Guided Study Program in System Dynamics
System Dynamics in Education Project
System Dynamics Group
MIT Sloan School of Management[1]

Assignment #12

Assigned on: Friday, December 4, 1998

Due by: Monday, December 14, 1998
12:00 PM (Noon)[2]
WE WILL REVIEW THE RESPONSES ON MONDAY
AFTERNOONS, BOSTON TIME.
LATE SUBMISSIONS WILL NOT RECEIVE FULL
ATTENTION.

Please email assignment solutions, questions, or comments to:
gsp@sysdyn.mit.edu
Save solutions with the filename XYZ-S12.doc
(where XYZ are your initials)

Reading Assignment:

Please refer to Road Maps 5: A Guide to Learning System Dynamics (D-4505-4) and read the following paper from Road Maps 5:
- Generic Structures: S-Shaped Growth, by Terri Duhon and Marc Glick (D-4432)

Please read the following:
- *Principles of Systems*,[3] by Jay W. Forrester, Chapter 3

Please refer to Road Maps 7: A Guide to Learning System Dynamics (D-4507-1) and read the following paper from Road Maps 7:
- Graphical Integration Exercises Part 4: Reverse Graphical Integration, by Laughton Stanley (D-4603)

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[2] The deadline is in United States Eastern Time, equivalent to Greenwich Mean Time minus 4 hours during US daylight savings time, and Greenwich Mean Time minus 5 hours for the rest of the year.
[3] Forrester, Jay W., 1968. *Principles of Systems*, (2nd. ed.). Waltham, MA: Pegasus Communications. 391 pp.

Exercises:

1. Generic Structures: S-shaped growth

After reading this paper and doing all the included exercises, answer the questions below:

A. This paper introduces two generic structures for S-shaped growth and studies the types of behavior that can result from such structures. Refer to Figure 7b on Page 13. Build the "New Product Life Cycle" model in Vensim PLE by following the equations for the Epidemic model in Appendix A, pages 21-23. In your assignment solutions document, please include the model diagram and documented equations.

Use the following values for the constants:

product lifetime = 2 Years
probability of buying = 0.25
population interactions = 16 / Year
There are 2000 people in the system.

B. What types of behavior can the New Product Life Cycle exhibit? Why?

C. For each type of possible system behavior mentioned in part B, find a pair of initial stock values for Owners and Non-Owners that gives such behavior. Remember that the sum of the stocks must always equal 2000 people. In your assignment solutions document, include graphs of behavior for each pair of initial stock values.
    Example: When initial value of Owners is X, and initial value of Non-Owners is (2000-X), the system exhibits _____ behavior as shown in the following graph.

D. Find the ranges of stock values for which each type of behavior is exhibited. Explain your answer.
    Example: When initial value of Owners is between Y and Z, and initial value of Non-Owners is between (2000-Y) and (2000-Z), the system exhibits _____ behavior.
Hint: To answer this question, it is sufficient to consider only the behavior of the stock "Owners." Looking only at the behavior of a stock, however, may sometimes be misleading. Instead, you may want to look at the behavior of the net flow into the stock, the difference between the inflow and the outflow. What behavior does the stock exhibit when the net flow is increasing? What behavior does the stock exhibit when the net flow is decreasing?

2. Principles of Systems

Please read chapter 3 of *Principles of Systems* and do the workbook exercises for this chapter (located at the end of the book). Let us know if you have problems or questions

about the material in this reading. You do not need to submit anything for this reading assignment.

3. Graphical Integration Exercises Part 4: Reverse Graphical Integration

Please read this paper and do all the included exercises.

Using the skills that you acquired in the paper, please reverse integrate the following stock behavior:
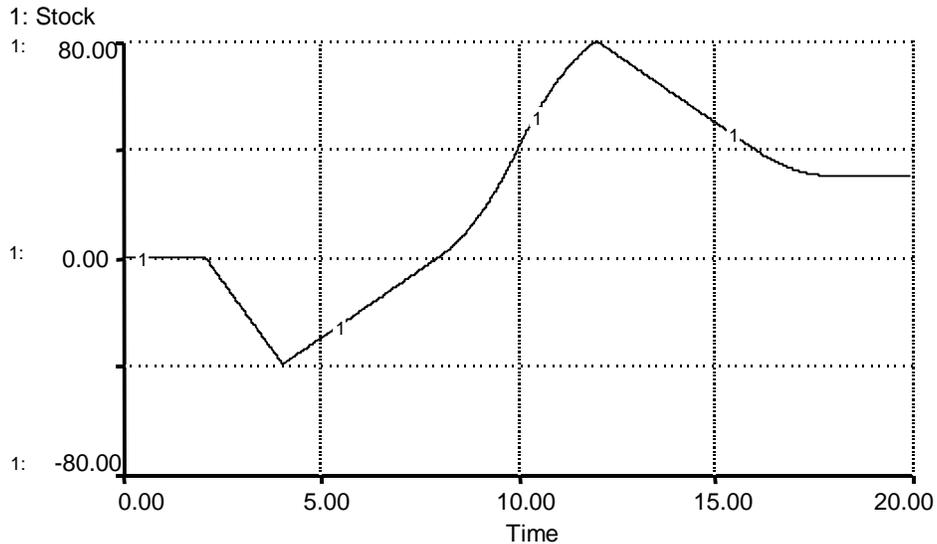
From time = 0 to time = 2, the stock remains at 0. From time = 2 to time = 4, the stock decreases linearly from 0 to –40. From time = 4 to time = 8, the stock increases linearly from –40 back to 0. From time = 8 to time = 10, the stock increases parabolically from 0 to 40. From time = 10 to time = 12, the stock increases by "negative parabolic" growth from 40 to 80. From time = 12 to time = 16, the stock decreases linearly from 80 to 40. From time = 16 to time = 18, the stock decreases parabolically from 40 to 30. The stock then remains at 30 until time = 20.

4. Independent Modeling Exercise: Internet

In Assignment 1, you were asked to talk about the forces behind the explosive growth of the Internet, as well as the limits to its growth. In this exercise, we will be analyzing some of the simple systems you came up with.

A. Perhaps the strongest force attracting people to the Internet is word-of-mouth. One person surfs, loves it, and tells his friends about it. His friends then decide to try it out also, then in turn tell their friends, and so on. Let's assume that each user influences 0.5 friends per year, and that there are initially 1 million users of the internet in the US at the time of our study (we will only be concerned with the United States in this problem).

Identify the elements of the system, label each as either a stock, flow, or constant, and label its units.

Simulate the model for 30 years and examine the behavior (remember to use an appropriate time step). In your assignment solutions document, include the model diagram, documented equations, and a graph of model behavior.

B. In Part A, we did not account for the fact that as colleges and workplaces offer access to the Internet, a somewhat constant number of people is being exposed to the Internet annually, making them internet users. Let's say that an additional 100,000 people become internet users every year simply due to circumstance. Add this flow to the model from part A and simulate the model for 30 years. In your assignment solutions document, include the new model diagram, modified equations, and a graph of model behavior.

C. Often, hardware limitations prevent some that wish to get on the Internet from doing so. The growth of Internet service providers (ISPs) has not come close to the growth of demand for Internet access. What if the total number of people who have the hardware capability to be an Internet user is limited to 15 million? (Each user still influences 0.5 friends per year). In this scenario, you do not need to account for the inflow of 100,000 people from part B. Modify the model from part A and simulate the model for 30 years. In your assignment solutions document, include the new model, documented equations, and graphs of model behavior. Explain the behavior that you observe.
Note: Keep in mind that special functions, such as IF-THEN-ELSE, should not be used unless absolutely appropriate-and it is not appropriate in this situation.