

Computer Project 2: Modeling Population

Goals: The first goal of this project is to reinforce the process of performing matrix multiplication and interpreting the results of matrix multiplication that models real world situations. The second goal of this project is to give students hands-on experience using a spreadsheet (Microsoft Excel). Students will create formulas and apply them to data, and learn how to use the “paste special” operation.

I. Whale population.

- Launch Microsoft Excel.

This exercise is based on the Discovery Project on page 540. We begin by doing some formatting on our spreadsheet, so that our results will be clear and easy to read.

- Type “transition matrix” into cell B1, “current population” into cell F1 and “population after 1 year” into cell H1. Notice that the words you are typing come out in the formula bar above the column headings. While you are typing, a checkmark and an X appear to the left of the formula bar. Clicking the checkmark is essentially the same thing as pressing enter. Clicking the X aborts the typing and returns the cell to its original state. After you have typed each word, click the checkmark, or press enter.
- Before column A, there is a gray column containing the row numbers. Click on the row number 1 in the gray area. Click the **B** in the tool bar to make the entries in this row bold.
- Type the word “immature” in cell B2, and click the checkmark. With Cell B2 selected, go to the edit menu and choose copy. Click on cell A3, and choose paste from the edit menu. Also paste the word immature into cell A9.
- Type the word “juvenile” in cell C2 and the word “adult” in cell D2. Copy and paste the word “juvenile” into cells A4 and A10. Copy and paste the word “adult” into cells A5 and A11.

Whales are considered immature for their first year of life, juvenile for their second year and adult thereafter. We will construct a transition matrix to model the whale population.

1. Write the information given below into the following table. Put in 0.8 for 80%, etc.

	% of immature whales that	% of juvenile whales that	% of adults that
become/produce an immature whale			
become a juvenile whale			
become an adult whale			

Six of the entries come from this data; use common sense to fill in the other three. 0% of the immature whales remain immature. (Immature is only for the first year.)

0% of the juvenile whales remain juvenile. (Juvenile is only for the second year.)

80% of the adult whales remain adult whales (20% of the adults die each year.)

10% of the immature whales survive to become juveniles.

30% of the juveniles become adults.

The number of immature whales born each year is 40% the number of adults.

- Type the matrix into your spread sheet in cells B3 through D5.
2. Currently (in year 0), there are 600 immature whales, 400 juveniles and 3500 adult whales. The number of immature whales next year (in year 1) is given by

number immature whales in year 0	*	percent of immature whales that remain immature	+	number of juvenile whales in year 0	*	percent of juvenile whales that become immature	+	number of adult whales in year 0	*	percent of adult whales that give immature whales
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Write this as a product of two matrices, a 1x3 matrix and a 3x1 matrix. Calculate the result and write a sentence giving the result.

3. Write down two matrices, one 3x3 and one 3x1 that you can multiply to get the (3x1) matrix with entries that show the number of immature, juvenile and adult whales in year 1. Do the matrix multiplication and express your answer as a 3x1 matrix. You will use this answer to check that your spreadsheet calculation is correct.

- Type the current numbers of immature, juvenile and adult whales into cells F3-F5.
- You will use the spreadsheet to calculate the population after 1 year. Here is how to type in the formulas. The first one is typed in for you. Write in the other two, and then type them, including the equals sign into cells H3, H4 and H5, respectively.

<p>These are the cells containing your transition matrix</p> <table border="1"> <tr><td>B3</td><td>C3</td><td>D3</td></tr> <tr><td>B4</td><td>C4</td><td>D5</td></tr> <tr><td>B5</td><td>C5</td><td>D5</td></tr> </table>	B3	C3	D3	B4	C4	D5	B5	C5	D5	<p>These cells contain matrix with the current population</p> <table border="1"> <tr><td>F3</td></tr> <tr><td>F4</td></tr> <tr><td>F5</td></tr> </table>	F3	F4	F5	<p>Multiply the matrices to get formulas for the population one year later.</p> <table border="1"> <tr><td>=B3*F3+C3*F4+D3*F5</td></tr> <tr><td>=</td></tr> <tr><td>=</td></tr> </table>	=B3*F3+C3*F4+D3*F5	=	=
B3	C3	D3															
B4	C4	D5															
B5	C5	D5															
F3																	
F4																	
F5																	
=B3*F3+C3*F4+D3*F5																	
=																	
=																	

- When you type these formulas into the spread sheet, it should show the answer that you found for the last part of question 2.

Now you are going to use this formula to figure out the population in subsequent years.

- In cell A8 type the word "year." In cell B8, type 0, in cell C8 type the formula =B8+1, and press enter. Now with cell C8 selected, put your cursor on the bottom

right hand side of the cell. Your curser should change into a small black plus shape. Hold the mouse so that the curser shows that plus shape, press the left mouse button, and holding it down, drag to the left to cell L8. You should now see the numbers 0 through 10 in these cells.

- Select the 3x1 matrix in cells F3-F5, and go to the edit menu and choose copy. Notice you can tell which cells have been copied by the flashing dashed border on the cells. Click on cell B9 to activate it. Choose paste from the edit menu.
 - Select the 3x1 matrix in cells H3-H5, go to the edit menu and choose copy. Click on cell C9 to activate it. If you simply choose paste from the edit menu, you would get an error (try it if you want); when you paste a formula, Excel changes the cells in the formula. What we want to do is paste only the values, not the formulas, into cells C9-C11. To do this, choose paste special... from the edit menu. Click on values, and click OK.
 - Save your work.
 - Now you are going to start with the data from year 1 and use your matrix to calculate the populations in year 2. Copy the data in cells H3-H5, if the border is not already flashing. Click on Cell F3. Choose paste special from the edit menu, click on values, and click OK. The values in cells H3-H5 will change accordingly, to show the populations a year after the populations you put into cells F3-F5. Copy the data in cells H3-H5 if the border is not already flashing. Click on cell D9, and do paste special (values).
 - Now repeat the process to calculate the population in years 3-10, and paste them into the table. You can use the keystroke control-c instead of choosing copy from the edit menu; however there is no keystroke for paste special. At the end of this process you should have data in cells B9-L11.
 - Save your work.
 - In cell A12, type "total." In cell B12, type $=B9+B10+B11$
Click the checkmark. Now with cell B12 selected, put your curser on the bottom right hand side of the cell. Your curser should change into a small black plus shape. Hold the mouse so that the curser shows that plus shape, press the left mouse button, and holding it down, drag to the left to cell L12. Excel should calculate the total population in each of the years.
 - Save your work.
4. What is happening to the whale population of adult whales as time progresses? Do you think the number of adult whales will ever increase? Answer in a sentence.

Now we will make a chart plotting the total whale population as a function of years. First we will make a table showing just the totals as a function of year.

- Select cells A8-L8, and copy. Click on cell A15, and choose paste special... from the edit menu. Click two things: values and transpose. Then click OK.
- Select cells A12-L12, and copy. Click on cell B15, and choose paste special... from the edit menu. Click two things: values and transpose. Then click OK.

Now we will make an xy-scatter plot of this data.

- Select the data (cells A16 to B26).
- Choose Chart... from the Insert menu. A dialog box called “Chart Wizard – Step 1 of 4 – Chart Type” will appear. Click on x-y scatter plot. Click Next.
- The title of the dialog box changes to Step 2 of 4 – Chart Source Data. We won’t use these options at this time. Click Next.
- Step 3 of 4 – Chart Options. Click on the Titles tab, if it is not already selected. Type a title for your chart. For the Value (X) axis, type Year. For the Value (Y) axis, type Total Whale Population. Click the tab at the top of the dialog box that says Gridlines. Check Major gridlines under Value (X) axis and Value (Y) axis. Click Next.
- Step 4 of 4 – Chart Location. This dialog box allows you to choose whether the chart will appear in a new window, or as a part of the worksheet containing the data. Mark the “As an object in” radio button, if it is not already marked. Click Finish.

The relationship between the x and y values on this graph do not quite appear linear. In fact this model is exponential. You will now add a trendline that is exponential. Click on the chart to make it active (black squares will appear around its perimeter).

- From the menu bar, click the Chart menu and then choose Add Trendline... A dialog box will appear.
- Under Trend/Regression Type, click on Exponential. Click on the Options tab. Click in the box beside Display equation on chart. Click OK.
- An exponential curve of best fit should now appear, along with the equation of the line. Click on the equation itself and drag it to the white space where it shows.
- Click in cell A1. From the menu bar, choose File and then “Print preview.” You will see an image showing how the page will print. Click close. You will see dotted lines showing the page breaks in your document. Drag and drop the chart so that it fits entirely in the first page. You may need to adjust the chart’s size. Do this by clicking on the chart to activate it, and then clicking and dragging one of the corners of the chart, to adjust its size. Click in cell A1, and do Print preview again. If all is well, click print.
- Save your work.