Guided Practice: Arrays in MATLAB

OVERVIEW:

Define, index, and manipulate vectors and matrices in MATLAB

LEARNING OBJECTIVES:

Basic:

1) Identify array variables in MATLAB
2) Distinguish between matrix and vector array variables in MATLAB
3) Distinguish between column vector and row vector array variables in MATLAB

Advanced

4) Create and store array variables in MATLAB
    a. Create array variables from scratch
    b. Create array variables using MATLAB built-in functions
    c. Create array variables from other array variables
5) Extract value(s) from an array variable in MATLAB (using indices)
6) Modify existing array variables in MATLAB, assign specific section(s) of an array variable
7) Operate on array variables in MATLAB correctly
8) Manipulate arrays in MATLAB to solve engineering problems

EXERCISES:

Part A: Complete the following activities <u>before</u> lecture:

1) Complete (finish work started in previous modules) "Learn to Code with MATLAB" tutorial parts 3 – 4: https://learntocode.mathworks.com/portal.html
2) Watch "Working with Arrays in MATLAB": https://youtu.be/q8lUOI0uqTo until minute 5:00 (you can watch entire video, but some topics have not been covered yet and result in confusion)
3) Watch "Matlab Tutorial – 39 – Multiplying and Dividing Matrices Element-by-Element": https://youtu.be/qfvd2cHaXQw
4) Read "MATLAB for Engineers" by Holly Moore:
5) Chapter 2, p. 14
6) Chapter 2, section 2.3.2, p. 27-38
7) Chapter 4, p. 119 – 140

Part B: Complete the following exercises <u>during</u> lecture. Please submit hard copies of your work before leaving class.

Activity 1:

The Module Quiz for Arrays in MATLAB will be available at the beginning of class (you will either be instructed to access it from Canvas or instructor will bring a hard copy for you). Refer to "Module Quiz – MATLAB Arrays.pdf" document and follow instructions on document.

Instructions for *Think-Pair-Share* activities:

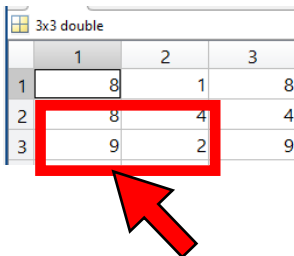| Steps	Description	Time
1. **Think:**	Think and write down your answers to the question(s) <u>individually and in silence.</u>	7 min.
2. **Pair:**	Pair with your neighbor, compare and discuss your answers, and <u>prepare</u> to share your findings.	3 min.
3. **Share:**	Discuss findings as a class	5 min.

Activity 2: Think-Pair-Share (refer to "Instructions for *Think-Pair-Share* activities" above)

The following command has been executed in the MATLAB Command window:
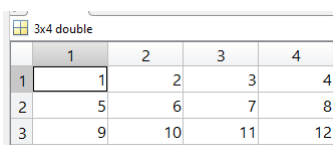>> A = [8, 1, 8; 8, 4, 4; 9, 2, 9]

Write the MATLAB command(s) to:

1) Take the elements of matrix A **column-wise** and put them together as a **column vector** named "a":

2) Take the elements of matrix A **row-wise** and put them together as a **column vector** named "b":

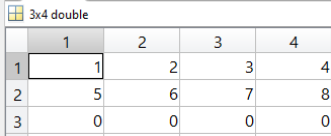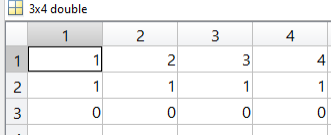3) Create a matrix named "C" with the elements in matrix A indicated in the red box:

Activity 3: Think-Pair-Share (refer to "Instructions for *Think-Pair-Share* activities" above)

Write the MATLAB command(s) to create the following matrices:

1)

2)

3x4 double	1	2	3	4
1	1	2	3	4
2	5	6	7	8
3	0	0	0	0

3)

3x4 double	1	2	3	4
1	1	2	3	4
2	1	1	1	1
3	0	0	0	0

4)

3x4 double	1	2	3	4
1	4	3	2	1
2	1	1	1	1
3	0	0	0	0

Activity 4: Think-Pair-Share (refer to "Instructions for *Think-Pair-Share* activities" above)

The following command has been executed in the MATLAB Command window:
```
>> A = [8, 1, 8; 8, 4, 4; 9, 2, 9]
```

Write the MATLAB command(s) to:

1) Take the elements of matrix A **column-wise** and put them together as a **column vector** named "a":

2) Take the elements of matrix A **row-wise** and put them together as a **column vector** named "b":

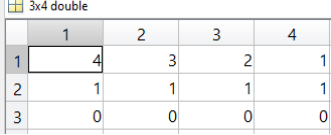3) Create a matrix named "C" with the elements in matrix A indicated in the red box:

Part C: Complete the activities in "AE 30 – Lab 02 – Arrays in MATLAB.pdf" during lab. Submission instructions are included in the document.

Lesson: Arrays in MATLAB

Timeframe: 5 hrs. 2 min. 57 sec.

Materials needed:
- Pre-class activities:
  - Access to Canvas to retrieve and submit assignments and access resources
  - Access to a computer equipped with:
    - Access to internet
    - Keyboard and mouse for navigation and text entry
    - Capability to stream online videos
  - Copy of textbook "MATLAB for Engineers" by Holly Moore
- In-class activities (lecture and lab):
  - Access to Canvas to retrieve and submit assignments and access resources
  - Copy or access to "Module Quiz – Arrays in MATLAB.pdf" posted on Canvas
  - Copy or access to "Guided Practice Lucia Capdevila_R1.docx" posted on Canvas
  - Writing utensils and paper
  - Graphing calculator
  - Access to computers in ENG 407 computer lab
- Post-class activities:
  - Access to Canvas to retrieve and submit assignments and access resources
  - Access to a computer equipped with:
    - Access to internet
    - Keyboard and mouse for navigation and text entry
    - Capability to stream online videos
    - MATLAB
  - Copy of textbook "MATLAB for Engineers" by Holly Moore

Objectives:

Overarching:
Define, index, and manipulate vectors and matrices in MATLAB
Basic:
1) Identify array variables in MATLAB
2) Distinguish between matrix and vector array variables in MATLAB

3) Distinguish between column vector and row vector array variables in MATLAB

Advanced

4) Create and store array variables in MATLAB
   a. Create array variables from scratch
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5) Extract value(s) from an array variable in MATLAB (using indices)
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Background to the Lesson: The typical composition of learners in AE 30 at SJSU are aerospace engineering students that have never programmed before and students that either do not know MATLAB or do not know C. Students are not required to have any linear algebra background prior to taking AE 30. This lesson, on arrays, takes place during the second "module" (lecture + lab sequence) of the semester. Prior to this class, students have become familiarized with the MATLAB environment, and have learned how to store single values in variables in MATLAB. Students usually struggle with identifying the indexes associated with certain elements in a matrix variable in MATLAB, for the purpose of extracting/inserting a value from/into a matrix variable.

Introduction to Lesson: Learning how to manipulate array variables in MATLAB will enable students to easily carry out computations and generate and/or manipulate data in MATLAB in order to complete engineering analysis. The current lesson familiarizes the students with MATLAB arrays before they come into the classroom through tutorial, demo videos, and reading. During lecture, the prep work will be assessed by means of a quiz. Then, we practice writing code by hand to learn how to manipulate arrays with simple small group activities. During lab, we use the skills acquired in class to solve engineering problems in MATLAB.

Procedure:

Pre-Class Individual Space Activities and Resources:

Step #	Instructions	Purpose	Estimated Time	Learning Objective(s)
1	Complete (finish work started in previous modules) "Learn to Code with MATLAB" tutorial parts 3 – 4: https://learntocode.mathworks.com/portal.html	Introduction to creating, manipulating, and indexing column vectors in MATLAB	23 min. 46 sec.	1-5, 7

Step #	Instructions	Purpose	Estimated Time	Learning Objective(s)
2	Watch "Working with Arrays in MATLAB": https://youtu.be/q8lUOI0uqTo	Demonstrate how to create and index vectors and matrices in MATLAB	5 min. (full video length: 8 min. 21 sec.)	1-5
3	Watch "Matlab Tutorial – 39 – Multiplying and Dividing Matrices Element-by-Element": https://youtu.be/qfvd2cHaXQw	Demonstrate how to do element-by-element array arithmetic (non- linear algebra operations)	11:23 min.	7
4	Read "MATLAB for Engineers" by Holly Moore: - Chapter 2, p. 14 - Chapter 2, section 2.3.2, p. 27-38 - Chapter 4, p. 119 – 140	- Introduction to creating arrays in the MATLAB Command Window. - Element-by-element operations, the dot operator and its use before *, /, and ^ operators. The transpose operator: '. - Define matrices, and how to extract values.	42 min. 48 sec.	1-5, 7

In-Class Group Space Activities and Resources:

Step #	Description	Purpose	Estimated Time	Learning Objective
1	(During lecture) Activity 1: - Take module quiz on MATLAB arrays. Refer to "Guided Practice Lucia Capdevila_R1.docx" and "Module Quiz – MATLAB Arrays.pdf" documents. - Collect - Go over answers	Assess effectiveness of pre-class individual space activities and readiness for class	5 min.	1-3
2	(During lecture) Think, pair, share for Activity 2 (see "Guided Practice Lucia Capdevila.docx" document)	Practice objective 4 and 5	15 min.	4-5

3	(During lecture) Think, pair, share for Activity 3 (see "Guided Practice Lucia Capdevila.docx" document)	Practice objective 4	15 min.	4
4	(During lecture) Think, pair, share for Activity 4 (see "Guided Practice Lucia Capdevila.docx" document)	Practice objective 5	15 min.	5
5	(During lab) Complete lab activities (see "AE 30 – Lab 02 – Arrays in MATLAB.pdf" document)	Practice objectives 6-7	2 hrs. 50 min.	6-7

***Post-Class Individual Space Activities and Resources*:**

Step #:	**Description**	**Purpose**	**Estimated Time**	**Learning Objective**
1	Finish lab activities if needed	Practice objectives 6-7	Activities are designed to be completed during lab and many students do, but sometimes students leave without finishing lab activities before lab time is over. Currently, I don't have any insight into how many hours students are taking outside lab to finish lab activities.	6-7

Evaluation:

Analysis. Students may not do the prep work. I also think there will be some inertia to doing the in-class activities, but students will do them. If students have not prepared, it may be more challenging to answer questions during class, but it should be OK.

Connections to Future Lessons. Arrays will be part of most lessons going forward. In the next module, students will learn how to plot data. It is necessary to understand how to manipulate arrays in MATLAB first in order to be able to generate graphics from the data stored in arrays later.

Lab 2: Introduction to MATLAB

Problem 1:

Create a MATLAB script that accomplishes the tasks in problem 2.14 on p. 59

Problem 2:

Create a MATLAB script that accomplishes the tasks in problem 3.16 on p. 115.
Report the maximum range and the angle when the maximum range occurs in the form of a comment at the end of your script.

Problem 3:

Posted together with this lab document there is a data file named **sensor.dat** that contains temperature sensor data in Farenheit for 5 different sensors. The first column, however, is time data in seconds. Download and save **sensor.dat** to the <u>same folder</u> where you are working on the script for this problem.

(a) Use the `load()` command in MATLAB to load the sensor data provided in the **sensor.dat** file. Use the `size()` command in MATLAB to calculate the number of rows and columns in the data.
(b) Calculate the minimum and maximum value for each sensor.
(c) Find the mean and standard deviation for each sensor, and for the entire data set.

Note: You may need to use the "Help" button/function in MATLAB to learn how to use some of the built-in MATLAB functions required to complete the tasks in this problem.

> ➢ Make sure your M-files comply with M-File Style Rules: Canvas > AE30 Course > Modules > Reference Documents > **AE30_Spring2018_MFile_StyleRules.pdf**
> ➢ Follow Canvas submission guidelines: Canvas > AE30 Course > Modules > Reference Documents > **AE30_Spring18_Canvas_Submission_Guidelines.pdf**
> ➢ Submit your m-files for problems 1 – 3 and the **sensor.dat** file to Canvas by the posted due date/time that appears on the Canvas assignment.
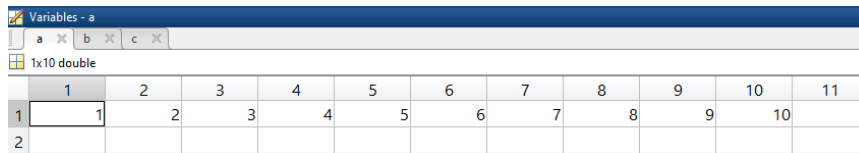
Module Quiz - MATLAB Arrays

Instructions/Rules:

- Time allowed is 3 minutes.
- Answer the following questions individually and in silence.
- When you are done, please raise your hand for your paper to be collected from you.
- We will go over answers as a class.

Questions:

1) Which of the following symbols is used to create a matrix variable in MATLAB? (select ALL that apply)
   a) ()
   b) []
   c) {}

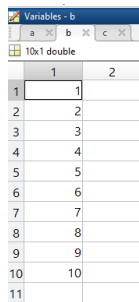2) For each of the following variables in MATLAB a) – c), select the corresponding variable type i – iii:

   a)
      i. Row vector array
      ii. Column vector array
      iii. Matrix array

   b)
      i. Row vector array
      ii. Column vector array
      iii. Matrix array

	1	2	3	4	5	6	7	8	9	10	11
1	1	2	3	4	5	6	7	8	9	10	
2	2	4	6	8	10	12	14	16	18	20	
3	3	6	9	12	15	18	21	24	27	30	
4	4	8	12	16	20	24	28	32	36	40	
5	5	10	15	20	25	30	35	40	45	50	
6	6	12	18	24	30	36	42	48	54	60	
7	7	14	21	28	35	42	49	56	63	70	
8	8	16	24	32	40	48	56	64	72	80	
9	9	18	27	36	45	54	63	72	81	90	
10	10	20	30	40	50	60	70	80	90	100	
11											

c)
    i.   Row vector array
   ii.   Column vector array
  iii.   Matrix array

3) Assume array c in question (1) above is already available in the MATLAB Workspace, what will be the value stored in variable x according to the command below:

```
>> x = c(3,4)
```