

Sample Questions Modeling Test 1

A typical test would contain four of the types of questions below.

1. Open the Excel spreadsheet **ball.xls**. It contains a table of data collected in an experiment with a freely falling object. A ball is dropped from a measured height and its height above the ground is measured at the times indicated. Use Excel to generate a **disconnected scatter graph** of the data with time on the horizontal axis. Place **two** trendlines, with equations and R^2 values, on the graph: one linear and one quadratic (polynomial of order 2). Copy the graph from EXCEL and paste it below. Type a paragraph below explaining which trendline is the better fit to the data and why.

2. Open the Excel spreadsheet **diving.xls**. It contains a table of data collected in an experiment on recovery time (time for dissolved nitrogen to leave one's body) after SCUBA diving. The time (measured in hours) required to recover from diving to a depth measured in meters is recorded as indicated. Use Excel to generate a **disconnected scatter graph** of the data with depth on the horizontal axis. Place **two** trendlines, with equations and R^2 values, on the graph: one linear and one exponential. (a) Copy the graph with trendlines and equations. (b) Based upon the foregoing, type a paragraph explaining which model (trendline) is the better fit to the data and why. (c) Now suppose you receive additional information: the time for recovery is measured for a 150 meter dive and is found to be 21 hours. Would you change your mind about which model (trendline) is best? Explain your answer.

Diving Data (from diving.xls)		Data from ball.xls	Time (seconds)	Height (meters)
Depth (meters)	Time (hours)			
			0.00	3.58
10	1.2		0.05	3.54
20	2.3		0.10	3.48
30	2.9		0.15	3.44
40	3.4		0.20	3.36
50	3.8		0.25	3.25
60	4.2		0.30	3.08
70	4.9		0.35	2.91
80	5.3		0.40	2.78
90	6.5		0.45	2.58
			0.50	2.28
			0.55	2.08

3. Using STELLA, create a model of your choice exhibiting **exponential growth (or decay)**. (a) Copy the model diagram, equations with units and documentation, and Behavior Over Time graph of the stock into the space below. (Copy from a selection in any STELLA window to the clipboard, and paste the selection into this Word document.) (b) Write a paragraph explaining your model, how it works, and what the numbers mean (paying attention to starting values, calculation of one or two time steps, ending values, and assumptions). Say where the feedback cycle is, if any, what kind of feedback it is (positive or negative), and why, and why the system grows (decays) exponentially.

4. Using STELLA, create a **convergence model** of your choice. Copy the diagram, equations with units, and graph of the stock and target into the space below. (Copy from

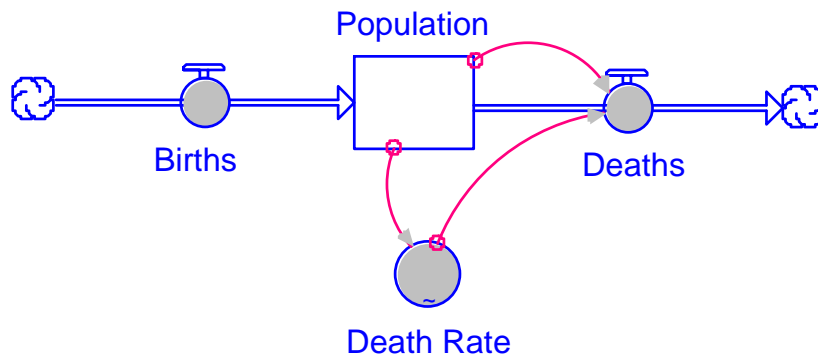
a selection in any STELLA window to the clipboard, and paste the selection into this Word document.) Then, write a paragraph explaining your model, how it works, what the numbers mean, where the feedback cycle is, if any, what kind of feedback it is, and why, and why the system converges toward the target. Include specific calculations to illustrate your arguments.

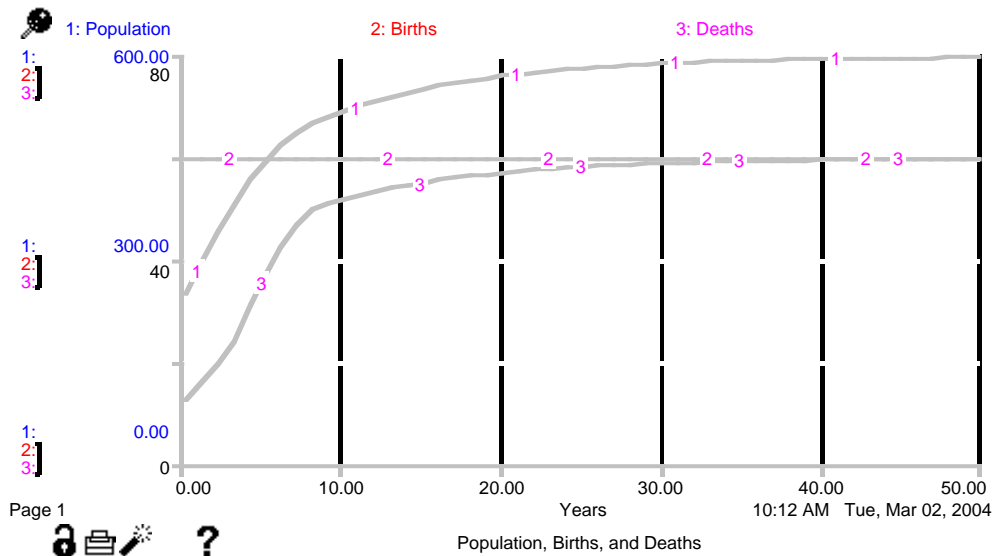
- Using STELLA, create a linear growth or decay model of your choice. Copy the diagram, equations with units, and a graph into the space below. (Copy from a selection in any STELLA window to the clipboard, and paste the selection into this Word document.) Then write a paragraph explaining your model, how it works, what the numbers mean, where the feedback cycle is, if any, and why the system grows (decays) linearly.
- Below is the STELLA diagram of a population model. Accompanying it is the Behavior Over Time graph of the stock **Population** and the flows **Births** and **Deaths**. It may help you to know that the flow **Births** is a constant (60 people/year), but the **Death Rate** is a graphical converter depending upon Population (with a Death Rate range of 0.0 to 0.10, increasing continuously as population increases from 0 to 500). The flows are defined by the equations:

$$\text{Births} = 60 \text{ \{people/year\}}$$

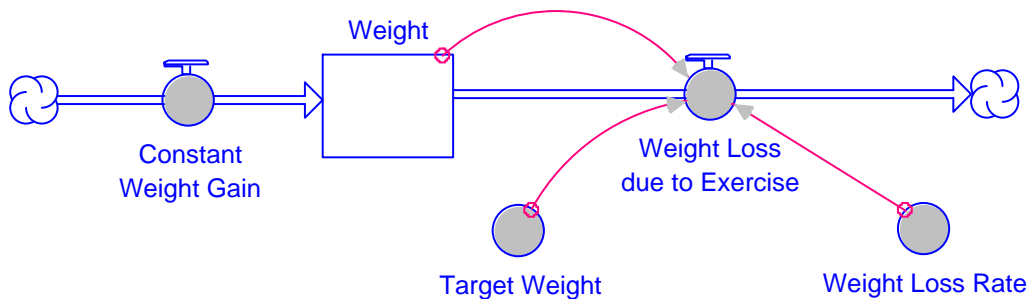
$$\text{Deaths} = \text{Death_Rate} * \text{Population} \text{ \{people/year\}}$$

Based on your understanding of the diagram, the equations, and the graph, write a paragraph addressing what happened to the population over time, why it leveled off, and what the leveling-off means. What does it mean that the Births and Deaths graphs coincide over the last 15 years or so? What does it mean that the Population graph is above the Deaths graph and crosses the Births graph? Describe the feedback loop(s) in the model, if any, and say what kind of feedback (positive or negative) each loop is, and why.





7. Refer to the STELLA diagram and equations below. We are modeling a weight-loss program where the subject always eats enough to gain 5 pounds per week, but loses weight through exercise at a rate proportional to the difference between his current weight and target weight. (a) Given the equations, initial values, and constants in the model, the Behavior Over Time graph of the stock **Weight** will exhibit which of the following shapes: increasing at a constant rate, increasing at an increasing rate, increasing at a decreasing rate, decreasing at a constant rate, decreasing at an increasing rate, or decreasing at a decreasing rate? Explain your answer in terms of the feedback loop(s), mathematical relationships, and specific numbers in the model. What kind of feedback (positive or negative) is exhibited by the outflow of this model? Explain your feedback answer. (b) From the Stella difference equation in the model, derive the differential equation that Stella numerically simulates (more and more closely as **dt** goes to 0).



EQUATIONS

STOCK:

$$\text{Weight}(t) = \text{Weight}(t - dt) + (\text{Constant_Weight_Gain} - \text{Weight_Loss_due_to_Exercise}) * dt$$

$$\text{INIT Weight} = 200 \text{ {pounds}}$$

INFLOWS:

$$\text{Constant_Weight_Gain} = 5 \text{ {pounds/week}}$$

OUTFLOWS:

$$\text{Weight_Loss_due_to_Exercise} = \text{Weight_Loss_Rate} * (\text{Weight} - \text{Target_Weight})$$

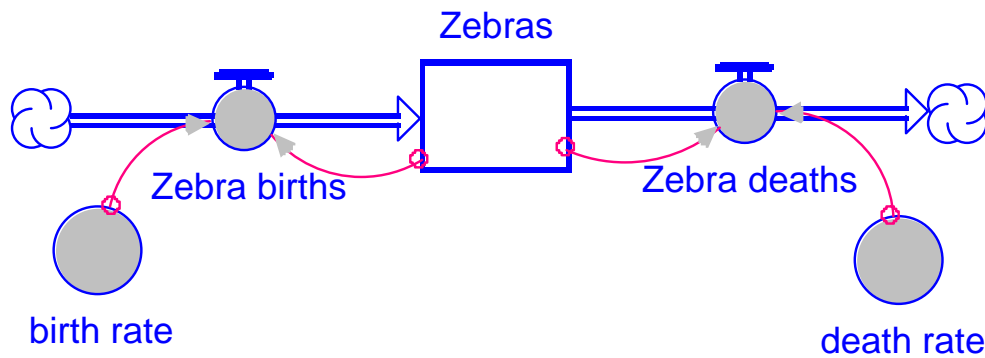
{pounds/week}

CONVERTERS:

$$\text{Target_Weight} = 150 \text{ {pounds}}$$

$$\text{Weight_Loss_Rate} = 0.2 \text{ {pounds/pound/week}}$$

8. Below is a STELLA model and its equations. Choose appropriate letters to stand for the different quantities (variables and constants) in the model and derive the differential equation(s) which the model numerically simulates. Type the steps of your derivation in the space indicated below.



$$\text{Zebras}(t) = \text{Zebras}(t - dt) + (\text{Zebra_births} - \text{Zebra_deaths}) * dt$$

$$\text{INIT Zebras} = 100 \text{ {zebras}}$$

INFLOWS:

$$\text{Zebra_births} = \text{birth_rate} * \text{Zebras} \text{ {zebras/year}}$$

OUTFLOWS:

$$\text{Zebra_deaths} = \text{death_rate} * \text{Zebras} \text{ {zebras/year}}$$

$$\text{birth_rate} = .2 \text{ {zebras/zebra/year}}$$

$$\text{death_rate} = .05 \text{ {zebras/zebra/year}}$$

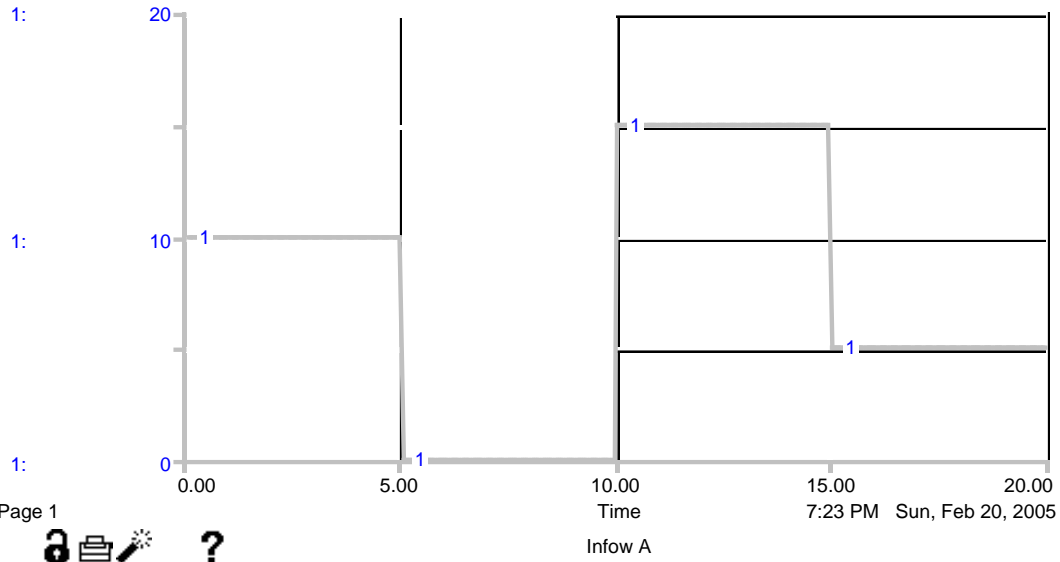
9. Below is the graph of the inflow (Flow_A) into a stock (Stock_A). There are no other flows into or out of Stock A. The equation that defines the flow is

$$\text{Flow_A} = \text{GRAPH}(\text{time})$$

$$(0.00, 10.0), (5.00, 0.00), (10.0, 15.0), (15.0, 5.00), (20.0, 5.00)$$

The graph is set to be a step function. You are given that the initial value of Stock_A is 10. Carefully sketch the corresponding graph of Stock_A on the axes below. Be sure to put an appropriate scale for the stock on the vertical axis.

1: Inflow A



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