INTRODUCTION TO MATHCAD

Importing Data Files Into MathCAD and Data Reduction For The Thermocouple Lab

This tutorial will enable you to import into MathCAD a set of data that is held in a text data file. The tutorial also introduces some useful ideas for getting your worksheet to (semi) automatically extract selected parts of the data for later analysis. This is useful since data acquisition systems often record more data than the amount needed for a project. In this case, you need to down-select the data before analysis.

Finally, this tutorial goes through the data reduction and analysis that will be needed for the thermocouple laboratory.

These notes are synchronized with the accompanying MathCAD worksheet and raw data file. Unlike the other tutorials in this Tutorial series, you are given a MathCAD worksheet and a file of data to work with. The worksheet has the outline of the MathCAD code for this tutorial. You will be editing this worksheet as you progress through the tutorial.

You need to download both the MathCAD worksheet and data file to your computer. Read through and note the following instructions, since you will temporarily loose them from the screen as you download the files. These instructions assume you are accessing the Tutorial directly from the EM375 web page, using a "live" version. If you are working from a paper copy of this Tutorial, you will have to modify the instructions accordingly.

Click the Internet Explorer **Back button** to return to the main EM375 MathCAD Tutorial page.

Now use the **RIGHT mouse button** to click on the link to the **Accompanying MathCAD worksheet**. Select the **"Save Target As..."** option and save the file to your PC or your Cadig N: network drive. After the file has downloaded you get a small "Download Complete" window. Click on **"Open"**. This should launch MathCAD with the worksheet file you just downloaded (leave Internet Explorer running so you can get back to this Tutorial).

Go back to the Internet Explorer window and use the **RIGHT mouse button** to click on the link to the **Accompanying data file**. Select the **"Save Target As..."** option and save the file to the same location where you saved the data file. After the file has downloaded, in the small "Download Complete" window click on **"Open"**. This will load the data file into Notepad.

Go back to Internet Explorer and use the mouse (normal left-click) to return to this **"Importing Data Files"** tutorial.

Resize and move the Explorer and MathCAD windows around the screen until you can see and use both of them.

Before continuing, make sure you have both this document and the MathCAD worksheet visible on your screen.

DATA FILE PREPARATION:

There are at least two ways of importing a file of data into MathCAD. The way we select and demonstrate in this tutorial is most suitable if you only need to import the data once. An alternative way (not described further in this Tutorial) is to set up a read/write link to the file. See MathCAD's help for more information.

The data file should be in "raw text" format. For multiple-column data, the columns can be separated by the tab character (ASCII character 9), or by commas.

The downloaded file should already be open in Windows Notepad. Look at the file. In this example, the columns are comma-delimited, with two columns of data. For this sample file, the first column contains time (in seconds), and the second contains the temperature recorded with a thermocouple. Note that the columns do not have to "line up". The comma separates the columns.

There should be NO BLANK LINES anywhere in the file. If your file is not in this format, edit it.

```
0, 70.41109
0.08333334, 70.06685
0.1666667, 70.15903
0.25, 69.57912
0.3333333, 69.6039
0.4166667, 70.54948
0.5, 69.02804
etc……..
```

If you made any changes to the file, ***Save*** it. If you used Notepad, the file is automatically saved in the correct format. If you used a word processor, make sure you save the file in ASCII text format.

Close Notepad or the word processor you used to look at the data file.

IMPORT THE FILE INTO MATHCAD:

1. Move focus to the MathCAD window that has your outline worksheet. Click somewhere near the top and select menu item **Insert, Component, Input Table*.***

You will get an empty table. At the placeholder, type in the MathCAD variable name you want to use for the table. The attached worksheets use variable name ***RawData,*** so use this name if you want to continue with the tutorial! (Remember that variable names are **CaSe sEnSiTiVe**.)

2. **Click** on a blank area of screen, and then **right-click in the empty table**. In the popup menu select **Import**. Look for, and select the raw text file you created in *File Preparation*.

3. Finally, click somewhere blank in your worksheet (or press the F9 key) and the data importing is complete. At this stage, column 0 contains the time record, and column 1 contains the recorded temperature. Below the table you should see a graph of the temperature vs. time data.

DATA SET REDUCTION IN MATHCAD

The complete data set is unsuitable for our analysis. This is because we only want to see the temperature ***after*** it has started rising. The file includes a relatively constant temperature record for the earlier times (up to about 4 seconds). We do not want to include this part of the data in our analysis. Neither do we want the data towards the end of the time history (we will discuss why later on).

The easiest way to remove the earlier and later data points is to declare variables that define which of the initial (and final) points should be eliminated. We then use the MathCAD function ***"submatrix"*** to extract a reduced data set. The sample worksheet has the following variables defined:

Start Used in the ***submatrix*** function to define the first element of the table that will be extracted to a new variable.

Stop Used in the ***submatrix*** function to eliminate the later data points since we don't use the points when the thermocouple has stabilized near T_∞.

The worksheet uses the `submatrix` function to extract the time (column 0) into a new variable, "`Time`", and the temperature into new variable `Temp`.

Enter different values for variables `Start` and `Stop`, and see the effect in the graph just after this point in the worksheet.

When you have finished experimenting, leave the values set as:

```
Start := 50
Stop := n - 90
```

THERMOCOUPLE DATA ANALYSIS

We will use the first few data points before the oven was closed to determine the initial temperature reading for the thermocouple. Similarly, we use the last few points to estimate T_∞. The example uses 30 data points to estimate T_i and a different number to estimate T_∞. You should think about how many you need to use for the data set you obtain during the laboratory.

THERMOCOUPLE THEORY: Let's hit some theory, so we know how to transform the data in preparation for a linear regression. Remember that the aim is to determine the time constant for the thermocouple.

The recorded temperature, T_i, depends on the initial temperature, T_{INIT}, the final temperature, $T_¥$, and of course, the time constant of the thermocouple, t.

$$(T_i - T_{INIT}) = (T_\infty - T_{INIT})\left(1 - e^{-(t-t_S)/t}\right)$$

In this equation, t is the clock time recorded in the data file, and t_S is the time when the oven door was closed and the thermocouple reading started to increase. We don't know t_S accurately enough to be able to guess it, so we need to keep it as a variable in the regression analysis.

Let's rearrange the equation into the form:

$$\ln\left\{\frac{(T_\infty - T_i)}{(T_\infty - T_{INIT})}\right\} = \frac{t_S}{t} - \frac{t}{t}$$

This is the equation of a straight line, with slope = -1/τ. So we transform the temperature data to give the left side of the above equation, and perform a linear regression to determine the slope, and hence time constant. We can also use the intercept of the regression to estimate t_S.

BACK TO MATHCAD: Look at the worksheet (second page).

Edit the **submatrix** command so that it extracts the first 30 temperature data points from the *original data set.*

Answer: 70.046
NOT 70.066

Look at the second **submatrix** command on this page and work out how many data points it extracts from the end of the temperature record.

How can you check that you are right? Put some code into the blank space in the worksheet to check your answer.

Did the thermocouple actually reach T_∞? What happens if you manually "program in" a value for T_∞ in your MathCAD worksheet, rather than using this 'automatic' approach? Which gives the better result? How can you tell?

Save your worksheet.

SUBMIT to your instructor:
Your instructor will tell you if they require anything to be submitted for this tutorial.

Additionally, you will be required to develop and submit **your own worksheet** for your Thermocouple Lab report.

Close MathCAD.
This introduction to Importing Data is finished!