





## How to...Build a Model

Double click on the STELLA icon. When the full screen appears, click on the icon of the world  once. It should change to an . The top bar looks like this:

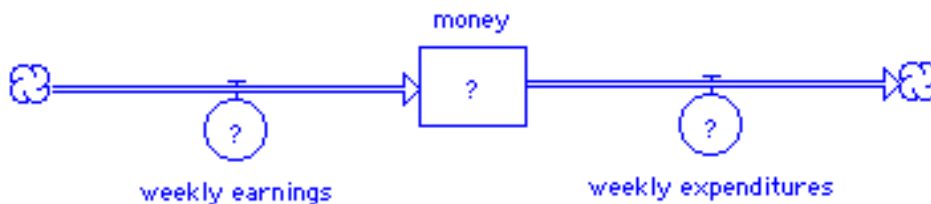


This is the source of the icons we will use to build our model. First click on the icon that looks like this : . This is known as a stock. Now slide your pointer out into the open field and click again. A large stock should appear with the word **Noname 1** highlighted. Before doing anything else, **type** the name of the quantity that the stock represents (eg. **money**)

Now click on the icon which looks like this: . This is a flow. Slide your pointer to a position some distance to the left of the stock, **click and drag** until the arrow just touches the stock and the stock becomes shaded. Let go of the mouse button. A flow pointing into the stock represents the rate at which the stock is being changed by the addition of a quantity over time (eg. **weekly earnings**). Your diagram might look like this:



Suppose you spend part of your money each week. To show the **weekly expenditures**, use a flow that points away from the stock to indicate subtraction. To do this, click on the flow icon, place the flow icon inside the stock, then click and drag the flow to the right of the stock. Your diagram might look like this now:



Hint: If the name of a stock or flow is placed so it is difficult to read, simply select the name with the mouse and drag it to a new position near the icon.

## How to ... Enter Values and Units in a Stock

In a model, each question mark indicates that a value or formula or graph needs to be input. For the stocks, the initial value of the stock needs to be given. **Double-click** on the stock. When the window opens, **enter** in the shaded region the value at which you wish the stock to begin and **click** on **OK**. For example, if the stock represents money, you may be starting with 100. In order to indicate the units (dollars, cents, etc.), you should write the units inside curly braces.

Setting the initial amount of money in the stock

The dialog box is titled "Setting the initial amount of money in the stock". It contains the following elements:

- Radio buttons for "money" (unchecked), "Reservoir" (checked), and "Conveyor" (unchecked).
- A checked checkbox for "Non-negative".
- An "Allowable Inputs" list box containing "weekly\_earnings" and "weekly\_expenditures", both with question mark icons.
- A numeric keypad with buttons for "E", "(", ")", "^", "7", "8", "9", "\*", "4", "5", "6", "/", "1", "2", "3", "-", "0", ".", "+", and a left arrow key.
- An unchecked checkbox for "INITIAL(money) = ...".
- A text input field containing "100 {dollars}" with a cursor at the end.
- Buttons for "Document", "Message...", "Cancel", and "OK".

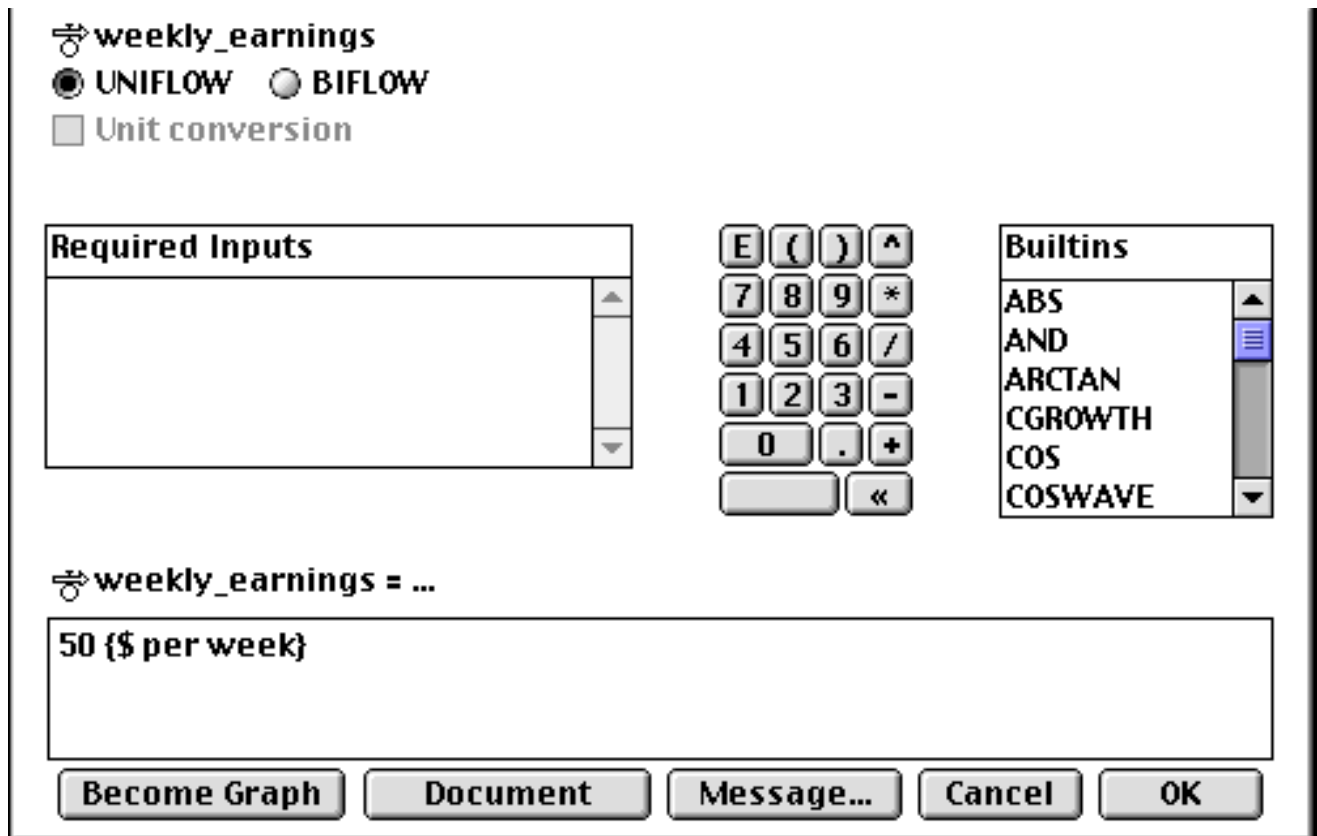
You should note that the **Non-negative** option is checked. This means that if the stock ever becomes negative because more is subtracted from it than added to it, the stock will be reset to zero. To avoid that action, click on the check mark and it will disappear, thereby permitting a representation of going into debt.

Also note the keypad in the center of the dialogue box. You may click on the values on the keypad rather than using the keyboard if you prefer.

## How to ... Enter Values and Units in a Flow

In a model, each question mark indicates that a value or formula or graph needs to be input. For each flow, a value, formula or graph must be entered. **Double-click** on the **weekly\_earnings** flow. When the window opens, **enter** in the shaded region the amount of money you are earning weekly and **click** on **OK**. In order to indicate the units (dollars, cents, etc.), you should write the units inside curly braces.

### Entering a constant in a flow




You should note that the **UNIFLOW** option is checked. This means that the quantity in the flow must always be non-negative. If the flow ever becomes negative during the running of the model, it will be reset to zero. To avoid that action, click on the **BIFLOW** button, thereby permitting a negative number to be added to a stock (very useful in physics models).

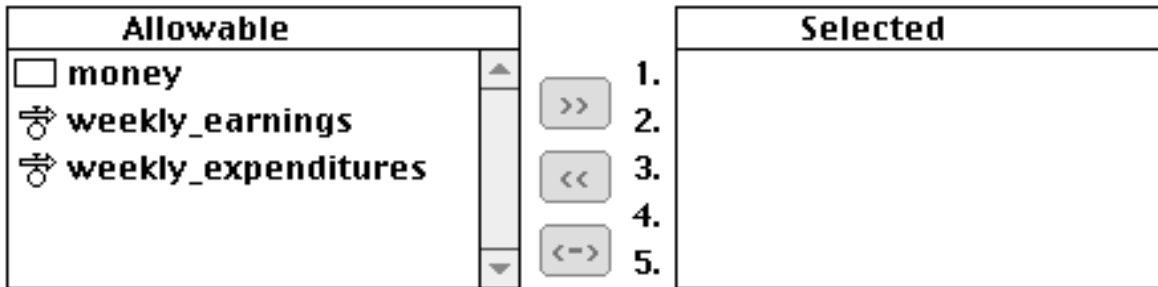
Also note the keypad in the center of the dialogue box. You may click on the values on the keypad rather than using the keyboard if you prefer. The **Builtins** box contains a number of math functions which are useful in certain circumstances.

After you have defined the **weekly\_earnings**, click **OK** and go to the **weekly\_expenditures** flow. Determine a reasonable level of expenditures for this problem, and enter the number.

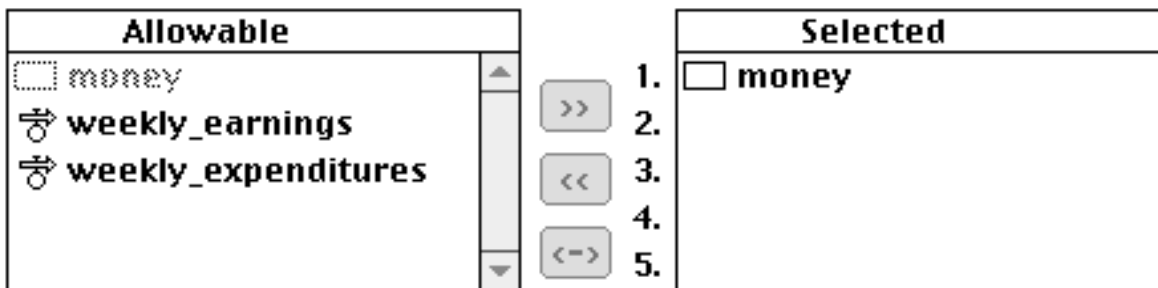
## How To ... Graph the Output of Your Model

To create a graph of the output of your model, **click** on the graph icon, which

looks like this: . Slide your mouse pointer to a clear spot in the window and **click** again. A small graph icon should appear and immediately be replaced by a large gray graph. **Double-click** anywhere in this graph and a new window will open. In the top center of this window, you will see two boxes which contain the quantities you may put in a graph:



**Click** on one of the **Allowable** variables, then click on the >> symbol. **Repeat** for as many as four more allowable variables. You may have up to five variables on one graph. The boxes might now look like this:



**Click** on OK.

To prevent the graph box from disappearing every time you run the model, you should pin down the graph window.

- Move your pointer to the horizontal bar at the top of the graph window.
- Drag the graph so it fits on the white space below the model.
- Click on the black circle (looks like a push pin) in the upper left-hand corner of the graph.

In order to have the graphs appear on the screen, you must run the model. First check to see that all question marks are gone from the model diagram. Then decide the length of time you wish to run the model and the time unit that is appropriate. From the very top menu bar, **Click and hold** at the word **Run**, then without letting go of the mouse button, slide down to **Time\_Specs** on the menu and release.

## How To ... Set Time Specs

From the very top menu bar, **Click and hold** at the word **Run**, then without letting go of the mouse button, slide down to **Time\_Specs** on the menu and release.

Time Specs Before Changes

**TIME SPECS**

<p><b>Length of simulation:</b></p> <p>From: <input style="width: 100px;" type="text" value="0"/></p> <p>To: <input style="width: 100px;" type="text" value="12"/></p> <p>DT: <input style="width: 100px;" type="text" value="0.25"/></p> <p><input type="checkbox"/> DT as fraction</p> <p>Pause interval: <input style="width: 100px;" type="text" value="∞"/></p> <p><b>Integration Method:</b></p> <p><input checked="" type="radio"/> Euler's Method</p> <p><input type="radio"/> Runge-Kutta 2</p> <p><input type="radio"/> Runge-Kutta 4</p>	<p><b>Unit of time:</b></p> <p><input type="radio"/> Hours</p> <p><input type="radio"/> Days</p> <p><input type="radio"/> Weeks</p> <p><input type="radio"/> Months</p> <p><input type="radio"/> Quarters</p> <p><input type="radio"/> Years</p> <p><input checked="" type="radio"/> Other</p> <p><input style="width: 100px;" type="text" value="Time"/></p> <p><b>Interaction Mode:</b></p> <p><input checked="" type="radio"/> Normal</p> <p><input type="radio"/> Flight Sim</p>
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First select the appropriate **Unit of time**. For this model, we are thinking in terms of weeks. Next, determine the **Length of simulation**. To track a year's worth of money, highlight the **To:** box and type in 52. **DT** represents the time-step of the model. Do we deposit money every quarter of a week ( $DT = 0.25$ ) or once a week? Set **DT** to 1 to represent once a week. The other settings will remain at the default. See the next page for the new Time Specs settings. Then click **OK**.

## Time Specs After Changes

**TIME SPECS**

**Length of simulation:**

From:

To:

DT:

DT as fraction

Pause interval:

**Integration Method:**

Euler's Method

Runge-Kutta 2

Runge-Kutta 4

**Unit of time:**

Hours

Days

Weeks

Months

Quarters

Years

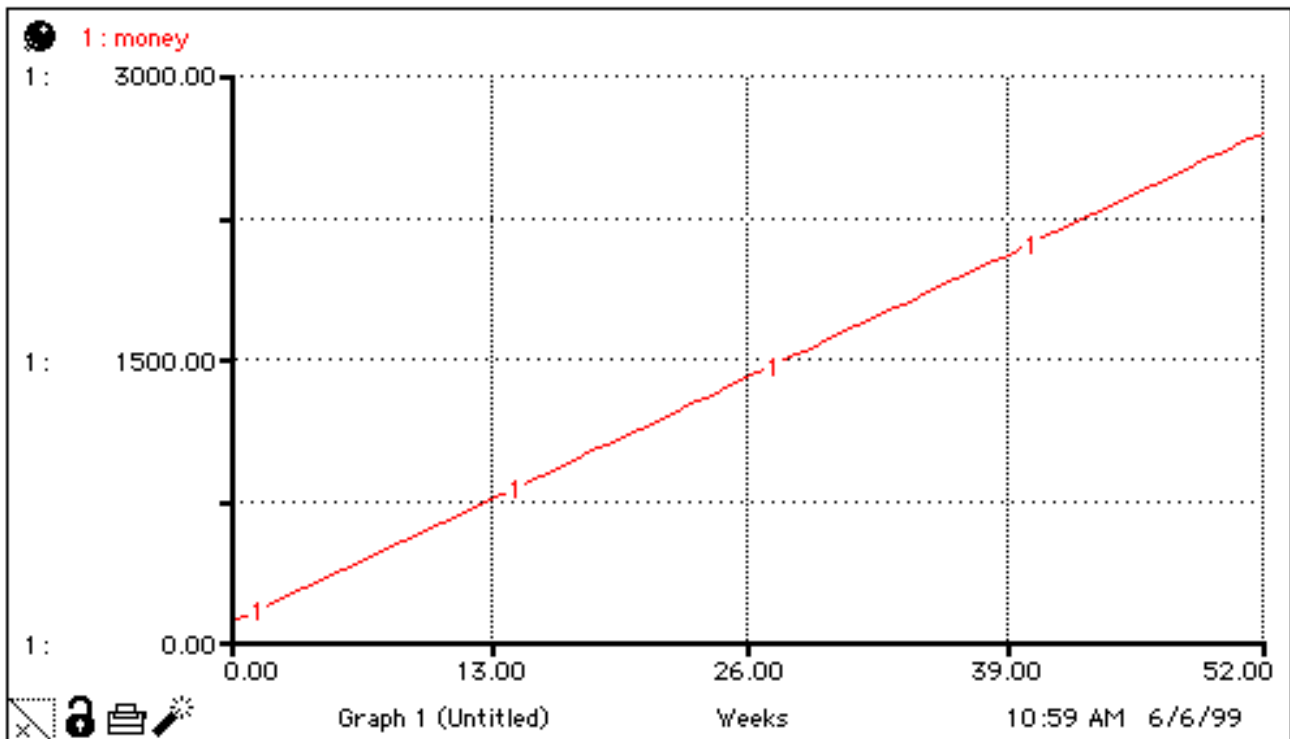
Other

**Interaction Mode:**

Normal



Flight Sim

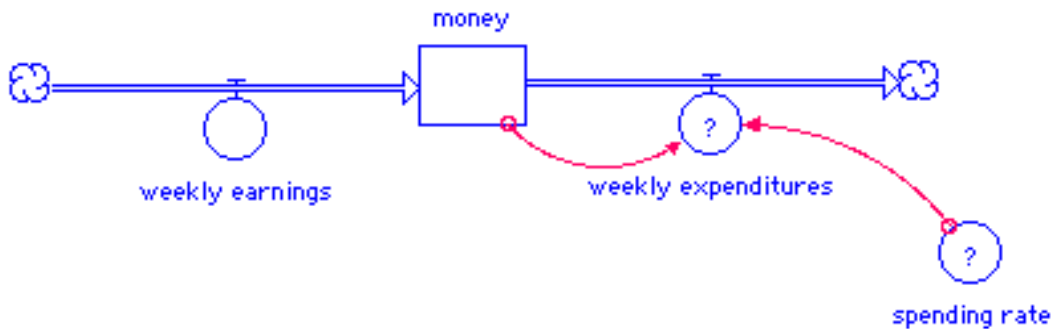
From the very top menu bar, **Click and hold** at the word **Run**, then without letting go of the mouse button, slide down to **Run** on the menu and release. Your graph should look like this if weekly earnings are set to \$50 and weekly expenditures are \$0.



## How To ... Enter a Formula or Equation into a Model

Sometimes a flow is not a constant, but depends on the value of another variable in the model. For example, in the Money model, you may allow yourself to spend 10% of the money in your stock. That way, the wealthier you become, the more money you can spend. To be able to show this relationship,

we must connect **money** to **weekly expenditures** with a connector , as seen below. To do this, slide the connector pointer inside the **money** stock and click and drag until the arrow touches the **weekly expenditures** flow. Let go of the mouse button. To make it explicit that you are using a particular **spending rate**, you should use a converter  which will also be connected to the **weekly expenditures** flow as in the diagram below.



Double-click on the **spending rate** converter and enter 0.10 to represent 10%.

Double-click on **weekly expenditures** and enter the equation **money\*spending\_rate** by clicking on **money** in the **Required Inputs** box, then \* for multiplication, then **spending\_rate**. The window should look like the one below:

🌀 weekly\_expenditures

● UNIFLOW ○ BIFLOW

Unit conversion

**Required Inputs**

money

spending\_rate

E	(	)	^
7	8	9	*
4	5	6	/
1	2	3	-
0	.	+	
			«

**Builtins**

ABS

AND

ARCTAN

CGROWTH

COS

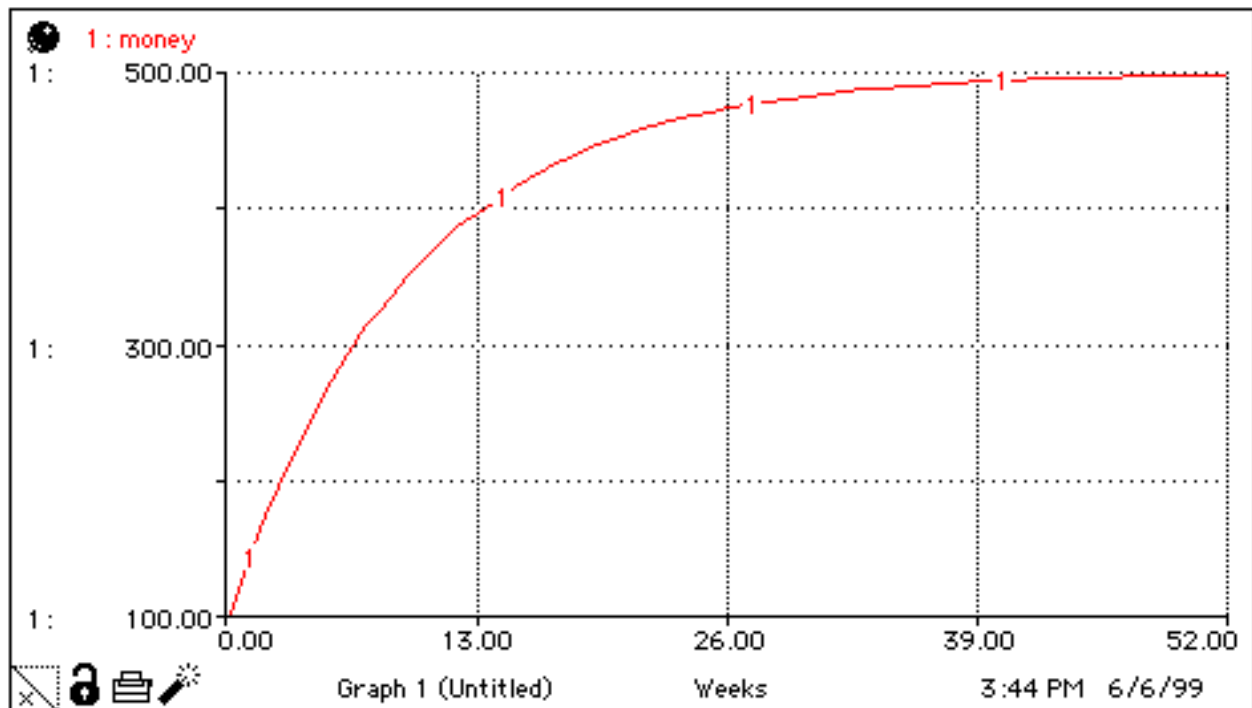
COSWAVE

🌀 weekly\_expenditures = ...

money\*spending\_rate

Become Graph
Document
Message...
Cancel
OK

Run the model and see what the graph looks like now. Your result should appear as:




What has happened to your bank account? How do you explain the shape of this graph?

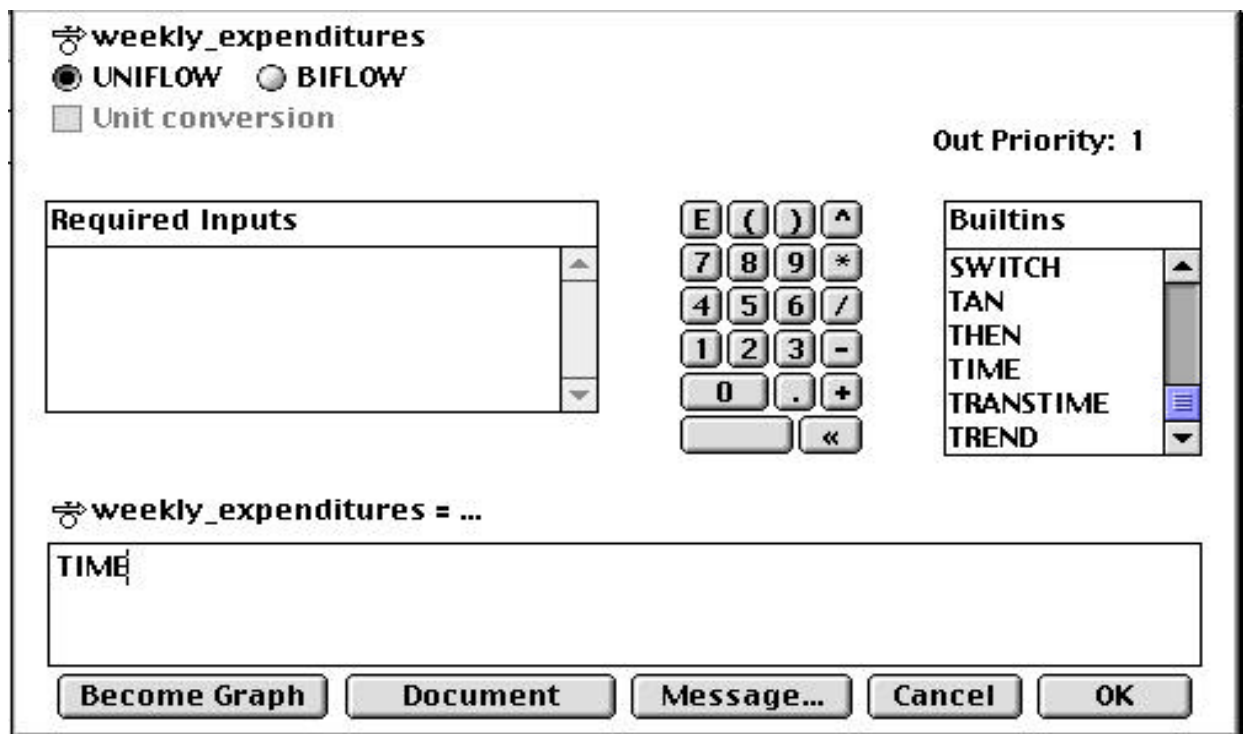


## How To ... Enter a Graph as input to a Model

Sometimes instead of a single value, equation or formula, you have data that you wish to use in your model. For example, in the Money model, you may know your weekly expenditures, but you may not be able to represent them as an equation. STELLA allows you to enter data in the form of a table or graph. But first, you must delete the converter and connectors which you no longer need.

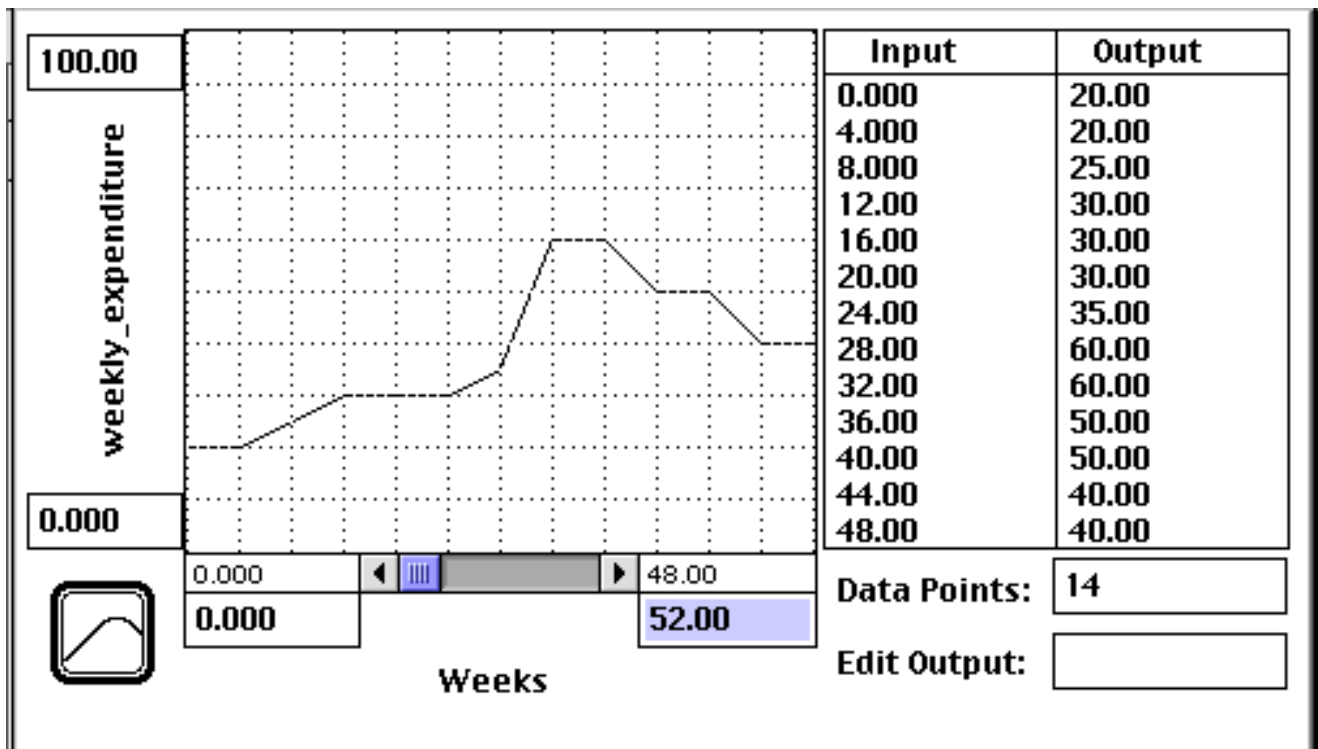
Use the stick of dynamite  to blow up the **spending rate** converter by placing the head of the dynamite in the center of the circle. Blow up the **connector** from **money** to **weekly expenditures** by placing the head of the dynamite on the small pink circle at the beginning of the arrow on the edge of the money stock. WARNING! A steady hand is required so you don't blow up the stock itself.

Double-click on **weekly expenditures** and enter **TIME** in the shaded box. **TIME** will be placed on the x-axis of the input graph you are going to create. This makes sense since expenditures vary week to week.

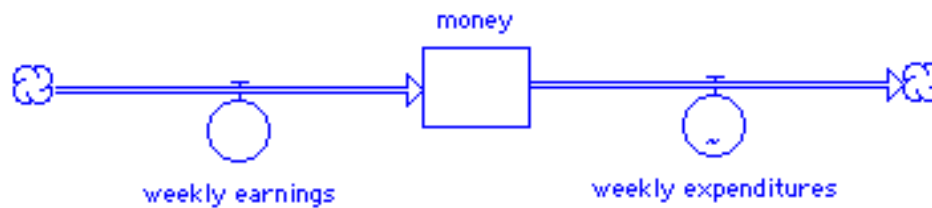


Click on the **Become Graph** button.

The next window that opens allows you to enter values in a table. There are several parts to consider. Looking at the x-axis, you will see that it is labeled **Weeks** and is set from 0.000 to 52.00. In the Money model, that would represent 52 weeks. The **Input** column also runs 0.000 to 52.00. You may change the **Input** column by adjusting the min and max on the axis or by adjusting the number of Data Points in the **Data Points** box or by doing both. To simplify matters, you should type 14 in the **Data Points** box and hit Return on your keyboard so that the input numbers become multiples of 4. This will allow you to change the **Output** values every four weeks. You could choose to use 53 data points to make the changes weekly, but that would require more data entry. Once you have the **Input** column set up to suit your model, you should look at the min and max on the y-axis. Notice below that the y-axis is labeled **weekly\_expenditure** and the range is 0 to 100. If the range should be different, you can change it by typing in each of the boxes. Once the range is correct, you should click on the first entry in the **Output** column on the right and type the desired value. Hitting Return on your keyboard after each number will advance you to the next entry. As you type the numbers, the associated points will appear on the graph, connected by line segments. The input graph might look like this:



Click OK and the model will look like this: The symbol inside the **weekly expenditures** circle is called a tilde.



Run the model and you may get this result:

