ENGR 162 - Fall 2004

Lab Assignment 3: Matrices, Graphs & Statistics w/MathCAD

Required Reading: ENGR 162 Textbook, Chapters 1, 2 and 5.

This week we introduce MathCAD, another program that performs computations. Not surprisingly, there are differences between the Excel and MathCAD user interfaces. Excel was designed for business applications, and adapted for engineering and scientific users. MathCAD was designed for mathematical and scientific applications, and its functionality and style reflect this audience.

In MathCAD, it is easy to write and evaluate equations. Indeed, we write equations in MathCAD just as we do in everyday mathematics. The MathCAD computer screen “worksheet” is similar to a blank piece of paper. Take a moment to examine the screen. The overall layout conforms to Windows conventions; thus the Title Bar, Menu Bar, Tool Bar and Format Bar should all be familiar, except for a few new icons and commands.

Toolbars:
From the Menu Bar, select View, then Toolbars.
• The first three items (Standard, Formatting and Math) should be checked.
• Examine the Math toolbar; move the cursor to each icon and dwell on it until its description appears.
• Click on the Calculator and Evaluation icons and place the resulting menus conveniently on your screen. Examine the contents of both. By dwelling on an entry, you can see a verbal description of its meaning or function (and sometimes the keyboard entries which produce the same result as the icon).

Three Types of Equal Signs:
• Notice the three types of equal signs in the Evaluation Toolbar (=, :=, ≡).
  o The “equal” used to define or assign a value to a variable is := and may be entered from the keyboard by typing “:=”.
  o The “=” sign is used when you want MathCAD to evaluate a result.
  o The “≡” sign represents global assignment—we won’t worry about this one yet.

Use the toolbars to select Greek letters, evaluation symbols, and functions.
• To enter a superscript, use the caret ^ . To enter a subscript, use a period.
• To enter π, use Ctrl-Shift-P.

Start entering the equations as shown below and observe what happens.

\[
\begin{align*}
x & := 45 \\
y & := 4 \\
r & := 9 \text{in} \\
L & := 10 \text{in} \\
l & := r \ast y \\
z & := (x + y) \\
p & := \log (x)
\end{align*}
\]

\[
\begin{align*}
l & = 0.914 \text{m} \\
z & = 49 \\
p & = 1.653 \\
A_{cyl} & := 2\pi \ast r^2 + 2 \ast \pi \ast r \ast L \\
A_{cyl} & = 0.693 \text{m}^2 \\
\text{Area}_{\text{circle}} & := \pi \ast r^2 \\
\text{Area}_{\text{circle}} & = 0.164 \text{m}^2 \\
\text{Vol}_{\text{cyl}} & := \pi \ast r^2 \ast L \\
\text{Vol}_{\text{cyl}} & = 0.042 \text{m}^3 \\
\text{Sphere}_{\text{surfarea}} & := 4 \ast \pi \ast r^2 \\
\text{Sphere}_{\text{surfarea}} & = 0.657 \text{m}^2 \\
\text{Sphere}_{\text{vol}} & := 4/3 \ast \pi \ast r^3 \\
\text{Sphere}_{\text{vol}} & = 0.05 \text{m}^3
\end{align*}
\]

IMPORTANT:
Note that MathCAD works from top to bottom and left to right. MathCAD can only evaluate a result if the information needed is above or directly to the left of the point of evaluation. Note also how MathCAD handles units.
Entering an array of data

An array is a set of data arranged as a list or table. To enter an array, use the Matrix menu, and select the Matrix or Vector command. Insert an array C with 10 rows and one column, then another array D, with the values indicated to your right.

Computing Statistics on an Array

MathCAD can compute several statistics on a set of data, including the mean, median and standard deviation. For the arrays C and D above, obtain values for the statistics shown below. Let MathCAD compute the answers.

\[
\begin{align*}
\text{mean}(C) &= 5.3 \\
\text{median}(C) &= 5.5 \\
\text{stdev}(C) &= 2.685 \\
\text{mean}(D) &= 7.2 \\
\text{median}(D) &= 7.5 \\
\text{stdev}(D) &= 3.156
\end{align*}
\]

Graphing in MathCAD

Two vectors can be plotted against each other. On the Math toolbar, find the Graph icon, and select the X-Y Plot. A Graph area will appear. The small boxes near the axes are placeholders. Select one and enter the name of one of the vectors, then place the name of the other vector on the other axis. The plot may look strange, but you can edit it. Click on the graph, then press the right mouse button and select Format. Look at the Trace. See if you can make your graph look like the one shown at right.

Linear regression

Linear regression and several other curve fitting techniques are really easy in MathCAD. The relevant statistics and coefficients are defined on the vectors. Slope, intercept and correlation are pre-defined functions, so you can call them and use them in expressions. Below, we compute several statistics on arrays C and D, and then use those values to define the regression line. Finally, we plot the data and the regression line using the X-Y graph option. Try it out!

\[
\begin{align*}
b := \text{intercept}(C, D) &= b = 1.731 \\
m := \text{slope}(C, D) &= m = 1.032 \\
r := \text{corr}(C, D) &= r = 0.878 \\
D_{\text{pred}} := b + m \times C
\end{align*}
\]

Lab Report Style, Format and Content

Every lab report you turn in for ENGR162 should be a work of art. At the very least it should be clear, coherent and well-organized. You should define the terms and quantities used in each problem, show the series of steps you have taken to reach a result, and then we expect you to tell us what the results mean. The key ideas are to document and to explain.
ENGR162 Lab Assignment #3:

Use the ENGR 162 textbook and work the following:

Problem A: (12 points) Problem 1 on page 38.

Problem B: (12 points) Problem 3 on page 39 (Instead of R = 3 cm and r = 1.5 cm, use R = 6 cm and r = 3 cm).

Problem C: (12 points) Problem 6 on page 40.

Problem D: (12 points) Problem 7a & b on page 41.

Problem E: (12 points) Problem 9 on page 42.

Problem F: (8 points) Problem 11 on page 43
( use E = 12 volts, R1 = 30 ohms, R2 = 40 ohms and R3 = 60 ohms).

Problem G: (12 points) Problem 1 on page 143. Add “c. Which remedy has the greatest variability?”

Problem H: (20 points) In Problem 10 on page 148, answer parts a) and b). Plot V(T), Vpred(T) & T in a single graph. Comment about the fit of the regression line (Note the typo: it is Problem 6, and not 5.8). Remember, these are values estimated from a plot, they are not computations.)