Homework Assignment 4: Due at the beginning of class 10/4/02

The specific learning goals of this assignment are for you to:

- Use numerical tests to determine whether data is perfectly exponential or not.
- Create graphs and use them to decide which sort of function would do the best job of representing trends in data.
- Use the regression capability of a graphing calculator to find an equations that represent exponential functions.
- Interpret the influence of contextual factors on the two parameters (initial value and growth factor) that define an exponential function.

Note: To complete Question 4, you will need to read the one-page document posted with this assignment.

The fundamental question addressed in this homework assignment is this: Why are drugs so expensive? Drugs, such as heroin, are simple agricultural products obtained using little or no technology[1] from inexpensive plants. Other substances that fit this description (such as the spices that you buy in the supermarket) are very inexpensive by comparison. One gram of cinnamon costs a few cents when bought in a supermarket, whereas one gram of heroin typically costs several hundred dollars when bought from a street dealer[2].

The most expensive spice in the world is saffron, which is often used in Indian and Middle Eastern cuisine. Table 1[3] gives the price of one kilogram (about 2.2 pounds) of saffron at each of the four stages of production.

Stage of production	Stage of production (independent variable)	Price of one kilogram ($)
Farm gate	1	220
Wholesale, country of origin	2	960
Wholesale, United States	3	4750
Retail, United States	4	12000

Table 1: Price of one kilogram of the expensive agricultural product, saffron.

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[1] Heroin is obtained through a simple, two-step chemical process. The principal ingredients are morphine, acetic anhydride and sodium carbonate. Morphine is extracted from the latex secreted by the seedpod of the opium poppy, *Papaver setigerum*. Full details of the chemical processes for manufacturing heroin are widely available. See, for example: http://www.rhodium.ws/chemistry/opium.html

[2] Source: Office of National drug Control Policy. 2001. *What America's Users Spend on Illegal Drugs*. Washington DC: Executive Office of the President.

[3] The data presented in Table 1 was obtained from the following sources:
- Palmer, J. 1983. Saffron. *Annual Journal of the Royal New Zealand Institute of Horticulture*, 11: 93-97.
- Rees, A. R. 1988. Saffron – an expensive plant product. *Plantsman*, 9(4): 210-217.
- Basker, D. 1993. Saffron, the costliest spice: Drying and quality, supply and price. *Acta Horticulturae* (ISHS), 344: 86-97.

Table 2[4] gives the price of one kilogram of heroin [5] at each of these four stages of production.

Stage of production	Stage of production (independent variable)	Price of one kilogram ($)
Farm gate	1	90
Wholesale, country of origin	2	2870
Wholesale, United States	3	80000
Retail, United States	4	290000

Table 2: Price of one kilogram of heroin.

1. Based on the numbers given in Tables 1 and 2, is price a perfectly exponential function of the stage of production for either saffron or heroin?

NOTE: You should include full details of any calculations that you do as evidence to back up your answer.

2. Using suitably large sets of carefully labeled axes, plot graphs showing price as a function of production stage for saffron and also for heroin. In each case, use the graph to decide which type of function (linear or exponential) would do the best job of representing the trend in the data.

3. Find equations for the functions that you identified in Question 2. (Figure 1 shows the steps involved in using a graphing calculator to find an equation for the exponential function that "best fits" a given data set.)

4. The equations that represent exponential functions are built up using two constants, the *initial value* and the *growth factor*. If the equation is of the form:

$$y = A \cdot B^x$$

where x is the independent variable and y is the dependent variable, then the constant A is the *initial value* and B is the *growth factor*. Read the description of heroin and saffron cultivation techniques posted on the Math Xa web site. Briefly explain (in a few sentences) how the differences in cultivation and harvesting methods are reflected in the two equations that you found in Question 3.

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[4] Source: United Nations Office for Drug Control and Crime Prevention. 1998. *World Drug Report, 1997.* New York: United Nations.

[5] Technically, at the "Farm Gate" stage of production the substance is opium gum (or latex) not heroin.

5. In Question 4, you will have discussed one of the two constants – either the *initial value* or the *growth factor*. Now consider the other constant. Is the value of this number the same for both heroin and saffron? If not, how can you explain the difference? Express your answer in a sentence or two.

NOTE: You might think, when answering Question 5, that the first reason that springs to mind is too obvious. It isn't – but unfortunately this reason is generally overlooked as an explanation for why so many well-meaning regulations and programs fail to reduce the harm that drugs do to society[6].
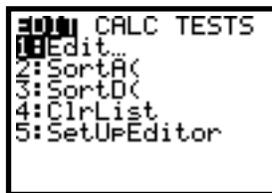

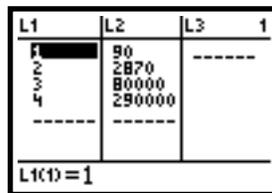Figure 1a: Press the [STAT] button on your calculator and choose "Edit."

Figure 1b: Enter the data provided into lists L1 and L2 on your calculator.

Figure 1c: Press the [STAT] button again. Use the arrow keys to select the CALC menu, and the "ExpReg" capability.

Figure 1d: Press the [ENTER] button on your calculator. The "L1" symbol can be obtained by pressing [2nd] [1], etc.
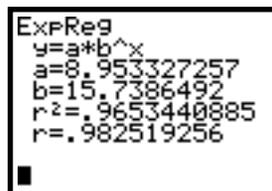
Figure 1e: Press the [ENTER] button again and your screen should display the equation for an exponential function.

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[6] The subtitle of a 2001 article in *The Economist* summarizes the situation: "The risks are high – but so are the rewards." The article, "Big Business" appeared in the July 28, 2001 edition of *The Economist*.