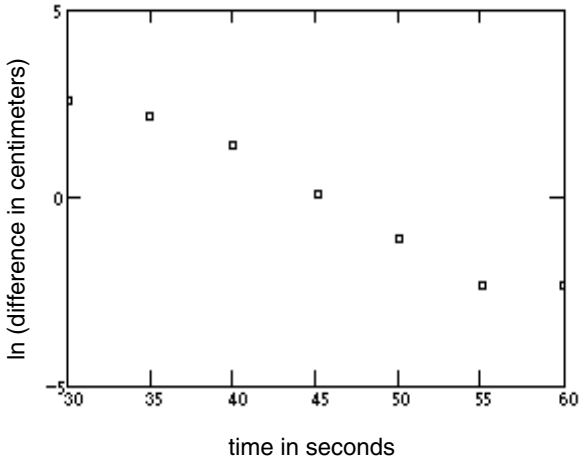

Figure 3 Re-expressed Toilet Data

Picking a value for the cut-off height h_2 is slightly tricky: using the actual cut-off from the data leads to the unacceptable ln(0); and the regression is quite sensitive to small perturbations of h_2 above this value. In Figure 3, a value of h_2 that is 0.1 cm above the actual cut-off has been chosen. Once all of these values are obtained, a plot of the analytic solution through the data gives a good confirmation of the analysis. Of course, it must be noted here that the theoretical toilet never actually shuts off.

The model can be modified to reflect the discontinuous jump to the cut-off height, simply by adding a third height interval to (1). It is equally instructive, however, to have students discuss the "practical" solution many people apply to an infinitely running toilet: bending the float stem. The effects of this stratagem are summarized in Figure 4.

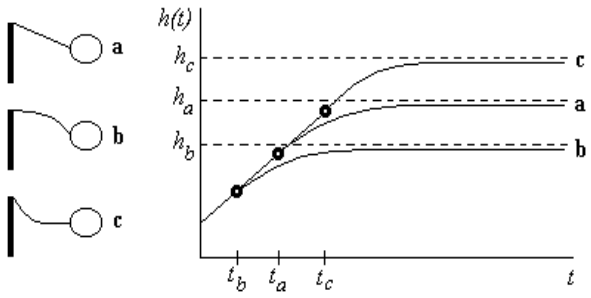

Figure 4 Bending the Float Stem

We see that bending the float stem does nothing to quiet the toilet's high-pitched explorations of the asymptote; it runs on just the same. Rather, the effect is to shift the solution, both horizontally and vertically. The only practical benefit comes from the water that would be saved by the lowered cut-off height in **b**.

By means of such a simple experiment and modeling exercise, students are able to carry away memorable lessons that can be usefully referred to throughout the semester. (There are also the less measurable lessons that come from making the "ancient heavenly connection" to the world outside the classroom. One group of students, for example, received a sumptuous Japanese meal, free of charge so proud were the proprietors of the restaurant to have "such mathematics" being carried out in their restroom. This cultural respect for mathematics was less evident at a local Denny's, where another group of students was asked to leave.) I have had students tell me, long after completing this project, that they *cannot* go to the bathroom without thinking about differential equations. They are usually glaring at me; and I am usually smiling. ❑

Sources:

[1] From *Howl*, By Allen Ginsberg, 1956.

[2] Women's restroom; Shelter Lounge; Tucson, AZ

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DIFFERENTIAL EQUATIONS
AN INTRODUCTION WITH MATHEMATICA BY CLAY ROSS
a book review by Marie Vanisko

At first glance, this text appears to be very similar to many traditional differential equations books, with an added supplement on Mathematica. However, after closer inspection, it is clear that Ross' book is distinctly different. In particular, linear algebra plays a key role throughout the text, not only in the chapters on systems of differential equations. Also, Mathematica is not just an add-on; it is integrated into nearly every section, with dialogue about what can be accomplished with it.

The book is intended for students who have had single-variable calculus and up through partial derivatives in multi-variable calculus; its coverage of linear algebra does not assume that students have already had that course. Although this book is written at a more sophisticated level than one would usually find for sophomores and although theorems with their

proofs are routinely presented, the focus is not on having students prove theorems themselves, but rather on having students understand what the theorems say so as to be able to apply them. The presentation makes a student feel that the author is talking directly to him or to her, thus making the text quite readable, despite its sophistication.

I found this text to be very satisfying from the mathematical perspective, because of its precision, its thoroughness, and its elegance. The notion of a linear space is introduced in the first chapter and then carefully developed and defined in a later chapter. The span, basis, and mappings of a linear space are introduced and then applied to differential equations, thus streamlining and unifying the presentation on linear differential equations and systems. The annihilator method is shown as an example of composition of linear operators. This book could easily have had a dual title of Differential Equations / Linear Algebra.

As was noted at the start, Mathematica is an integral part of the presentation throughout the text; the precise code for input and resulting output is given in examples. Additionally, text-specific packages have been written and are available through a Web sight (see `http://www.springer-ny.com/supplements/cross.html`). Users of the text are encouraged to add their own notebooks or packages to those available at the Web sight, so this could be an additional asset. The text itself contains three Mathematica appendices: one with general information, one on Mathematica style, and one on specific functions used in the solution of differential equations. The author stresses how the power of Mathematica makes it possible to avoid the tedious computations, to solve problems that could otherwise not be solved and thus "frees the student to think about what is happening, how the ideas work together, and what everything means." Emphasis is still placed on knowing whether or not what is being done is correct, but students are exposed to alternative ways to check their work and Mathematica's work using Mathematica itself.

Topic coverage encompasses first order differential equations, higher order linear differential equations, and linear systems of differential equations. Laplace Transforms, series solutions, and issues associated with equilibrium points are included. A wide variety of applications is presented throughout the text through examples. These include the standard physics applications, but also include problems like determining the age of the Shroud of Turin, estimating the effect that educating the population on AIDS has had on the spread of the disease, logistic equations, and the Volterra-Lotka equations to model predator-prey interaction. Problems in the exercises are quite brief, but deal with the issues presented quite thoroughly in the examples. ❑

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