Little Red Corvette

By John F. Mahoney

My brother-in-law, Duane, is part owner of a company which writes software for car dealers. Thus it was no surprise that he brought a copy of *Car and Driver* with him when our families went on vacation last summer. I borrowed the copy and turned, not surprisingly, to the review of the '99 Chevrolet Corvette Hardtop. As I turned 50 not too long ago, I keep anticipating what I would do to resolve a mid life crisis — were I to have one. A red Corvette would certainly fit the bill.

Car and Driver includes a significant quantity of numerical information about the cars it reviews. I quickly became immersed in it. For example, the Corvette accelerates very fast. (See *Car and Driver's* test results at bottom.)

I immediately thought about whether I could use my graphing calculator to make some sense out of this data. What is the data telling me in the table? Well, while the data is labeled acceleration, the numbers actually give the time it takes to achieve the specified velocity rather than the actual numerical values of "acceleration." I decided to plot the data using seconds as the horizontal axis and mph as the vertical axis. See Figure 1.

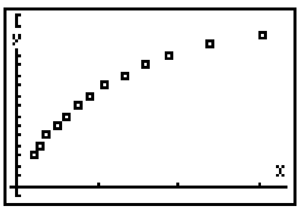

Figure 1

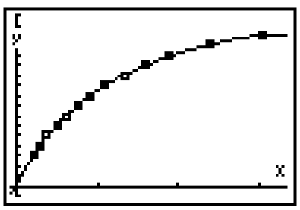

Figure 2

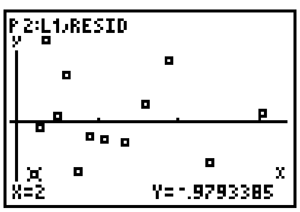

Figure 3

When I tried to fit a quadratic function to the data it seemed to fit fine (r^2=.9936), but the residual graph had a pattern to it which looked cubic. I then fit a quartic function to the data (see Figure 2) and the residual graph showed no apparent pattern (see Figure 3).

Readers who aren't familiar with the TI-83's data handling capabilities and its automatic computation of residuals should read pages 12-2 through 12-9 in the TI-83 Guidebook. It is available on line at: education.ti.com/guides

Obviously though, using a quadratic, cubic, or quartic function to model this data is probably not appropriate, for the Corvette should go faster and faster with time — at least to some extent — and my quartic model gives negative values for t > 50. I then decided to use the maximum speed given in the article: 169 mph, and considered modeling the difference between 169 mph and the above speeds vs. time. The graph of this appeared to be exponential and I found an equation which appeared to model it. The residuals, however, seemed to have somewhat of a pattern to them. How to compare the residuals from the quartic graph and the exponential graph? I decided to consider the sum of the squares of the residuals. I used sum(L_6^2) in order to do this. I didn't expect the results I got. The quartic function fit much better over the domain than the exponential one did.

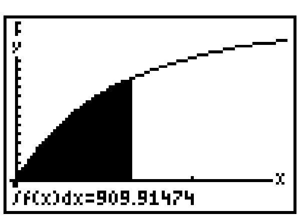

Figure 4

When I tried to verify the fact that the car did a "standing 1/4-mile" in 13.2 seconds finishing at 110 mph, I integrated the quartic model from 0 to 13.2 seconds and got a result of 909.914.

What are the units here? Well, since the vertical axis of the original graph was in mph and the horizontal axis was in seconds, the units of the integral are in $\frac{\text{miles}}{\text{hours}}$ x seconds. Since there are 3,600 seconds in an hour, I needed to divide my answer by 3,600 to get $\frac{909.914}{3,600}$ or just over the 1/4 mile I had expected. The exponential model gave an answer of 922.2692 which is the equivalent of 0.256 miles.

What about braking? Can the car brake faster than it can accelerate? We are told that the car could brake from 70 to 0 mph in 173 feet. According to the original data, the car reaches 70 mph in 5.9 seconds, so when we integrate the velocity model from 0 to 5.9 and make the necessary unit conversions, we find that the car travels 347 feet during that acceleration — so clearly the car can brake much faster than it can accelerate (which is a good safety measure). How much time does it take the car to brake from 70 to 0 mph in 173 feet? Well, let's assume that the deceleration of the car is constant = a. Then integrating a with respect to time we get $v = at + v_0$. Integrating again with respect to time, we get $s = at^2/2 + v_0t + s_0$. We can let $s_0 = 0$. We can use the TI-89 to convert 70 mph to 102.67 ft/sec and set v_0=102.67 (Figure 5). Using these values then we need to find the value of t such that when $v = 0$, s =173 feet. Well, this was an excellent opportunity for me to test my TI-89's algebraic solving system as shown in Figure 5.

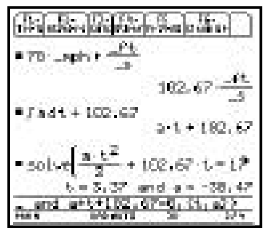

Figure 5

The TI-92 Plus and the TI-89 have the feature of being able to solve simultaneous equations as shown in Figure 5. The full text of the command is:

$$solve\left(\frac{a \cdot t^2}{2} + 102.67 \cdot t = 173 \text{ and } a*t + 102.67 = 0,\{t,a\}\right)$$

Consider asking your students to perform similar computations with some of the other cars *Car and Driver* tested in its September, 1998 issue (**CV**-Corvette, **SZ**-Suzuki Grand Vitara JLX, **GA**-Pontiac Grand Am GT, **TC**-Toyota Camry Solara SE V-6, **OI-**Oldsmobile Intrigue GLS, **IG**-Infiniti G20):

Acceleration: 0 to ?... in seconds

Speed	CV	SZ	GA	TC	OI	IG
30 mph	2.0	2.7	2.6	2.4	2.9	3.9
40 mph	2.8	4.3	3.8	3.7	4.2	5.6
50 mph	3.6	6.4	5.6	5.2	5.8	7.9
60 mph	4.8	9.0	7.7	7.0	7.9	10.9
70 mph	5.9	12.5	10.0	9.4	10.4	14.3
80 mph	7.5	17.0	13.5	12.1	13.4	20.0
90 mph	9.0	24.4	17.9	15.6	17.3	27.9
100 mph	10.9	38.4	23.7	20.9	23.0	39.0
110 mph	13.2	—	31.6	27.4	29.7	48.9
120 mph	15.8	—	43.7	37.5	40.1	—
Top speed	169	107	126	135	126	118
1/4 mile*	13.2/110	17/80	16/86	15.6/90	16.2/87	18.4/77
Stopping**	173	203	179	180	205	182

* "Standing quarter-mile" in seconds/Finishing speed in mph
** Number of feet required to go from 70 to 0 mph.
Figure 5 is the result of cropping, on a word processor, several screen shots from a TI-89. The data from *Car and Driver* is reprinted with permission.