector, two 3.5" HD disks with PC software (Windows 3.1 and DOS 5.0 versions), User's Guide. Requires open PC serial port (9-pin to 25-pin).

F1015A Serial Interface Cable, for IBM-compatible PC's.

Includes 1.5-meter serial cable, 4-pin to 10-pin connector.

F1023A Serial Cable Adapter Kit, for IBM-compatible PC's.

Includes 9-pin to 25-pin serial modem adapter, 9-pin to 25-pin serial PC adapter, 9-pin to 25-pin serial printer adapter, 9-pin to 9-pin null modem adapter.

F1208B Serial Interface Kit, for HP 38G/HP 48G Series to Macintosh. Transfers files between calculator and Mac: libraries, programs, grobs, data sets or ApLets. Screen grabber utility saves calculator screen images.

On the HP 48G Series, controls calculator memory remotely from a Mac. (Has a file editor and archive command to back up compressed memory.) On the HP 38G, controls file storage remotely, from the calculator.

Includes 1.5-meter serial cable, 4-pin to 10-pin connector, 3.5-inch disk with Macintosh software, User's Guide. Requires open PC serial port (9-pin to 25-pin).

F1016A Serial Interface Cable, for Macintosh computers.

Includes: 1.5-meter serial cable, 4-pin to 10-pin connector.

Classroom Overhead Display

The Overhead Display Unit (ODU) is the perfect way to teach or present lessons. It's easy to demonstrate HP 38G or HP 48SX/GX calculations to the whole class—step by step!

Just set this unit on an overhead display projector, connect it to your calculator with the proper cable, and you're ready to conduct class.



You can adjust contrast and screen positioning, and the ODU has cables for the HP 38G and HP 48SX/GX—and a built-in compartment for easy cable storage.

HP F1212A Overhead Display Unit

Includes: Display unit, one 9V battery, 2 cables, User's Guide.

Printing

The battery-powered infrared printer is a revolutionary companion for your HP graphic calculator. Operating via an invisible infrared beam, it needs no cord to connect to the calculator; producing hard copies in the field or office couldn't be easier! And you get easier-to-read output and automatic shutoff for extended battery life.

Operating this printer is easy. Just aim your calculator at the printer (up to 18 inches away), send print instructions, and you get a neat, clean copy of your calculations. Print a complete record of your work, or select only what you need. Just 4 AA alkaline batteries give the printer go-anywhere portability. Or, to extend battery life, plug in the optional AC adapter.



HP 82240B HP Infrared Printer

Includes: Printer, 4 AA alkaline batteries, 1 roll of paper, User's Guide.

HP 82175A Thermal Paper, for HP 82240B or HP 82240A Infrared Printers.

Includes: 6 rolls, 2 1/4" x 80" (5.7 cm x 25 cm), black.

HP F1011A AC Adapter for HP 82240B or HP 82240A Infrared Printers.

(continued on page 30)

Memory Cards

Take advantage of additional RAM! Develop large programs and store more data in your HP 48GX. Choose the memory configuration you need. Add to the main memory or use the plug-in card as an electronic disk. You save your information even when you unplug the RAM card from the HP 48GX! Each card is powered by its own long-lasting battery.



HP 82215A 128 KB Battery-backed RAM Card, for the HP 48GX.

Includes: 128 KB battery-backed RAM card, CR2016 battery, installation card.

HP 82216A 1 MB Battery-backed RAM Card, for HP 48GX (indep. memory only).

Includes: 1 MB battery backed RAM Card, CR2016 battery, installation card.

Other Accessories

There's also plenty of concise information in book form available for the HP 48G Series calculators—either replacement Owner's Manuals or extended help with programming and other advanced topics.

00048-90136 HP 48G Series Advanced User's Reference Manual

Includes: Programming Techniques; Programming Examples; Comprehensive Command Reference; Equation Reference; Table of System Messages; Table of Units; Table of System Flags and Table of Reserved Variables.

00048-90126 HP 48G Series Replacement Owner's Manual and Quick Start Guide

82221-60001 Soft Case, replacement case for HP 48 Series.

Where to Buy HP Graphic Calculators and Accessories

Distributors

Azerty...check local area listings
Carolina Wholesale...Check local area listings
Commonwealth...Check local area listings
D&H Distributors...800-877-1200
Douglas Stewart Co....800-279-2795
El Dorado Trading Co....800-227-8292
NEAMCO...check local area listings
PRO Distributors...Check local area listings
S.P. Richards...Check local area listings
Taylor...Check local area listings

National Retailers

Best Buy (HP 38G only)...check local area listings
Boise Cascade...check local area listings
CDW Computer...check local area listings
Circuit City...check local area listings
Corporate Express...check local area listings
CostCo...check local area listings
Fry's Electronics...408-487-1000
J&R Computer World...800-221-8180
Nobody Beats the Wiz...800-846-NBTW
Office Depot...800-685-8800
OfficeMax (HP 48G only)...800-788-8080
Service Merchandise...800-251-1212
Staples...800-333-3330
United Stationers...check local area listings
Walmart...check local area listings

Local and Independent Retailers

Alabama	Auburn University Bookstore ...1360 Haley Center...Auburn, AL 36849...334-844-1354 Off Campus College Bookstore ...1020 Henderson Rd....Huntsville, AL 35816...205-837-9529
Alaska	University Supply ...P.O. Box 870291...Tuscaloosa, AL 35487...205-348-6168 Lewis & Lewis Computer Store ...611 Fairbank St....Anchorage, AK 99501...907-277-9432 Alaska Pacific Univ. Bookstore ...4101 Univ. Dr....Anchorage, AK 99608-4625...907-564-8218 University of Alaska ...2905 Providence Dr....Anchorage, AK 99508-4630...907-786-4759
Arizona	University of Alaska ...PO Box 750127...Fairbanks, AK 99775-0001...907-474-7348 Computer Physicians Unlimited ...10211 N. 60th Dr....Glendale, AZ 85302-1255 Arizona State University Bookstore ...Tempe, AZ 86287-0310...602-965-7928 Arizona Bookstore ...815 N. Park Ave....Tucson, AZ 85719...520-622-4717 University of Arizona Bookstore ...850 E. 18th St....Tucson, AZ 85719...520-621-8870

(continued on page 32)

California

ASUC Store...Bancroft at Telegraph...Berkeley, CA 94720...510-642-7010
Associated Students Bookstore...Chico, CA 95929-0001
Off Campus Bookstore...236 A St....Davis, CA 95616...916-758-2665
UC Davis Bookstore...Davis, CA 95616...916-752-5907
Kennel Bookstore...Fresno, CA 93740-0022...209-278-4062
UCI Bookstore...Irvine, CA 92717-1550...714-824-7877
UCSD Bookstore...Mail Code 0008...La Jolla, CA 92093-0008...619-534-7095
Forty Niner Shops, Inc....6049 E. 7th St....Long Beach, CA 90840-0001...562-985-7704
UCLA Student's Store...308 Westwood Blvd....Los Angeles, CA 90024-8311...310-206-0825
University Bookstore...840 Childs Way...Los Angeles, CA 90089-0009...213-740-8993
Matador Bookstore...18111 Nordhoff St....Northridge, CA 91330-0001
Titan Shops...2875 Orange-Olive Rd....Orange, CA 92665
Bronco Bookstore...CA St Ply U Building 66...Pomona, CA 91768-2557...909-869-3274
Golden State Business Systems...1787 Tribute Rd., Suite E...Sacramento, CA 95815...916-922-9221
Hornet Bookstore...6000 J St....Sacramento, CA 95819-2605...916-278-7297
Adams Office Supply...3038 University Ave....San Diego, CA 92104-3072...619-295-4131
Aztec Shops Ltd....San Diego, CA 92182-1701...619-594-7508
USD Bookstore...5998 Alcala Park...San Diego, CA 92110...619-260-4551
Franciscan Bookstore...1650 Holloway Ave....San Francisco, CA 94132-1781...415-338-7369
Spartan Bookstore...San Jose, CA 95112...408-924-1817
El Corral Bookstore...San Luis Obispo, CA 93407...805-756-1101
UCSB Bookstore...University Center...Santa Barbara, CA 93107-3400...805-893-8579
Stanford Bookstore...Stanford, CA 94305-3079...800-533-2670

Colorado

Mawson Computer...3343 Industrial Dr., Ste. 1...Santa Rosa, CA 95403...707-528-2841
University Book Center...Campus Box 36...Boulder, CO 80309...303-492-6411
Cadet Bookstore...Bldg. 2360, Vandenburg Hall...USAF Academy, CO 80841...719-472-6268

District of Columbia

Follett's CSM Bookstore...Ben Parker Student Ctr....Golden, CO 80401-1887...303-273-3113

Florida

Follett's GWU Bookstore...2110 "I" St., N.W....Washington D.C 20052-0001...202-994-6870
University of Miami Bookstore...University Center...Coral Gables, FL 33124...305-284-3592
ERAU Bookstore...Embry-Riddle Aeronautical Univ....Daytona Beach, FL 32114...904-226-6062
Florida Bookstore & Computer Ctr....1614 W. Univ. Ave....Gainesville, FL 32604...904-376-5606
Mr. Data...3206 S.W. 35th Blvd....Gainesville, FL 32608...904-335-9616
University Book & Supply...1227 W. University Ave....Gainesville, FL 32601...904-377-1788
University of Florida Bookstore...Stadium Rd.-Hub...Gainesville, FL 32611-2011...904-392-0194
International Calculator...2916 Corrine Dr....Orlando, FL 32803...407-898-0081
Univ. of Cent. Florida Comp. Store...4000 C. Florida Blvd....Orlando, FL 32816...407-823-0145
University Bookstore...P.O. Box 25001...Orlando, FL 32816-0444...407-823-3028
Mayes Printing & Office Supply...6120 Pensacola Blvd....Pensacola, FL 32589...904-477-1111
Florida State Univ. Store...New Union Bldg. #0127...Tallahassee, FL 32306...904-644-2072
Univ. of South Florida Bookstore...4202 Fowler Ave....Tampa, FL 33620-6550...813-974-0523

Georgia

Allen Precision Equipment...3427 Oakcliff Rd....Atlanta, GA 30340...800-241-6223
Engineers Bookstore...748 Marietta St., N.W....Atlanta, GA 30318...404-221-1669
Georgia Tech Bookstore...Atlanta, GA 30332-0001...404-894-2513
Allen Precision Equipment, Inc....1550 Boggs Rd....Duluth, GA 30136...770-458-8885
Southern Tech Bookstore...Marietta, GA 30060-2896...770-528-7355

**Hawaii
Idaho**

A. Baldwin Ag. College Bookstore...2802 Moore Hwy....Tifton, GA 31793-0016...912-386-3226
Univ. of Hawaii Bookstore...2465 Campus Rd....Honolulu, HI 96822-2216...808-956-6612
Oregon Digital...5511 Kendall St....Boise, ID 83706...208-377-1521
University of Idaho Bookstore...Moscow, ID 83843...208-885-6469
Ricks College Bookstore...Manwaring Center 116...Rexburg, ID 83460-2211...208-356-2211

Illinois	Illini Union Bookstore ...715 S. Wright St....Champaign, IL 61820...217-333-2050
	Follett College Store ...627 S. Wright St....Champaign, IL 61820-5709...217-356-1368
	TIS Bookstore ...707 South 6th St....Champaign, IL 61820-5716...217-337-4900
	Follett's Commons ...3200 S. Wabash Ave....Chicago 60616-3821...312-791-0770
	Student Book Exchange, Inc. ...1737 Sherman Ave....Evanston, IL 60201-3712...847-328-2717
	The Alamo II ...319 North St....Normal, IL 61761-8100...309-452-7400
	Book Center in the Illini Union ...Urbana, IL 61801-2917...217-244-3743
Indiana	The Write Stuff, Inc. ...1 S. 781 Country Club...Wheaton, IL 60564-5646...708-871-8545
	Purdue Bookstore ...Library Building...Hammond, IN 46323-2051...219-844-1081
	Follett's Purdue West ...1400 W. State St....West Lafayette, IN 47906-3405...765-743-9642
Iowa	University Book Store ...360 State St....West Lafayette, IN 47906...765-743-9618
	Campus Bookstore ...2300 Lincoln Way...Ames, IA 50010...515-292-1616
Kansas	Iowa Book & Supply Co. ...Box 2030...Iowa City, IA 52240-3912...319-337-4188
	University Bookstore ...Iowa Memorial Union...Iowa City, IA 52242...319-335-3179
	Kansas Union Bookstore ...Jayhawk Blvd....Lawrence, KS 66045-0501...913-864-4640
	University Book Shop ...1116 W. 23rd St....Lawrence, KS 66045...913-749-5209
Kentucky	K-State Union Bookstore ...Manhattan, KS 66506-2809...913-532-6583
	University Book Store ...623 N. Manhattan...Manhattan, KS 66502-5333...913-539-0511
	University Book Store ...106 Student Center...Lexington, KY 40506-0001...606-257-6304
	Louisiana State Univ. Bookstore ...110 Union Bldg....Baton Rouge, LA 70893...504-388-5137
Louisiana	University Bookstore ...P.O. Box 41209 USL...Lafayette, LA 70504-1209...318-482-6922
	Computer Store of Louisiana ...1440 Canal Street...New Orleans, LA 70112...504-486-9055
Maine	Maine Surveyors Supply ...28 U.S. Route 1...Yarmouth, ME 04096...207-846-5143
Maryland	U.S. Naval Academy Store ...101 Wilson Rd....Annapolis, MD 21402-5081
Massachusetts	Maryland Book Exchange ...4500 College Ave....College Park, MD 27040-3326...301-927-2510
	The University Shop ...Campus Center...Amherst, MA 01003-0146...413-545-2619
	Boston University Bookstore ...660 Beacon St....Boston, MA 02215...617-267-8484
	Campus Camera & Video ...660 Beacon St....Boston, MA 02215...617-236-7476
	Harvard Coop ...1400 Mass. Ave....Cambridge, MA 02238...617-499-2000
	MIT Comp. Connection ...84 Mass. Ave., Rm. W20-021...Cambridge, MA 02139...617-253-7241
	Central Street Assoc., Inc. ...18 Kenneth Terr....Stoneham, MA 02180...781-438-8622
	Worcester Polytechnic Institute ...Daniel Hall...Worcester, MA 01609...508-831-5247
	Ulrich's ...549 E. University Ave....Ann Arbor, MI 48104...313-662-3201
	Lundberg Bookstore ...Rankin Ctr....805 Campus Dr....Big Rapids, MI 49307...616-592-2607
Michigan	Instrument Sales & Service ...24037 Acacia...Bretford, MI 48239...313-535-5252
	Gibson's Tech. Bookstore ...128 W. Grand River Ave....East Lansing, MI 48823...517-332-8681
	MSU Bookstore ...East Lansing, MI 48824-1035...517-355-3450
	Mott College Store ...1401 E. Court St....Flint, MI 48502...810-762-0232
	Michigan Surveyors Supply ...4655 Willoughby...Holt, MI 48842-2162...517-694-4600
	Michigan Tech Bookstore ...1503 College Ave....Houghton, MI 49931-1295...906-487-2410
	Western Michigan University ...Bernhard Center...Kalamazoo, MI 49008...616-387-3930
	SSI Solutions, Inc. ...Westland, MI 48185
	Univ. Ctr. Bookstore ...175 Kirby Student Ctr....10 Univ. Dr....Duluth, MN 55812...218-726-7286
	Harold Smith Bookstore ...259 19th Ave., S....Minneapolis, MN 55455...612-626-0522
Minnesota	Office Products of Minnesota ...7794 Bush Lake Rd....Minneapolis, MN 55439...612-835-6776
	Univ. of Minn. Bookstore ...231 Pillsbury Dr., S.E....Minneapolis, MN 55455...612-626-1782
Mississippi	Miss. State Univ. Bookstore ...Colvard Student Union...Miss. State, MS 39762-5568...601-325-1576
Missouri	University Bookstore ...Brady Commons...Columbia, MO 65201...573-882-7611
	Rolla Bookstore ...788 University Center, W....Rolla, MO 65401...314-341-4705
	Washington University Bookstore ...One Brookings Dr....St. Louis, MO 63130...314-935-5500
Montana	University Store ...University Union 128...Warrensburg, MO 64093...816-543-4801
	MSU Bookstore ...185 Student Union...Bozeman, MT 59717-0020...406-994-5836
Nebraska	Montana Tech Bookstore ...W. Park St....Butte, MT 59701...406-496-4190
	CRC Computer Store ...501 N. 10th St., Rm. 123...Lincoln, NE 68588-0200...402-472-8444
Nevada	Nebraska Bookstore ...1300 Q St....Lincoln, NE 68508...402-476-0111
	A.S.U.N. Bookstore ...Reno, NV 89507-8049...702-784-6597

(continued on page 34)

New Hampshire	Dartmouth College... 33 South Maine St....Dartmouth, NH 03755...603-643-3616
	Campus Store... Castle Point Station...Hoboken, NJ 07030...201-420-5101
New Jersey	New Jersey Inst. of Technology... 150 Bleeker St....Newark, NJ 07103-3902...973-596-3200
	Princeton University Store... 36 University Place...Princeton, NJ 08540-5116...609-921-8500
New Mexico	Holman's Inc.... 420 Wisconsin St., N.E....Albuquerque, NM 87123...505-343-0007
	Univ. of New Mexico Bookstore... Main Campus...Albuquerque, NM 87131-0001...505-277-6364
New York	New Mexico State Univ. Bookstore... Corbett Center...Las Cruces, NM 88001...505-646-4431
	Follett's University Bookstore... 200 Lee Entrance...Buffalo, NY 14260-0001...716-645-3131
	Collegetown of Ithaca, Inc.... 111 N. Aurora Street...Ithaca, NY 14850-4301...607-272-4477
	47th Street Photo... New York, NY ...212-921-1287
	Columbia University Bookstore... 2926 Broadway...New York, NY 10027-7088...212-854-4131
	New York Inst. of Tech. Bookstr... Student Lecture Ctr....Old Westbury, NY 11568...516-686-7584
	BASIX... Stony Brook Union, Rm. 046...Stony Brook, NY 11794-0001...516-632-9281
	Orange Student Bookstore... Marshall Square Mall...Syracuse, NY 13210-1731...315-478-6821
	Syracuse Univ. Bookstore... 303 University Pl....Syracuse, NY 13244-0001...315-443-1647
	ITS Product Center... Rensselaer Polytechnic Institute...Troy, NY 12180-3590...518-276-8164
North Carolina	Rensselaer Union Bookstore... Sage & 15th St....Troy, NY 12181...518-276-4021
	Surveyors Supply Co.... 1511 N. Salem St....Apex, NC 27502...919-362-7000
	Southern Photo & Supply... 734 Chapel Hill Rd....Burlington, NC 27215...910-227-3477
	Duke University Stores... PO Box 90850...Durham, NC 27708...919-684-2344
	Southern Photo & Supply... 314 E. Russell St....Fayetteville, NC 28301...919-483-4909
	NC A&T Bookstore... Brown Hall...Greensboro, NC 27411-0001...910-334-7593
	Southern Photo & Supply... 340 N. Wrenn St....High Point, NC 27260...919-882-3127
	Addam's Univ. Bookstore... 2109 Avent Ferry Rd....Raleigh, NC 27606-2137...919-832-9938
	DJ's Textbooks... 2416 Hillsborough St....Raleigh, NC 27607-7248...919-787-3512
	NCSU Bookstore... Dunn Ave....Raleigh, NC 27695-0001...919-515-2161
North Dakota	Varsity Mart... PO Box 5476...Fargo, ND 58105-7761
Ohio	Univ. of N. Dakota... Univ. Station, Campus Dr....Grand Forks, ND 58202...701-777-2681
	Safe Technologies Corp.... 4131 State Park Dr....Akron, OH 44319...800-638-9121
	College Book Store... 50 S. Court St....Athens, OH 45701...614-594-3505
	Univ. of Cincinnati Bkstr... 123 W. Univ. Ave., ML 217...Cincinnati, OH 45221-0001...513-556-1900
	Long's College Book Co... 1836 N. High St....Columbus, OH 43201-1146...614-294-4674
	Ohio State Univ. Bookstore... 2009 Millikin Rd....Columbus, OH 43210...614-292-2991
	Case Western Reserve University... 11111 Euclid Ave...Cleveland, OH 44106...216-368-2650
	University Bookstore... Thwing Center...Cleveland, OH 44106-1715...216-368-2650
Oklahoma	OU Computer Store... Norman, OK 73019...405-325-1925
	Union Bookstore... 900 Asp...Norman, OK 73019-0001...405-325-2171
	Applied Computer Systems... 2726 Classen...Oklahoma City, OK 73106...405-524-6852
	Cowboy Books, Ltd.... 109 N. Knoblock...Stillwater, OK 74074...405-743-1383
	Smith's Bookstore... 301 S. Washington...Stillwater, OK 74074-3332
	Copier and Computer Systems... 6136 E St....Tulsa, OK 74135...918-622-0612
Oregon	Calculating Edge... 899 N.W. Grant Ave....Corvallis, OR 97330...800-677-7001
	Corvallis System Sales Corp... 800 N.W. Starker, Ste. 35...Corvallis, OR 97330...541-752-4419
	OSU Bookstore... 2301 S.W. Jefferson...Corvallis, OR 97331...541-737-4323
	University of Oregon Bookstore... 895 E. 19th Ave...Eugene, OR 97401...541-346-4331
	Paper Owl Bookstore... 3201 Campus Dr....Klamath Falls, OR 97601...541-885-1050
	Portland Comm. Coll. Bookstore... 1200 S.W. 49th Ave...Portland, OR 97219...503-977-4910
	Power Source – PSU Bookstore... 626 S.W. College...Portland, OR 97201...503-295-1130
	Chemeketa Comm. College Bookstore... P.O. Box 14007...Salem, OR 97309-7070...503-399-5131
Pennsylvania	Lehigh Univ. Bookstore... Maginnes Hall, Bldg. 9...Bethlehem, PA 18015-3073...610-758-3376
	Drexel University Store... 33rd & Chestnut St....Philadelphia, PA 19104...215-895-2855
	Temple Univ. Bookstore... 13th & Montgomery Ave....Philadelphia, PA 19122...215-204-7385
	Univ. of Penn. Bookstore... 3729 Locust Walk...Philadelphia, PA 19104-3610...215-898-7595
	Carnegie Mellon Univ. Bookstr... Baker Hall, Schenley Pk....Pittsburgh, PA 15213...412-268-2966
	Penn State Bookstore... Bookstore Bldg...University City, PA 16802...814-863-3250

Puerto Rico	Relojes y Calculadoras...Mayaguez Mall...Manaquar, PR 00680...787-834-5559
Rhode Island	HP Only...Binero Avenue #1031...Puerto Nuevo, PR 00920...787-793-8033
South Carolina	Brown University Bookstore...71244 Thayer St....Providence, RI 02912-0001...401-863-3216
	J & J Electric...384-7 College Ave....Clemson, SC 29631...864-654-3663
	Clemson Bookstore...P.O. Box 2096...Clemson, SC 29632-2096...864-656-2050
	Student Off-Campus Bookstore...359 College Ave....Clemson, SC 29633...864-654-3000
	Carolina's...629B Main...Columbia, SC 29201...803-799-7406
	Follett's Addam's Univ. Bkstr...601 Main St....Columbia, SC 29201-4058...803-256-6666
	Follett's Univ. Bookstore...The Russel House...Columbia, SC 29208-0001...803-777-4160
South Dakota	Tech Bookstore...501 E St....Rapid City, SD 57701...605-871-1984
Tennessee	University Center Bookstore...Box 5075...Cookville, TN 38505...931-372-3226
	Surveyors Module, Inc....412 Payne Ridge Rd....Church Hill, TN 37642...423-357-8931
Texas	Univ. Book & Supply...U.T. Center, Rm. 147...Knoxville, TN 37916-4800...423-974-1040
	University Cooperative Society...2246 Guadalupe...Austin, TX 78705...512-476-7211
	Professional Computing...505 Church St....College Station, TX 77640...409-846-5332
	U Bookstores & Aggie...700 University Dr., E....College Station, TX 77840...409-846-4818
	CompuCom Systems, Inc....9333 Forest Ln....Dallas, TX 75243...972-783-1252
	Holman's...5776 N. Mesa...El Paso, TX 79936
	Century Business Equipment...6810 Larkwood...Houston, TX 77074...713-777-2673
	Rice Campus Store...6100 S. Main St....Houston, TX 77005...713-527-4052
	Executive World...3312 Santa Ursula Ave....Laredo, TX 78040...956-722-6385
	Palmtop Connection...6814 Leyland...San Antonio, TX 78239...210-590-7444
Utah	Utah State University Bookstore...Logan, UT 84322...801-797-1667
	Weber State University Bookstore...Ogden, UT 84408-2103...801-626-6352
	BYU Bookstore...Provo, UT 84602...801-378-6808
	University Bookstore...Salt Lake City, UT 84112...801-581-3582
	R H Enterprises, Inc....3601 S. 2700 W....West Valley City, UT 84119...801-576-8301
Virginia	Tech Bookstore...118 S. Maine St....Blacksburg, VA 24060...703-552-6444
	Southern Photo & Supply...3813 Old Forest Rd....Lynchburg, VA 24502...804-385-6060
Washington	Student Book Corp....N.E. 700 Thatuna...Pullman, WA 99163...509-332-2537
	Univ. of Washington Bookstore...4326 University Way, N.E....Seattle, WA 98105...206-634-3400
	Pacific Lutheran Bookstore...Tacoma, WA 98447...253-535-7665
Wisconsin	Weiherts Business Machines...18050 Continental Dr....Brookfield, WI 53045-1203...414-782-0909
	Your One-Stop Palmtop Shop...170 S. Jackson St....Janesville, WI 53545...800-709-9494
	University Bookstore...711 State St....Madison, WI 53703...608-257-3784
	Ace Electronics...1540 N. 68th St....Milwaukee, WI 53213-2806...414-771-8484
	B J TV Service...3429 S. 13th St....Milwaukee, WI 53215-5011...414-643-8555
	Blue & Koepsell, Inc....739 N. Mayfair Rd....Milwaukee, WI 53226-4281...414-476-5041
	The H. H. West Co....P.O. Box 1570...Milwaukee, WI 53233-1570...414-344-1000
	Tele-Port, Inc....7120 W. Good Hope Rd....Milwaukee, WI 53223-4611...414-358-1923
	University of Wisconsin Bookstore...Milwaukee, WI
	University Bookstore...Student Center...Platteville, WI 53818...608-342-1486
Alberta	Univ. of Calgary Bookstore...2500 University Dr., N.W....Calgary T2N 1N4...403-220-4765
British Columbia	Trentech Office Products...2828 18th St., N.E., #3...Calgary T2E 7B1...403-250-9267
	UBC Bookstore...6200 University Blvd....Vancouver V6T 1Z4...604-822-2665
	Cariboo College Bookstore...900 College Dr....Kamloops V2C 5N3...250-828-5141
Nova Scotia	St. Francis Xavier University Bookstore...Antigonich B2G 1C0...902-867-2450
	Bookstore – Tech. Univ. of Nova Scotia...P.O. Box 1000...Halifax B3J 2X4...902-420-7707
Ontario	McMaster University Bookstore...1280 Main St., W....Hamilton L8S 4L8...905-525-9140
	Queens Univ. Campus Bookstore...Queens Univ. Grounds...Kingston K7L 3N6...613-545-2955
	Downtown Electronics...356 Yonge Street...Toronto M5B 1S5
	University of Waterloo Bookstore...200 University Ave., W....Waterloo N2L 3G1
Quebec	COOP Concordia...1455 de Maisonneuve, O....Montreal H3G 1M8...514-848-3615
Saskatchewan	University of Saskatchewan Bookstore...Marquis Hall...Saskatoon S7N 0W0...306-966-4468

Frequently Asked Questions

About the HP 48G Series

Why does my HP 48 flash when I turn it on, or pause momentarily during a calculation?

This is normal. The pauses are to “tidy up” memory (needed more often as more memory is used).

What does the  annunciator indicate?

It signals either a low battery or past-due alarm. To find out, turn the machine off, then on.

How can I find out if the calculator is malfunctioning or if I’m doing something incorrectly?

See page A-9 of your User’s Guide, “Testing Calculator Operation.”

How do I determine how much free memory my calculator currently has?

To find out, press  **MEMORY** .

How do I change the format or number of decimal places displayed by the calculator?

Use  **MODES** or  **MODES** . See page 4-2 of your User’s Guide.

What does an **E in a number mean?**

It’s scientific notation (e.g. $6.02E23 = 6.02 \times 10^{23}$).

I lost/broke my calculator’s battery door, port cover, or rubber foot. How do I get a new one?

Call Calculating Edge at 888-338-2252.

What replacement batteries should I get for my calculator?

Use three size AAA, all of the same brand. Note that NiCad batteries are not recommended, due to their low capacity and short warning time. See also page A-5 of your User’s Guide.

How do I adjust the display to be easier to read?

While holding the **ON** key down, press  or  repeatedly.

My calculator is “locking” up or behaving strangely. How can I check and/or correct this?

See “Special Memory Operations” on page 5-16 of the User’s Guide.

Why can't I find the variable(s) I stored?

You're now in a different directory than where you stored the variable(s).

Why am I getting wrong results with trig functions?

Check the angle mode. If you see the annunciator **RAD** or **GRAD**, the machine isn't using degrees. Use \leftarrow **RAD** or the \rightarrow **MODES** menu to adjust accordingly.

Why don't I get 0 when I take the sine of pi?

If you get 'SIN(π)', the calculator is in Symbolic Results mode (i.e. Flag -3 is clear) but not in **RAD**ians mode. Set **RAD**ians mode (via \leftarrow **RAD**), then use either \leftarrow **NUM** or **EVAL**. **EVAL** will return the trig identity, 0, if Flag -2 (Symbolic Constants) is also clear. Otherwise, **EVAL** behaves like \leftarrow **NUM**, which never returns 0, because it does its calculation on a 12-digit approximation of π , 3.14159265359. (No machine uses a numerically exact value of π ; it has an infinite number of digits.) And the sine of 3.14159265359 radians is simply not zero. For similar reasons, pressing $2 \sqrt{x} \leftarrow x^2$ on the HP 48 doesn't return 2.

Why am I getting an Undefined Name error when integrating or differentiating?

The machine is in Numeric Results mode (Flag -3 is set) but is encountering symbolic arguments. Either change the flag or numerically define the arguments.

Why do I get a complex number when I evaluate '(-1)^(2/3)'?

The machine returns a complex principal solution for expressions with fractional exponents. To get a real-valued result to the above, use 'XROOT(3, (-1)^2)' (or its keyboard equivalent: $1 \div \leftarrow x^2 3 \rightarrow x^y$).

Why do I get error messages such as Too Few Arguments or Bad Argument Type?

The command you attempted needs more or different-type arguments than what it currently finds on the stack. (See also Appendix B in your User's Guide.)

How do I turn off the HALT annunciator?

Use **KILL**: **PRG** **NXT** **HALT** **HALT**.

My machine seems to gradually slow down. Why?

It may need to clean up fragmented sections of memory. To do a cleanup, while holding down **ON**, press and release **C**. (This clears both the stack and **PICT**.)

Why am I getting mixed units in the Equation Library Solver even after I have specified ENG or SI?

The Solver creates only variables not already present in the current directory; the already-present variables may have unintended units. For unit consistency, first select your desired equation category in the Equation Library, press **W3** **NXT** **PURE**, then select your units.

Frequently Asked Questions About the HP 38G

What calculus can I do with the HP 38G?

Some instructors have already written calculus ApLets, but even without ApLets, the HP 38G can help you study derivatives and integrals numerically and Taylor polynomials either numerically or symbolically.



Where can I find examples and information about writing my own ApLets?

Go to http://www.hp.com/calculators/products/hp38g_aplets.html.






Does the HP 38G handle any symbolic algebra?

The HP 38G is more limited in this area than the HP 48G/GX, but it offers symbolic features such as POLYFORM, which expands and simplifies polynomial expressions.

How can I trace along the FIT that I determine when working with a scatter plot?

First, set up the Statistics and Function ApLets identically. Next, draw the scatter plot and store $PREDY(X)$ into $F1(X)$. Check only $F1(X)$ in **FUNCTION SYMBOLIC VIEW** ( with $F1(X)$ highlighted to see the fit), and then choose **Overlay Plot** via  **VIEWS**.

How do I print the current display of the HP 38G on my infrared printer?

When viewing the display, hold down  and press . Align the printer's input port with the triangle atop the HP 38G—within 18". Press  and type **PRVAR**  .

How do I get ApLets from the HP ApLets Library?

Go to http://www.hp.com/calculators/products/hp38g_aplets_lib.html on the Internet, then select HP 38G ApLets Library and then your desired topics/ApLets.

ApLets in the HP Library are compressed with **pkzip**, so after downloading, “unzip” the package. The files inside include a Word 6.0 file, a text file, and files tagged with **.000** (e.g. **HP38DIR.000** and **HP38DIR.CUR**). (Note that all ApLet packages contain the **HP38DIR.000** file, so be careful not to overwrite this file by unzipping or copying other packages of ApLets into the same directory or folder.)

How to Contact HP

Why

- If your calculator needs repair.
- If you don't understand something in the manuals.
- If you want to locate an HP retailer near you.
- If you want to learn more about HP products.

Where

- **Phone:** North American technical support: **970-392-1001**
Pre-sales product/dealer information: **800-752-0900**
- **Internet:** **www.hp.com/calculators**

When

- **Phone:** 8 am - 5 pm Pacific Time
- **Internet:** Anytime!

Educators! Keep in mind the
HP Educators Program at:
The Math Learning Center (MLC)
P.O. Box 3226
Salem, OR 97302-0226
Phone: **800-750-8130** (8-5 PT M-F)
Fax: 503-370-7961
E-mail: hp@bbs.mlc.pdx.edu

Your Turn

Re-Sounding Thanks

“We’ve been using the HP 48G Series in calculus classes for five years and every year we find new ways of exploration in mathematics and physics.

“This past year my class was really interested in the sound capabilities. And just like magic—the April edition of **hp^c** gave us some good ideas.... These seem to catch the eyes (and ears) of our underclassmen, and we’ll use anything to encourage further studies in mathematics and science. Thanks for anything you can give us.... Keep up the excellent work! And keep sending your newsletters—they’re great.”

– Mrs. Beverly A. Gravelle, Mathematics Chair
Georgetown High School, Georgetown, MA

Feedback on the New **hp^c**

“Hard to read...the font was small, overly thick, not easy on the eyes.... The layout was not inviting—the middle of the front page (cover) was empty—that’s where you look first. Pictures, representational graphics would have added interest...”

– Comments from teachers at A.C. Flora High
School, Columbia, SC

[Editor’s note: Hopefully we’ve addressed most of these stylistic and readability concerns this issue. But, as always, don’t hesitate to speak up on any point—style or content. Let us hear from you!]

Send all opinions and letters to the editor regarding **hp^c** to:

Grapevine Publications, Inc.
Attention: Chris Coffin
P.O. Box 2449
Corvallis, OR 97339-2449

To submit articles to **hp^c**, contact Dianne Hart at 541-737-5177 or dkhart@math.orst.edu.

hp^c is available as a free subscription, mailed to your home or school. To subscribe (or change your address), contact the **MLC** (see previous page) or use the tear-out response card here. --->