APM 153 LECTURE THREE – Variables, Review of Matrix Math, Assignment One

Variables

(1) We can think of a variable as a “box” that holds one or more pieces of data.

(2) In Matlab, if we type **x = 2**, we create a variable called “x” and place the value 2 inside it.

(3) If we type **x = [2, 4, 6]**, we create a variable of the same name with three values stored inside as a single row of numbers.

(4) And last, if we type **x = [2, 4, 6; 4, 5, 6]**, we create a **two dimensional array** of values stored as a set of two rows and three columns.

(5) If a variable is set to hold **one number** it is called a **scalar**.

(6) A **single column** or a **single row** of numbers is called a **vector.**

(7) A two dimensional arrays is a matrix. The **plural** of matrix is **___________________**

(8) Often in mathematics we use letters of the alphabet (x, y, z, etc.) to represent variables. However in programming often we also use words or names.

(9) For example, if I wanted to store a number that represented the speed of light, I might create a variable written as **Speed_of_Light** written with underscores between the words or **SpeedOfLight** written as one word.

(10) We write variables this way to keep from **confusing** the computer which would interpret the three separate words “Speed”, “of”, and “Light” as three separate variables.

(11) Following mathematical convention, we usually use capital letters to represent matrices and lower case letters to represent vectors as in,…

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix} \quad \text{and} \quad b = [1 \;\; 2 \;\; 4]$$

Review of Matrix Math

(1) Matrix math differs from regular mathematical operations. For example, **matrix multiplication** combines **multiplication and addition**. The most important thing to remember however is what should be the result of different matrix operations.

(2) Multiplication of a **scalar by a scalar** $3 * 4 = 12$ $u * v = uv$
The result is a **scalar.**

(3) Multiplication of **vector by a scalar** $3 * [2, 4, 6] = [3*2, 3*4, 3*6] = [6, 12, 18]$
The result is a **vector** of the same length as the original vector.

(4) Multiplication of a **matrix by a scalar** $3 * \begin{bmatrix} 2 & 4 & 6 \\ 1 & 2 & 3 \end{bmatrix} = \begin{bmatrix} 3*2 & 3*4 & 3*6 \\ 3*1 & 3*2 & 3*3 \end{bmatrix}$

The result is a **matrix** of the same size $= \begin{bmatrix} 6 & 12 & 18 \\ 3 & 6 & 9 \end{bmatrix}$

(5) Multiplying by a scalar effects every **element** of a vector or matrix equally.

(6) The result of multiplying a **vector by a vector** is a **scalar**, which is also known as the **dot product** of the two vectors. (Note **both vectors** must be of the **same length**.)

b = [1 2 3] c = [3 4 5] b*c = [1*3 + 2*4 + 3*5] = **26**

(7) Multiplying a **matrix by a vector** results in a **vector** as shown below.

$$b = [5\ \ 6\ \ 7] \qquad A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 4 & 9 \end{bmatrix}$$

b*A = [(5*1 + 6*4 + 7*7), (5*2 + 6*5 + 7*8), (5*3 + 6*6 + 7*9)] = [**78, 96, 114**]

(8) When multiplying a matrix by a vector, the **length of the original vector** must be equal to the height of the matrix. The **length** of the **resulting vector** is equal to the width of the **matrix.**

(9) For example, take a look at the vectors **a, and b**, and matrices **A, B, and C** below.

a = [2 4] b = [2 3 4]

$$A = \begin{bmatrix} 2 & 4 & 6 \\ 8 & 10 & 12 \end{bmatrix} \qquad B = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix} \qquad C = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

Which of the following are possible and what would be the length of the resulting vector?

a*A ________________________ a*B ________________________

b*A ________________________ b*B ________________________

a*C ________________________ b*C ________________________

(10) Multiplying a **matrix by a matrix** results in **new matrix**.

(11) In order to multiply two matrices together, the number of **columns of the first matrix** must be equal to the number of **rows of the second matrix**..

(12) The shape of the resulting matrix will be as tall as the first and as wide as the second matrix. In other words, the resulting matrix will have the same number of **rows as the first** and the same number of **columns as the second** matrix

(13) Given the two rules outlined in statements 11 and 12 above, which of the following operations are possible and if it is possible, what would be the shape of the resulting matrix?

A*B ________________________ B*A ________________________

B*C ________________________ C*B ________________________

A*C ________________________ C*A ________________________

(14) One last aspect of matrix math we need to examine is the difference between **row** and **column** vectors.

(15) A vector is a string of numbers. If the numbers are arranged in a single row, we say that the vector is a **row vector**. If the numbers are arranged as a single column of numbers we say that is a **column vector**.

Typing a = [1 2 3] in Matlab creates a **row vector.** a = [1 2 3]

Typing b = [1; 2; 3] in Matlab creates a **column vector**. b = $\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$

(16) The difference between column vectors and row vectors matters because the **shape** (the number of rows and columns) of both vectors and matrices determines whether or not you can multiply one shape by the other.

(17) For example, given the row and column vectors **a and b** above and the matrices **A, B, and C** below, which of the following operations is possible?

$A = \begin{bmatrix} 2 & 4 & 6 \\ 8 & 10 & 12 \end{bmatrix}$ $B = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$ $C = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$

A*a ____________________________ A*b ___________________________

B*a ____________________________ B*b ____________________________

C*a ____________________________ C*b ____________________________

(17) When multiplying a vector by a matrix as in the six examples above, what is the result of all the operations above that are possible?

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Assignment One (Due at the beginning of lab on Friday, January 27th)

Start the Matlab program, change the working directory to your USB drive, and open a new diary file by typing in the following

```
                diary   assignment1.txt
followed by     diary   on
```

Use Matlab to solve the following problems. As you work, the diary file will record everything you type in and every result Matlab returns.

(1) Suppose that the variables x = 1 and y = 3. **Evaluate** the following equations.

(a) $\frac{4x}{3y}$ (hint, how do you **multiply** and **divide** in Matlab?)

(b) $\frac{2y^{-2}}{(x + y)^2}$ (hint, how do you use **exponents** in Matlab?)

(c) $\frac{y^3}{x^3 - y^3}$ (hint, what should you put in **parentheses**?)

(d) $\frac{4}{3}$ p y^2 (hint, how do you use p in Matlab?)

(2) Assume that A, B,c, D are defined as follows, and calculate the results of the following operations, if they are possible. If they are not possible, explain why.

A = [2 -2]
[-1 2]

B = [1 -1]
[0 2]

c = [1]
[2]

D = [1 0]
[0 1]

(a) A plus B (hint, how do you add matrices?)

(b) A times D (hint, how do you multiply matrices?)

(c) A .* D (hint what does .* do? - page 49)

(d) A times c

(e) A .* c

(f) A \ B (hint, what is the difference between \ and / ?

(g) A .\ B

(h) A .^ B (hint,… well, you get the hint)

3. Question - What kind of matrix is D? (hint, what does the book say about matrices that consist entirely of ones and zeros?

What to turn in for Assignment One

(1) After you have completed the calculations listed above, your diary file will contain a record of all the stuff you typed into Matlab as well as the results. If you made an error and had to type something in twice, both versions will be in the diary file. If you tried to multiply two matrices together and Matlab wouldn't let you, the error message you got will be in the diary file.

(2) Once you have finished working in Matlab, exit the program. Your diary file will be stored on your USB drive. Start Microsoft Word and OPEN your diary file from your USB drive.

(3) Edit your diary file. Start by typing your name, course number, assignment number, and date at the top of the diary file.

Joseph Cornell
APM 153
Assignment One
January, 27 2006

(4) Next, edit your diary file to clean it up. If you made an error, you can delete the part of the diary file that recorded the error.

(5) Last, add comments to your diary file. If you need to explain why something did or did not work in Matlab, write a comment about what happened at that point in the diary file.

(6) Finally, save your edited diary file as a Microsoft Word document (Assignment1.doc). Print out a hardcopy of your document. You will turn in the hardcopy of Assignment1.doc in lab on Friday. Turn your work in on time!