# Medicine Drop

A Use of Quadratic Polynomials - Excel Version

A virus produces a large circular patch on the skin of its victim. Medication to stop its spread is very expensive and has a shelf life of only a few hours. For these reasons, the hospital must special order it in exact quantity for the immediate needs of each victim. The application procedure is as follows: first rub the affected area with petroleum jelly; then apply drops of the medication, using a medicine dropper, until the patch is covered exactly so that no surrounding skin is affected. If too much medication is ordered, money is wasted. If too little is ordered, the uncovered virus continues to spread.

We would like to measure the diameter of the circular patch and use that measurement to compute the exact number of drops of mediation needed. That is, we need a *function* that relates **diameter** (X) to **number of drops** (Y). Since the medication has about the same mass and surface tension characteristics as water, we can simulate the application of the medication by dropping water from a medicine dropper to form an increasingly larger *circular* puddle on a vinyl placemat or similar surface. The diameter of the puddle and the corresponding number of drops needed to form that size puddle give ordered pairs of data from which we can produce the function.

| Diameter of Puddle (X) | Number of Drops (Y) |
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Perform this experiment at least a dozen times with the number of drops increasing from around ten to at least one hundred. For example, if a puddle of diameter 20mm requires 9 drops, you should record (20,9) as one data point. Record your data in the table at right. Using Excel, graph your data on an XY(Scatter) Graph and note the shape. Notice, in particular, that it is not linear. Save and print your graph and spread sheet for inclusion in your report on this project.

Now that you have the data in Excel, let's produce a function to predict number of drops from puddle diameter. Highlight the cell of the spreadsheet just to the right of your first (diameter,#drops) pair. Then enter a formula that will produce the square of the value in the "diameter" cell of that row. Enter it and copy it (the formula) to all cells of that column which correspond to a data pair. Excel should immediately respond by placing the square of each diameter value in the corresponding cell of that row. Now you are ready to compute the function that predicts the number of drops from the diameter measurement.

From the Tools menu, select Data Analysis, Regression[1]. In the Independent variable box

1 If Data Analysis does not appear at the bottom of your Tools menu, go to Tools|Add-Ins and add the Analysis ToolPak.

(called the Input X Range), put addresses of the cells corresponding to your Diameter Squared values. In the dependent variable box (Input Y Range), put the cells corresponding to your #drops data. Check the Output box and put a cell location to the right of all your data, so that there will be room for the output. Check the Constant is Zero box. Then click O.K. Your output should include information like the graphic at right. Of course, your numbers will differ.

The coefficient of your independent variable is the slope of the linear form. In this case, it is the coefficient of the square of the diameter. So your formula becomes

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9890056 |
| R Square | 0.9781321 |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-* |
|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | # |
| X-square | 0.0192096 | 0.00044 | 43.6233 | |

#Drops = (Coeff)$\times$ (Diameter)$^2$

I. (a) Write your formula here: ______________________________________

(b) How many drops does your model predict will be needed for a blotch that is 48 mm in diameter? __________________

(c) If you have only 72 drops of medication, what size blotch are you equipped to heal?
________________________

(d) The hospital administration wants to decide on a conservative procedure for ordering that will minimize the chance of ordering too little while not being too extravagant with the patient's money. One administrator wants always to order 3 drops more than your formula calls for. Another wants to overestimate the blotch diameter by 3mm. Modify your formula for each alternative and write each new formula below:

"3 Drops More" alternative: ______________________________________

"3mm More" alternative: _________________________________________

II. Which of these alternatives will be more costly to the patient, assuming *your* formula gives the exact amount needed? Justify your answer with a calculation or an attached graph:

III. (a) Can you think of a good reason for using the square of the diameter as the independent variable? (Hint: Consider the formula for the area of a circle.)

(b) Why did we choose to set the constant to zero in the regression procedure?