Faculty of Engineering
MM1CPM

Worksheet 3

Q1: Simple array manipulation – student marks

This question involves building a script file to process student marks. Each time you change the script, rerun it to see if your changes to the script work.

a) Define the array called student_marks as [80 70 80 60 30 80 0 70].

b) Set variable 'a' equal to the 1st element of student_marks.

c) Set variable 'b' equal to the 2nd element of student_marks.

d) Calculate the average of the variables a and b.

e) Using the bracket notation '(' ')' calculate the average student mark for all students excluding the student who got the 0.

f) A secretary made a mistake when entering one student's mark. You type student_marks(5)=80 into your MATLAB script to correct this. What has happens to the array? Describe this in one sentence and add it to your script as a comment.

g) One student was ill and could not take the exam she got awarded 0 marks. After resitting the exam, she got 80. Add a line of code to your script to change the 0 value to the correct mark.

Q2: Simple array manipulation – temperature data

You are processing temperature data from a weather station on a volcano. You are given the following array of data [30 31 31 33 100 32 32 34 30 31 31 100 19 32 32 34] containing temperature readings in degrees Celsius. Either type this array into MATLAB or copy and paste it from the PDF on moodle to form a new array called 'temp', you should do this in a new script file called volcano.m. The whether station records one temperature value every day, the first data point in the array represents a Monday.


Figure 1: Mt Cleveland erupting

a) On Friday of the first week the volcano starts erupting - spewing out hot gasses and the weather station records a value of 100 C this is not representative of weather around the volcano. Try to correct the data to calculate what the air temperature would be if the volcano were not erupting by taking the average temperature from the day before and the day after the eruption. Extract these values from the array, and average them. Then overwrite the value of 100 C with the averaged temperature value.

b) The volcano erupts again on the following Friday, again try to guess what the actual air temperature would be if the volcano were not erupting by averaging the air temperature between the Thursday and the Saturday. Again update the array to contain a more realistic temperature value for the region.

c) Plot the array with the corrected temperature values. Give the x-axis and y-axis an appropriate label with appropriate units. Then place a title on the graph.

d) Using the : notation (see the lecture notes for an example) form two new arrays called week_a and week_b containing all the temperature data from the first and second week.

e) Calculate the average temperature for the first and second week, both for the corrected data and for the uncorrected data.

Q3: Defining 2D arrays by hand

In a new script define the following arrays in MATLAB:

a) $a=\begin{bmatrix} 1 & 2 \\ 4 & 5 \end{bmatrix}$ b) $b=\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 9 \\ 6 & 7 & 8 \end{bmatrix}$ c) $c=\begin{bmatrix} 1 \\ 2 \\ 3 \\ 1 \\ 4 \\ 5 \\ 9 \\ 1 \end{bmatrix}$

d) $d=\begin{bmatrix} 0 & 1 & 2 & 3 & 4 & 3 & 2 & 1 & 0 \end{bmatrix}$ e) $e=\begin{bmatrix} 1 & 2 & 3 & 1 \\ 4 & 5 & 9 & 1 \end{bmatrix}$

f) Using the : notation extract the array [1 2 3 4 3 2 1] from array d, there are examples of how to do this in your lecture notes.

Q4 Defining 2D arrays automatically:
This question lets you practice generating 2D arrays using MATLAB built in functions, each time you edit the script check that your changes work by running it. Make a new script that does the following things:
a) Define a 2x2 2D array called 'a' containing random numbers between 0 and 1. There is an example of how to do this in the lecture notes.

b) Print the element at 1,1 from array a.

c) Print the element at 2,2 from array a.

d) Swap the elements 2,2 and 1,1 in array 'a', by first storing the element at 1,1 in a new variable 'temp'. Then overwrite element 1,1 with the value in 2,2. Finally overwrite element 2,2 with the value stored in temp. This should swap the values.

e) Define a 1x10 2D array containing random numbers between 0 and 1 called 'e'.

f) Define a 10x1 2D array containing random numbers between 0 and 1 called 'f'.

g) Use the **zeros** function to make an array containing just zeros of size 4x4.

h) The command **eye** works just like the **rand** and **zeros** commands. By experimentation with it or using the help can figure out what it does?

i) By experimentation figure out what the command **ones** does.

j) Define the array g as a random 2D array of 40x40 points, use the surf command to plot this in 2D. Try to rotate the figure using the tools in the tool bar until it lies flat and you have a 2D image.

Q5: Manipulating 1D arrays loaded from a file – Part 1
Download the zip file co2.dat from moodle. This file contains the monthly CO2 in the earth's atmosphere measured each month since 1958 at the Mauna Loa Observatory in Hawaii, USA.
a) Load this data file into the array a.

b) Calculate the size of the array.

c) To plot this data you will first have to split it up into two separate arrays. Extract the first and second column of data from the array into two new arrays called x and y. There is an example about extracting 1D arrays from 2D arrays in the notes.

d) Plot the x array against the y array using the plot command.

e) Label the x-axis 'Time - Years' and the y-axis 'CO2 - parts per million'.

f) What is the overall trend of the graph? Would you say the CO2 concentration is increasing linearly or exponentially? Zoom in on the graph you have just generated using the zoom tools. Can you see a recurring 12 month pattern? What could this be due to – hint it's to do with plants.

g) If you look carefully at the data, you will see that before 1970, there are some values of -99.9 recorded. This is due to missing data. Using an average of the values either side of the missing data, replace the negative values in the data with a good estimate for what the CO2 concentration could have been. Re-plot this 'corrected data'.

h) Use bracket notation to extract the first value of CO2 recorded by the observatory and store this in variable 'co2_first'

i) Use bracket notation to extract what the last value of CO2 recorded by the observatory and store this in variable 'co2_last'

j) Use bracket notation to extract the time the first observation was taken and record this in variable t1

k) Use bracket notation to extract the time the last observation was taken and record this in variable t2

l) Calculate the time the observatory has been running and store this in a new variable dt.

m) Calculate the change in CO_2 in the atmosphere since the observatory has been running and store this in a new variable 'dco2'

o) What is the rise in CO_2 level per year?

p) How many years will it take the CO_2 to reach 600 ppm – double it's current level. Hint you can do this by multiplying the rise in CO_2 per year by a guess.

Q6: Manipulating 1D arrays loaded from a file – Part 2

The data in the previous question was taken from the Mauna Loa Observatory in Hawaii. Before the 1950s regular CO_2 readings were not being taken from the atmosphere. To understand CO_2 concentrations before 1950 we have to use ice core data. When ice is formed in the Antarctic, it traps CO_2 within it. By drilling an ice core and measuring the CO_2 at each depth we can find out how much CO_2 was in the atmosphere in the past.

a) The file co2_ice_core.dat contains CO_2 data from an ice core from the West Antarctic Ice Sheet. Just as you did in question 4, plot this data on a labeled graph.

Figure 2: Coal fired power station

b) We now wish to produce a plot of CO_2 in the atmosphere from the year 900 to the present day. To do this load the data from co2.dat and append it to the data from co2_ice_core.dat before plotting it. Now you will be able to plot the graph of CO_2 in the atmosphere over the last 1000 years. Why do you think the CO_2 concentrations starts to suddenly rise at 1800? Hint: The arrays in the files co2_ice_core.dat and co2.dat run vertically, you will therefore have to use the following notation to append them c=[a ; b].

Q7 Loading and saving arrays from a file:

In questions 1-3 we got MATLAB to generate the arrays itself. Often however, you will need to load an array into the computer from a file. This exercise revises the examples covered in the lecture. From moodle download the file mars_data.zip save the file to the root of your z: drive. You will then need to extract the file mars_data.dat. For MATLAB to find the file, you will have to change the working directory of MATLAB to your z: drive. You can change the working directory by typing ***cd 'z:'***. If you have difficulties doing this ask a demonstrator. Now write a script to perform the following actions:

The file mars_data.dat shows the elevation of the entire surface of mars.

a) Load the file mars_data.dat in the variable a. Hint you can prevent the entire content of the file being displayed by adding a ; to the end of the line loading the file.

b) Use the surf command to plot the data. Why do you think the data does not look like the plots in the lecture? Use the command surf(a,'edgecolor','none') to replot the data. Does this look better – why? Many MATLAB commands can be fine tuned in this way to make your final plots look better. If a graph does not look how you expect it to look it is often worth looking at the help.

c) Use the size command to find the dimensions of the 2D array a.

d) The size command returns an array of dimensions 2x1, using the bracket notation, extract the first element of the array store and the result in variable y_len. Again, using the bracket notation, extract the second element of the array store the result in variable x_len.

e) By multiplying x_len and y_len find out how many data points are in the array. If each data point represents 21.3x21.3 km. What is the area of Mars? Do you think this figure is correct?

f) Add a colorbar to the side of the plot.

g) Rotate the plot using the tools in the toolbar of the plot window. Try to turn the 3D plot into a birds eye view, to reproduce the plots we looked at in the lecture. On the bottom right of the plot there is a large impact crater. What coordinate is this impact crater at? Again using the bracket notation, extract the depth of the impact crater.

h) It is possible to extract 2D sub regions from a larger 2D array using the : notation. Extract the region in which the crater is shown to a new array called impact. Now plot this array in 3D.

i) Extract horizontal and vertical slices of the crater again using the bracket notation to two new arrays called, v_slice and h_slice. There are examples of doing this in the lecture notes.

j) Plot v_slice and h_slice and label the axes, using the xlabel,ylabel and title commands. You can make your figures appear in a new window, by issuing the figure command before plot or surf.