### Computer Project: Population Migration

**Name_________________________________________**

**ATTACH YOUR PLOTS AND TURN IN WITH THIS PAPER.**

**Purpose**: To study the population movement described in Exercise 11, Section 1.9 in more detail.

**Prerequisite**: Section 1.9

**MATLAB functions used**: *, /, :, for, end, plot, print; and Lay’s Toolbox

1. Read Exercise 11, Sec. 1.9. Notice this is a simple migration model, which assumes people just move around and the total population of the US remains constant; so if \( \mathbf{x} \) is a vector whose components are the number of people in each area this year, then \( \mathbf{Mx} \) is the number in each area next year.

   (a) To obtain the data for this exercise, type the lines
   ```
c1s9
11
```
   You will get
   \[
   \mathbf{M} = \begin{bmatrix} 0.9828 & 0.0026 \\ 0.0172 & 0.9974 \end{bmatrix} \quad \text{and} \quad \mathbf{x}_0 = \begin{bmatrix} 29716000 \\ 218994000 \end{bmatrix}.
   \]

   (b) (hand) Describe the calculations needed to produce the entries in \( \mathbf{M} \), based on the information in the text.

2. Continue to consider the migration model described above.

   (a) Calculate the population in CA and in the rest of the US for the years 1990 - 2000 and store that data as the columns of a matrix \( \mathbf{P} \).

   To do this, type the lines below. The first line converts the population data to millions. The second line builds \( \mathbf{P} \) one column at a time: the loop `for i = 1:10 end` causes MATLAB to perform the commands \( \mathbf{x} = \mathbf{Mx}; \ \mathbf{P} = [\mathbf{P} \ \mathbf{x}] \); ten times; each iteration calculates a new \( \mathbf{x} \) and adjoins that new column to the columns already in \( \mathbf{P} \). To learn more, type `help for` or see the MATLAB boxes in the Study Guide. The semicolons suppress printing during the calculations. The third line causes \( \mathbf{P} \) to be displayed after the calculations are finished.

   \[
   \mathbf{x} = \mathbf{x}_0/1e6 \\
   \mathbf{P} = \mathbf{x}; \ \text{for} \ i = 1:10, \ \mathbf{x} = \mathbf{Mx}; \ \mathbf{P} = [\mathbf{P} \ \mathbf{x}]; \ \text{end}
   \]

   Record the data from \( \mathbf{P} \) in the table below. Round each number to 5 digits.

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   (b) Plot the population in CA, and the population in the rest of the US, versus years, on the same graph. The following lines will do this:

   ```
yr = 1990:2000
plot(yr, P), axis([1990 2000 20 240])

(c) Print your graph, title it, and label each curve “CA” and “US.” You can do labeling by hand after printing, or use the commands title, xlabel, ylabel, gtext before printing. Attach the plot to this paper.

3. Suppose instead that the population is actually increasing each year because of immigration from outside the U.S., say 0.1 million people immigrate to CA and 2 million to the rest of the US each year. Then if data is expressed in millions and \( x \) is the population vector this year, \( Mx + \begin{bmatrix} .1 \\ 2 \end{bmatrix} \) will be the population vector next year.

(a) Calculate the new population predictions for 1990-2000; the following lines will do this:

\[
x = x0/1e6, \quad d = [.1; 2]
\]

\[
P = x; \quad \text{for } i = 1:10, \quad x = M*x + d; \quad P = [P \ x]; \quad \text{end}, \quad P
\]

Record the data from \( P \) in the following table. Round each number to 4 or 5 digits.

**Population in millions, assuming external migration**

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<td>Rest of US</td>
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(b) Arrow up to execute the plot command you typed before. This will produce a graph of the new data; print and label this graph as instructed above, and attach to this paper.

Notes about printing graphics:

In MATLAB 4 or 5, you can print the current graphics screen by typing the command print. Or you can display the graphics screen and choose Print in the pulldown File Menu on the Graphics screen. Type help print for more information.