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» [HP Mobile Calculating Lab for Middle Grades Science](#)

The powerful, easy to use HP Mobile Calculating Lab makes learning exciting by bringing students into the real world and out of the classroom through real time observations and concepts relevant to everyday life.

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Your articles



» [HP CAS part 2](#)

Use the power of the 40gs to discover some interesting numeric and algebraic concepts using CAS and the linear solver aplet.



» [How to find the speed of sound](#)

How fast is sound? Using a few objects and your handy HP 39gs calculator you can figure out just how fast it can be.



» [RPN Tip #9](#)

This month's RPN tip teaches you to solve the Quadratic Equation. You'll find many exercises that look difficult, but are made oh-so-easy with your HP calculator.

Upcoming HP Calculator events

CCIM	October 17-18
National Middle School Association (NMSA)	October 30 – November 1
California Mathematics Council South	November 7-8
NAR	November 7-10

Volume 9 October 2008

Welcome to the ninth edition of the HP Solve newsletter. Learn calculation concepts, get advice to help you succeed in the office or the classroom, and be the first to find out about new HP calculating solutions and special offers.

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Featured Calculator



» [Feature Calculator of the Month: HP Quick Calc](#)

HP Quick Calc is October's calculator of the month. You can attach it to your keys or stick it to metal surfaces like lockers, file cabinets or refrigerators for quick and convenient calculations anywhere!

[Learn more »](#)

HP Calculator Blog

Check out Wing Kin Cheung's blog, "The Calculating World with Wing and You."

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HP Mobile Calculating Lab for Middle Grades Science

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The powerful, easy to use HP Mobile Calculating Lab makes learning exciting by bringing students into the real world and out of the classroom through real time observations and concepts relevant to everyday life. The HP Mobile Calculating Lab provides a solution for teachers and students to stream data and collect data for analysis. The solution is simple! All you need is an HP 39gs or 40gs, a StreamSmart 400 and a probe that suits your experiment. There is virtually no setup and the students can collect data with ease. With no setup the students have more time to experiment and collect data.

HP has taken classroom experiments to a new level with the addition of the StreamSmart by allowing you to stream data at real time. Unlike the competitors which have data loggers, the Stream Smart 400 streams data which allows for a faster and more accurate data set. With up to 5,700 samples collected per second and 4 ports the StreamSmart makes data interactive with real-time data capture. Students can pan, zoom in and capture data sets as they happen. The StreamSmart only needs an HP 40gs or an HP 39gs Graphing Calculator to collect data; this sets the experiments in motion. Students are not confined to the classroom because the solution is lightweight and mobile unlike competitor's products which require a laptop to collect data.

Our first solution to launch offers Middle Grade Science educators a comprehensive solution for their classroom. HP has partnered with Fourier to produce a solution useable in all classrooms. Students are able to connect math and science lessons and are able pan, zoom and review datasets as then happen.

The Middle School Science Starter Solution Kit includes:

- StreamSmart 400
- 39gs Graphing Calculator
- Middle School Specific Curriculum Pack
- Distance Probe
- Microphone Probe
- 2 Temperature Probes
- Light Probe
- Voltage Probe
- pH Electrode Sensor and Adaptor Probe
- 4 8-pin mini-DIN cables
- Carrying Case

To access more information about the HP MCL and probes from Fourier Systems, visit www.hp.com/go/MCL and www.fourier-sys.com

Click here for more information about the [HP Calculators](#)

Feature calculator of the month: HP Quick Calc

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The compact, stylish HP Quick Calc is great for quick calculations on the go. It's simple to use and is available in a variety of colors. And so convenient – its unique design is small enough to carry with you on a keychain or lanyard strap, or you can attach it to a metal surface like a locker, file cabinet, or refrigerator. Available in a single or three pack.

Click [here](#) for more information about the HP Quick Calc.

RPN Tip #9

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Solving the Quadratic Equation Problem

Last month the RPN Tip provided the solution of the linear interpolation problem and illustrated the basic RPN problem solving guidelines for optimal problem solving – especially avoiding reentering data.

Developing good RPN problem solving habits will save endless hours of calculation time – until you move up to a graphing calculator. Solving the problem in an organized way so that you only enter the data values once is vital for efficient and accurate work.

A quadratic polynomial is a polynomial of degree 2. A univariate quadratic polynomial has the form $f(x) = a_2X^2 + a_1X + a_0$. An equation involving a quadratic polynomial is called a quadratic equation. A closed-form solution known as the quadratic formula exists, (1), for the solutions of an arbitrary quadratic equation.

The quantity under the radical, $B^2 - 4AC$, is called the discriminate. If A, B, & C are real, the value of the discriminant provides useful information about the roots of the equation. The value of the discriminant may be negative, zero, or positive:

Click [here](#) to learn more about [RPN](#).

HP CAS part 2

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In the last issue we introduced HP CAS on the HP 40gs. Now we will use the power of the 40gs to discover some interesting numeric and algebraic concepts using CAS and the linear solver applet.

See exercise [here](#).

Using the StreamSmart 400 to find the Speed of Sound

[← Previous](#) – [Article](#)

See exercise [here](#).



RPN Tip #9

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<u>Discriminate</u>	<u>Roots</u>
Negative	Imaginary
Zero	Equal
Positive	Real

$$X = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \quad (1)$$

Where: A is the coefficient, a_2 , of X^2
 B is the coefficient, a_1 , of X
 And C is the constant term, a_0 .

Equation (1) may be solved using the 18 RPN stack operation steps shown below. ~ is don't care, ↑ is ENTER.

Solve, find the two roots of, the following quadratic equation. $12X^2 + 36X - 48 = 0$

Step	1	2	3	4	5	6	7	8	9	10
T	~	~	~	~	~	-B=-36	-B=-36	-B=-36	-B=-36	-B=-36
Z	~	~	~	~	-B=-36	B^2	B^2	-B=-36	B^2	-B=-36
Y	~	~	-B=-36	-B=-36	B^2	A=12	A=12	B^2	AC	B^2
X	B=36	-B=-36	-B=-36	B^2	A=12	A=12	C=-48	AC	4	4AC
press	B=36	CHS	↑	X^2	A=12	↑	C=-48	×	4	×

Step	11	12	13	14	15	16
T	-B=-36	-B=-36	-B=-36	-B=-36	-B=-36	-B=-36
Z	-B=-36	-B=-36	-B=-36	-B=-36	$-B \pm \sqrt{B^2 - 4AC}$	$-B \pm \sqrt{B^2 - 4AC}$
Y	-B=-36	-B=-36	-B=-36	$-B \pm \sqrt{B^2 - 4AC}$	A=12	A=12
X	$B^2 - 4AC$	$\sqrt{B^2 - 4AC}$	$-B \pm \sqrt{B^2 - 4AC}$	A=12	A=12	2
press	-	√	+ or -	A=12	↑	2

Step	17	18	Answer
T	-B=-36	-B=-36	
Z	-B=-36	-B=-36	
Y	$-B \pm \sqrt{B^2 - 4AC}$	-B=-36	If step 13 = +, X = 1
X	2A	$\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$	If step 13 = -, X = -4
press	\times	\div	

Equation (1) as solved above does not comply with the basic RPN problem solving guidelines for optimal problem solving. “A” had to be entered twice (steps 5 and 14). The stack diagram nicely illustrates how the method of solution may be altered to eliminate entering data twice.

Equation (1) may be also be solved using the 21 RPN stack operation steps shown below. ~ is don’t care, ↑ is ENTER. This solution does not require any data to be entered more than once. The added keystrokes are justified because reentering data is very error prone and would require many more keystrokes to correct.

Solve, find the two roots of, the following quadratic equation. $12X^2 + 36X - 48 = 0$

Step	1	2	3	4	5	6	7	8	9	10	11
T	~	~	~	~	~	~	~	~	~	2A	2A
Z	~	~	~	~	2A	~	2A	~	2A	C=-48	C=-48
Y	~	A=12	~	2A	A	2A	AC	2A	C=-48	B=36	B=36
X	A=12	A=12	2A	A	C=-48	AC	4	4AC	B=36	B=36	-B=-36
press	A	↑	+	LASTX	C=-48	\times	4	\times	B=36	↑	CHS

Step	12	13	14	15	16	17	18	19
T	-B=-36	-B=-36	-B=-36	-B=-36	-B=-36	-B=-36	2A	2A
Z	2A	2A	2A	-B=-36	-B=-36	-B=-36	-B=-36	2A
Y	4AC	4AC	B ²	2A	2A	$\sqrt{B^2 - 4AC}$	-B=-36	-B=-36
X	B		4AC	B ² -4AC	$\sqrt{B^2 - 4AC}$	2A	$\sqrt{B^2 - 4AC}$	$-B \pm \sqrt{B^2 - 4AC}$
press	R↓	X ²	X↔Y	-	√	X↔Y	R↓	+ or -

Step	20	21	Answer
T	2A	2A	
Z	-B=-36	2A	
Y	$-B \pm \sqrt{B^2 - 4AC}$	-B=-36	If step 19 = +, X = 1
X	2A	$\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$	If step 19 = -, X = -4
press	R↑	\div	

Is this the optimum solution? It is probably is not optimum and a shorter solution is left as an exercise for the reader to reduce the steps required to solve this problem. Using a stack diagram helps visualize where the variables are on the RPN stack.

Here are 15 practice/test problems. #8 was used for the stack diagram examples above.

Table 1 — Quadratic Equation Practice Problems With Solutions

#	Equation	Coefficients A, B, C	Discriminate $B^2 - 4AC$	Category	Roots
1	$x^2 + 4x + 4 = 0$	1, 4, 4	0	Equal	-2, -2
2	$x^2 - 4x + 4 = 0$	1, -4, 4	0	Equal	2, 2
3	$x^2 - 4 = 0$	1, 0, -4	16	Real	2, -2
4	$x^2 + 4 = 0$	1, 0, 4	-16	Imaginary	(0,2), (0,-2)
5	$3x^2 - 3x + \frac{3}{4} = 0$	3, -3, $\frac{3}{4}$	0	Equal	0.5, 0.5
6	$x^2 + 2x + 5 = 0$	1, 2, 5	-16	Imaginary	(-1, 2), (-1,-1)
7	$6x^2 - x - 2 = 0$	6, -1, -2	49	Real	0.6667, -0.5
8	$12x^2 + 36x - 48 = 0$	12, 36, -48	3600	Real	1, -4
9	$x^2 - 2x + 1 = 0$	1, -2, 1	0	Equal	1, 1
10	$x^2 - x - 2 = 0$	1, -1, -2	9	Real	2, -1
11	$x^2 + x + 2 = 0$	1, 1, 2	-7	Imaginary	(-0.5,1.3229), (-0.5,-1.3229)
12	$x^2 + 4x - 5 = 0$	1, 4, -5	36	Real	1, -5
13	$2x^2 - 16x + 36 = 0$	2, -16, 36	-32	Imaginary	(4,1.41421), (4,-1.41421)
14	$x^2 - 14x + 49 = 0$	1, -14, 49	0	Equal	7, 7
15	$x^2 - 30x + 189 = 0$	1, -30, 189	144	Real	21, 9

CAS part 2

In the last issue we introduced HP CAS on the HP 40gs. Now we will use the power of the 40gs to discover some interesting numeric and algebraic concepts using CAS and the linear solver applet.

Exercise 1

Consider the linear equations

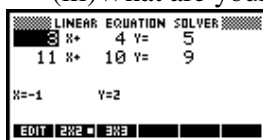
$$3x + 4y = 5 \quad \text{and} \quad 11x + 10y = 9$$

- (i) What do you notice about the coefficients in each equation?
- (ii) Using your knowledge of sequences what type of sequence do the coefficients make?

Using the linear solver applet and setting up a 2 X 2 matrix solve these two equations.



- (iii) What are your solutions?



Now, make another set of equations with the coefficients increasing consecutively in the first and decreasing consecutively in the second.

- (iv) What do you notice about the solutions?
- (v) Does this happen with all equations set up in this fashion?

Let's see.

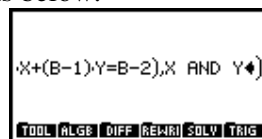
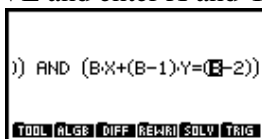
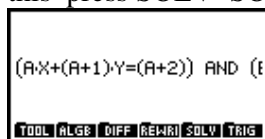
To prove this algebraically we will use CAS.

Press HOME and CAS. In the CAS screen we are going to solve the simultaneous equations $ax + (a+1)y = (a+2)$ and $bx + (b-1)y = (b-2)$

The initial key strokes are ALPHA VARS X $x + ($ ALPHA VARS +1 highlight (A+1) X ALPHA 2 then up arrow to highlight SHIFT . (ALPHA VARS +3.

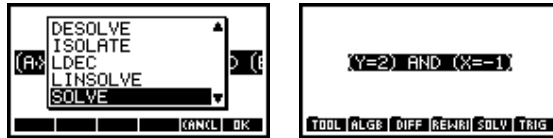
We have entered the first equation this must then be highlighted with the up arrow and press SHIFT (-)

Enter the second equation type The key strokes are ALPHA MATH X $x + ($ ALPHA MATH -1 X ALPHA 2 then up arrow to highlight SHIFT . (ALPHA MATH -3. You must then enter the unknowns that you wish to solve for. To do this press SOLV SOLVE and enter X and Y as below.



We have set up the equations in AP with the first increasing consecutively and the second decreasing consecutively. (Note there are also other algebraic combinations that can be used).

We will now solve these equations in CAS for x and y .



In the CAS screen choose SOLV menu and SOLVE and type x and y (as per the screen shots)

- (vi) What are the solutions?
- (vii) What can you conclude from this?

Extension 1

Consider the equations $2x+8y=14$ and $27x+20y=13$

- (i) Are the coefficients of the first equation ascending by a common difference? If so what is it?
- (ii) Are the coefficients of the second equation descending by a common difference? If so what is it?
- (iii) Use linear solver to find the point of intersection of the two equations.
- (iv) What do you conclude?
- (v) Use CAS to justify your conclusion. Hint use equations $ax+(a+d)y=a+2d$ and $bx+(b-e)y=b-2e$

Exercise 2

Consider the equations $3x+6y=12$ and $7x+21y=63$

- (i) What do you notice about the coefficients in each equation?
- (ii) Using your knowledge of sequences what type of sequence does the coefficients make?

Use the linear solver applet to solve the equations.

- (iii) What are your solutions?
- (iv) Would this be the same for all equations set up in this fashion? Try it with a couple of combinations of numbers.

Exercise 3

Consider the equations $2x+6y=18$ and $4x+8y=16$

- (i) How are these equations similar to the equations in exercise 2?
- (ii) Record the solution when they are solved simultaneously.
- (iii) What do you notice?
- (iv) Prove your findings using CAS. (Hint: set up equations $ax+2ay=4a$ and $bx+3by=9b$)

So, does this work with other GP's. to do this consider the equations

$5x+20y=80$ and $7x+49y=343$. Then the equations $5x+35y=243$ and $x+4y=16$

- (v) What do these equations have in common?
- (vi) Are their solutions consistent?
- (vii) Prove using CAS

Extension 2

If two equations are set up with the coefficients increasing by a common ratio of $r = b$ in the first and $r = d$ in the second. Find the relationship in terms of b and d the point of intersection of the two equations. CAS would be a handy tool to use.

Answer key

Exercise 1

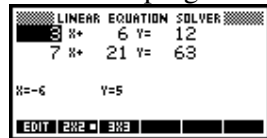
- (i) The coefficients of the first equation increase by consecutive numbers and the coefficients of the second equation decrease numerically.
- (ii) Arithmetic progression.
- (iii) $(-1,2)$
- (iv) Same $(-1,2)$
- (v) Yes
- (vi) When the coefficients of the first equation increase in arithmetic progression and the coefficients of the other equation decrease in arithmetic progression, the point of intersection is $(1,2)$

Extension 1

- (i) Yes $d = 6$
- (ii) Yes $d = -7$
- (iii) $(-1,2)$
- (iv) If one equation increases by a common difference of coefficients and another equation decreases by a common difference of coefficients, the point of intersection of the equations is $(-1,2)$.
- (v) Using the equations in CAS and solving for x and y the solution is $(-1,2)$

Exercise 2

- (vi) Increasing in by factor of 2 in the first and 3 in the second
- (vii) Geometric progression

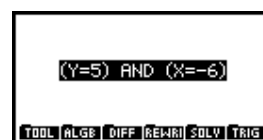
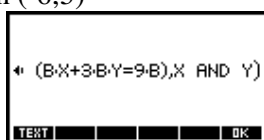
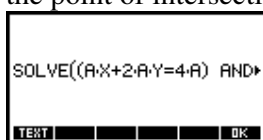


- (viii)

Exercise 3

- (i) They have the same common ratios as the previous equations
- (ii) $(-6,5)$

- (iii) Equations where the coefficients increase in consistent common ratio have the point of intersection $(-6,5)$



- (iv)
(v) Similar common ratios $r = 4$ and $r = 7$
(vi) Yes $(-28,11)$

Extension

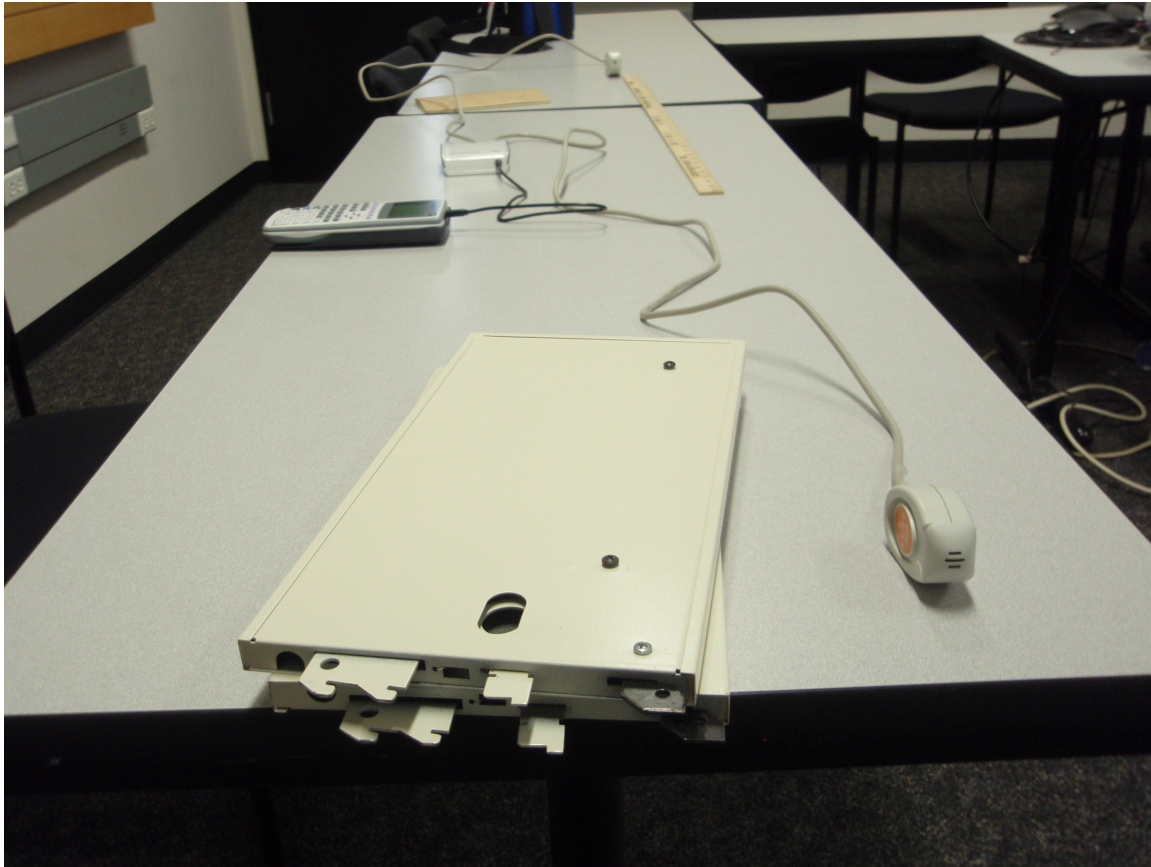
Set the equation up in CAS as $ax+aby=b^2a$ and $cx+dcy=d^2c$ and solve for x and



y. the solution is

How to find the Speed of Sound

Suppose that we wish to estimate the speed of sound by using two microphones set a certain distance apart and then making a loud sound and then looking at how long it took that sound to reach each of the microphones. With the MCL, we were able to place two microphones 6 feet apart, as shown in Figure 1. The StreamSmart 400 is connected to the HP 39gs as shown in the figure. The two metal plates in the foreground were slapped together to make a metal clapping sound. The signals from the microphones are recorded and plotted in real time on the HP 39gs graphing calculator.



Basically, one just starts the MCL. There is no need for any setup. The StreamSmart Aplet on the HP 39gs determines that microphones are attached and sets the width of the display to represent 0.1 seconds. With 131 pixel columns in the display, the result is that the width of each pixel represents just under 0.001 second. With the MCL, there is a real question for the students: Will the MCL be able to distinguish between the two points in time when the microphones register the metal clap?

The procedure is simplicity itself. Press the Start menu key, clap the metal plates together, and then press the Stop menu key. Given the speed of the data streaming in, one has to scroll (Pan) back to the left to “see” the clap in the data stream. Figures 2 and 3 indicate that the clap registered at around $t=0.892$ seconds for the near microphone in Channel 1, while the far microphone in Channel 2 picked it up at around $t=0.898$.

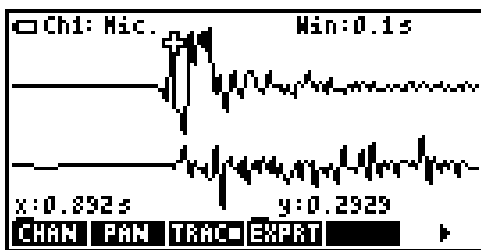


Figure 2

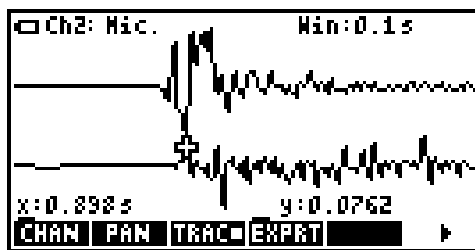


Figure 3

We estimate the speed of sound as $\frac{6}{0.898 - 0.892} = 1,000$ feet per second.

We then exported the data set from $t=0.8827$ to $t=0.9154$ to the Statistics Aplet to refine our estimate. Figure 4 shows the relevant data points. At $t=0.8923$ ($C1(6)$), the first microphone registered its relative maximum ($C2(6)=0.2929$), while at $t=0.8981$ ($C1(9)$), the second microphone registered the same spike ($C3(9)=0.0762$). Now our estimate for

the speed of sound is refined to $\frac{6}{0.8981 - 0.8923} = 1034.5$ feet per second.

n	C1	C2	C3	C4
5	.8904	.1113	.0156	
6	.8923	.2929	.0137	
7	.8942	-.1055	.0273	
8	.8962	-.1328	.0293	
9	.8981	-.2402	.0762	
10	.9	-.0703	.0371	
.9				
EDIT INS SORT BIG 2VAR STATS				

Figure 4

For reference, the speed of sound in dry air at 72° is approximately 1,130 feet per second. This naturally leads to a discussion of the margin for error.

Our estimate of error proceeds as follows. As can be seen from the table in Figure 4, the change in time between consecutive readings is approximately 0.0019 seconds. So the true spike for Microphone 1 could have been anywhere from $t=0.89135$ to $t=0.89325$. Likewise, the corresponding spike at Microphone 2 could have been anywhere from $t=0.89715$ to $t=0.89905$. This indicates an interval with a minimum of

$\frac{6}{0.89905 - 0.89135} = 779$ f/s to a maximum of $\frac{6}{0.89715 - 0.89325} = 1538$ f/s. The reference value of 1,130 f/s is clearly within this interval.

The discussion of error could easily lead the students to discuss ways of improving the estimate. What if pairs of students repeated identical experiments and the results were averaged? What could be done to improve the experiment itself: move the microphones further apart? Notice that the procedures and questions outlined above had little to do with setting up the experiment. This is the case with Data Streaming. Just start

experimenting – the HP MCL takes care of everything! From this example, it is clear that Data Streaming with the HP MCL puts data collection in a whole new light!