Massachusetts Institute of Technology

ESD.00 Introduction to Engineering Systems

Spring, 2011

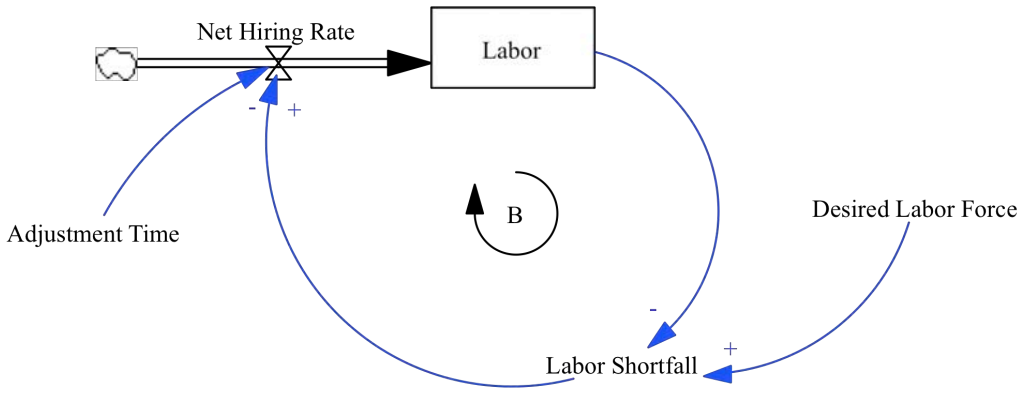
Assignment # 3

Assigned Date: Lecture 4
Due Date: Lecture 6

Building and simulating models of systems with feedbacks and delays is a critical skill necessary for analyzing and understanding complex systems. In this assignment you will improve your skills for graphical integration, build your intuition for dynamics of first-order systems and develop your ability to model complex socio-technical systems based on stocks and flows concepts. You will convert some of your previously built causal diagrams into stocks and flow structures and will formalize model behavior by specifying equations and assigning numerical values to your parameters and variables. You will then run simulations of your model and perform sensitivity analysis.

A. Goal-Seeking Behavior:

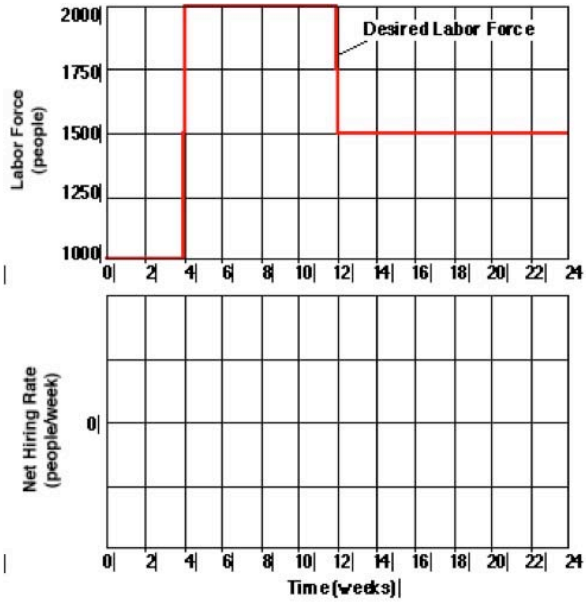
Consider the following description for labor force:



Assume that the net hiring rate is proportional to the gap between the desired and actual workforce and is given by: Net Hiring Rate = (L* – L) / T,

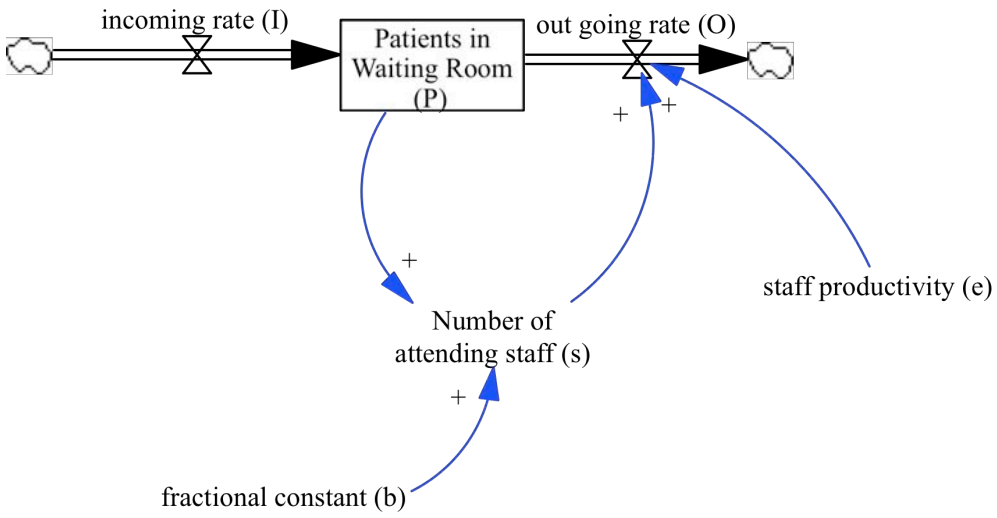
where L* is the desired labor force, L is the labor force and T is the adjustment time. Sketch the behavior of the workforce and net hiring rate for the following situations:

1. The desired workforce increases from 1000 to 2000 at week 4, then steps down to 1500 at 12 (as shown in figure below). Assume that the actual labor force initially equals the desired workforce, and the adjustment time is 4 weeks.
2. Repeat step 1 for the case where the labor force adjustment time T = 2 weeks.
3. What are your observations regarding the system behavior. Describe one or two key aspects that maybe relevant for a hiring manager.



B. Stocks and Flows:

Consider the stock and flow problem from the previous class assignment. In a hospital waiting room, incoming (non-emergency related) patients arrive at an 'incoming rate'. They have to wait until the hospital staff attends to them. Each patient is then sent off for further procedures as necessary. The rate at which the patients are attended to (and thus leave the waiting room) is the 'out-going rate'. The number of hospital staff attendants, s, that attends to the patients depends on the patients in the room. If the number of patients increase, more staff is called in to attend to them in order to increase the 'out-going rate'. The hospital tries to maintain a patient to staff attendant ratio defined by 'b'. The staff members have productivity, e, the hourly rate at which they process waiting patients. Assume that there are no delays in adjusting the staffing level.



a) Write the equations that are needed to define the model. Give units to each quantity and make sure the equations are dimensionally consistent.

b) Create this stock and flow structure in VenSim.

c) Set I = 10, b = 0.1, e = 6. How many patients are waiting at the end of 2 hours and 4 hours?

d) What happens when we decrease staff productivity from 6 to 4? How many patients are then waiting at 2 hours and 4 hours?

ESD.00 Introduction to Engineering Systems
Spring 2011