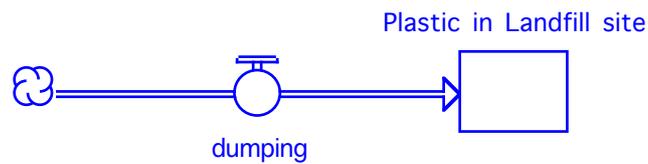


Introduction to System Dynamics

Stella Guide 2

Exercise on Constant Flow, Compounding and Draining Process



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Exercise 1 Landfill

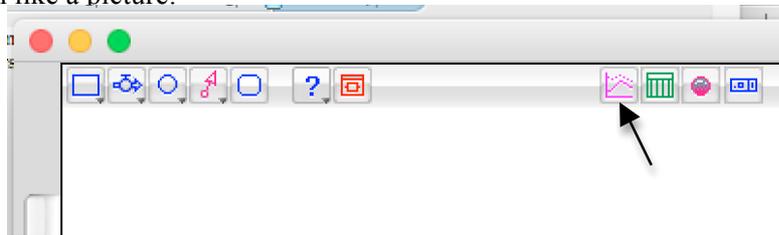
A city is building a new landfill site. The city council wants to know how large the landfill will be in 20 years time so that it can allocate enough space. 5000 gallons of plastic are to be dumped per day. Plastic does not decompose and the dump starts empty. Set up a systems dynamics model in Stella so to determine how many gallons of plastic have been dumped in 20 years.

Before you start your model

- Use mental arithmetic to determine its value after 20 years? _____
- Is the flow a constant flow or a compounding process? _____

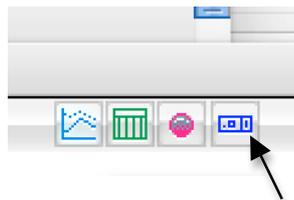
Displaying Results

Once you have your model you can display your results in a table by clicking the “table” icon and pinning down like a picture:



After pinning down the table *double click* it to get the table dialogue box. Set the stock that represents the amount of plastic as the display variable and make sure the Every DT box is *unchecked* and the Report Interval is 1.

You can also get the value as the program runs by clicking the numeric display.



- How much plastic does the model give after 20 years? _____
-

Exercise 2 Recruitment

Model 1

A small company recruits 20 new programmers each year. Given they start with 100 such people set up a systems model for the situation, displaying your result in a table and a graph. Check your answer is correct before moving on.

Model 2

In addition to the recruitment it is found that 10% of the staff leave each year. By setting this up as a draining process extend your recruitment model to include staff leaving.

You should find that the company size tends to a limit. Note you will need to extend the run time of the model.

- *What is the maximum staff size?* _____

Try and calculate this figure without using your model:

- *What would happen if the number of people in the company started above this maximum value?* _____
 - *Does the initial value make any difference to the final value?* _____
 - *Would you describe this situation as stable or unstable?* _____
-

Exercise 3 Fox Hunting

Model 1 - Births

The number of foxes born in a litter per year, that survive to the following year, is 2. This gives an average of 1 fox born per year per fox.

Set up a birth model as a compounding process.

- *Starting with 10 foxes how many are there after 10 years?* _____

Model 2 - Improved Time Specs

So far you have not thought about "Time Specs". As foxes only reproduce once a year the time step in Time Specs must be 1 with Euler's method selected.

- *Re-run the model, how many foxes are there left after 1 year?* _____

N.B. If changes take place over fixed periods you should use Euler with that period as the step length. Otherwise use RK4 with a small step length 0.1 or less.

Model 3 - Deaths

Due to old age, accidents and rivalry it is found that 70% of foxes die each year. Extend your model with a draining process

- *Re-run the model, how many foxes are there left after 1 year?* _____
- *From the graph would you describe this situation as stable or unstable?* _____

Model 4 - Hunting

In an effort to control the fox population the local hunt decide to meet a few times each year. However, they only succeed in catch one fox per year.

Extend your model by adding an extra flow to model hunting.

- *Is this a draining process or a constant flow?*
- *Is the fox population brought under control?* _____
- *Obtain a value for the number of foxes caught per year so that the population is kept level? What is that value?* _____
- *What happens if that value is exceeded?* _____
- *What happens if there are 20 foxes to start with rather than 10?* _____

This form of hunting is called "fixed quota".

- *From this model do you think fixed quota hunting could control a fox population?*
- *Would you describe this model as stable or unstable?* _____

Exercise 4 Loans

Sally borrows £5000 at a fixed interest rate of 4% per year.

Model 1

Set up a compounding process model to show how much the loan has become after 10 years.

Note: If you assume the interest is charged daily (as it usually is) then you should use RK4 with a small step length and ensure the time period is in years. This is because $1 \text{ day} \ll 1 \text{ year}$.

- *How much is the loan after 10 years?* _____

Model 2

Sally has to pay the loan off in 10 years. She pays a fixed amount every month.

Extend your model to include repayment remembering that your units are years so the repayment amount in your model is the annual total repayment.

- *By trying various repayments how much does she have to pay a year to pay off the loan?* _____

You might like to think whether time has been modelled in the best way in this model. Should it have been expressed in months with the interest rate turned into a monthly equivalent?

Exercise 5 - Landfill and Decomposing

Model 1 - Decomposition

Back to the first exercise on landfill. Instead of plastic it is suggested that the dump is filled with paper and cardboard because they reduces to half their size in one year. Given a dump containing 1 million gallons of such paper material and no further dumping takes place. Set up a systems model in Stella showing that this is the draining process.

- *How much paper is left after one year?* _____
- *It should be 500,000 gallons. If you model does not give this then explain why and try to correct it*

Model 2 - Dumping and Decomposition

The city council is now going to dump 5000 gallons of paper and cardboard per day. However this time we know it decomposes by 50% per year. Set up an appropriate systems dynamics model in Stella.

- *What size is the dump after 20 years?* _____
- *What will the maximum size of the dump become?* _____
- *Is this situation stable or unstable?* _____
- *If dumping stops after 10 years what size will the dump be after a further 10 years?*
