A Function for the Vet

A veterinary clinic called the university with an interesting request. A parasite had infected many horses in the area. The horse's body responded by sealing off the parasite in a tumor that developed on the lining of the stomach. X-rays of a dye injected into the bloodstream could easily determine the location and diameter of the tumor. And the solution to the problem was simple enough - simply drain the tumor. The problem was that the tumor didn't collapse uniformly when drained and vets found it very difficult to determine when the draining was complete. Several horses had to undergo multiple treatments to eliminate all the fluid. This was time consuming and expensive.

The vet said, "We need to know the volume of a tumor when given its diameter. Then we'd know how much fluid to expect and not terminate the procedure too quickly. If the tumor was spherical in shape, we'd be able to compute its volume quite easily, but it's not. Most are more tear-drop shaped."

"Like a child's party balloon?", I asked.

"Exactly!" he responded…

If you have studied section 5.2 of your booklet and have worked other data transformation activities in this course, you have the knowledge to produce a simple function vets can use in this situation. You'll need data. You can use that which I gathered below or follow this procedure to produce your own: First fill a regular tear-drop shaped balloon with a *carefully-measured* amount of water. I chose to start with a half-gallon (64 oz.). With the balloon submerged in water (so that its weight doesn't distort its shape) measure its diameter. Be as accurate as possible. Then remove a carefully-measured amount from the balloon (I chose to remove one cup) and measure the diameter again. Repeat until all the water is removed from the balloon. At each stage of the process, record the data pairs.

Question 1: Which variable, diameter or volume, does the vet want us to call the independent (X) variable? _______________ Why? ______________________________

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We are to predict volume from a linear measure. That prediction can be relatively simple since the balloon remains similar in shape as it deflates.

Question 2: Which of the following functions can serve as possible descriptors of volume? Circle all that apply:

$y = ax+b$ $\quad$ $y = ax^2 + b$ $\quad$ $y = ax^3 + b$ $\quad$ $y = \ln(x)$ $\quad$ $y = ax^3$

[Note to the instructor: We have eliminated some arguably good choices because of the requirement for a simple formula. Class discussion may reveal some better choices if this requirement is removed, but the lesson's "data transformation" objective will be altered.]

Question 3: Explain why you chose the function forms you circled in Question 2:

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Question 4: If you use the form $y = ax^3 + \mathbf{b}$ as your descriptor, what value do you expect for the parameter **b** in your regression? _______ Why? ______________________

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Now, for the sake of uniformity, choose $y = ax^3$ as your model and make the appropriate data transformation to obtain this form from linear regression. Refer to section 5.2 of your booklet if you need to. Record your data here:

Original Data

X								
Y								

Transformed Data

?___								
Y								

You may recall that spreadsheets such as Excel and Quattro Pro allow you to set the constant term (or intercept) to zero in a linear regression. If you do not have such technology, you may compute the parameter a in the model $y = ax$ with your calculator. The parameter a is simply the sum of the products of x and y divided by the sum of the squares of x. (If you have had precalculus, you may recognize this as the dot product of vectors **x** and **y** divided by the square of the length of vector **x**.) In formula,

$$a = \Sigma xy / \Sigma x^2 .$$

The values Σxy and Σx^2 are easily obtained on TI-82/3 calculators as quantities computed when you choose **2-Var Stats** from the **STAT|CALC** menu.

Now use the technology of your choice to produce the vet's function. Write your function here:

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Use your function to answer the following questions:

Question 5: If a vet found a tumor that appeared to be 4.11 inches in diameter, how much fluid should she expect to extract before terminating the procedure?

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Show your work:

Question 6: If a vet extracted 53 ounces of fluid from a tumor, what is the smallest diameter the tumor could be?

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Show your work:

Report assignment: Write a letter to the Raw Hide Veterinary Clinic (a) giving them the function you have constructed, (b) explaining how to use it, (c) explaining why the cubic model was chosen and (d) billing them at a rate of $30 per hour for your time spent in constructing the formula. Attach your letter to this handout.

My data:

Ounces of Water	Diameter in inches
64	5 1/2
56	5 5/16
48	5 1/16
40	4 13/16
32	4 1/2
24	4
16	3 9/16
8	2 5/8

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