WINTER 2017

ECE 102 ENGINEERING COMPUTATION
STANDARD HOMEWORK #3

ECE DEPARTMENT
PORTLAND STATE UNIVERSITY

ECE 102 Standard Homework #3 (HW-s3)

Problem List

15 pts   Problem #1 - Curve fitting

15 pts   Problem #2 - Plotting data from a file

15 pts   Problem #3 - Bad graphs

 5 pts   Following presentation format rules

General Instructions

For Problems #1 through #3:

a) Unless otherwise specified, you must show your equations and calculations to get full credit.

b) Solutions should be either hand-written on engineering paper or printed out using a computer.

c) Follow the presentation format discussed in the "Problem Solving" lecture.

   o For Problems #1 and #2, you may omit the Solution Check and Discussion.

   o For Problem #3, omit the Solution Check, but discuss your results.

   o For significant figures, you are allowed to do all of the calculations first and then round off at the end.

d) Either draw a <u>double underline</u> beneath or box the final answers you want graded.

e) Staple your paper sheets together.

f) Submit your solutions to the Instructor at the beginning of class on the due date.

Problem #1

The following table shows measured data for I_m versus V_m.

X-15 Gadget: Current vs. Voltage

Measured voltage V_m (V)	Measured current I_m (A)
1.00	8.26×10^{-2}
1.45	3.32×10^{-2}
2.15	1.31×10^{-2}
2.50	5.94×10^{-3}
3.05	2.56×10^{-3}
3.55	1.22×10^{-3}
3.94	5.11×10^{-4}
4.53	2.17×10^{-4}
4.97	9.64×10^{-5}

a) Write a MATLAB program that uses `subplot` to draw a 2×2 grid of I_m versus V_m using:
   - linear-linear axes
   - semilog axes (both lin-x,log-y and log-x,lin-y)
   - log-log axes

   Apply the principles of making "good" graphs (i.e., full axes labels, titles, markers, etc.). For fun, use a different marker type and marker color for each subplot. Also, turn on the grid to make it easier to see the scale divisions.

   Attach a printout of your graph to your paper assignment.

   Upload your MATLAB program to the appropriate D2L dropbox.

b) From examining the graphs, what type of functional relationship exists between the independent and dependent data (i.e., is it linear, power, or exponential)?

c) Calculate the numeric fitting parameters (i.e., m and b) for your selected relationship.
   - Derive the correct curve fitting equations.
   - You may perform calculations first and then round-off at the end.

Problem #2

A MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) is an active electronic component that can be used either as a digital switch or as an amplifier.
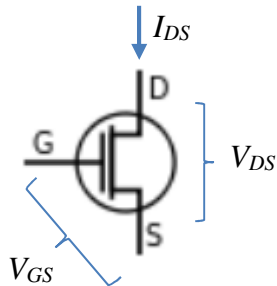

Figure 1 shows a three-terminal NMOS-type device. The terminals are the drain (D), source (S), and gate (G).

I_D is the drain current
V_{DS} is the drain-to-source voltage
V_{GS} is the gate-to-source voltage

Figure 1: NMOS symbol

For an NMOS transistor, applying a positive V_D voltage causes a current I_D to flow. The amount of current is controlled by the gate voltage V_G.

The drain current versus the drain voltage (i.e., I_D versus V_{DS}) is important when describing the performance of the transistor. Typically, the data is measured for several values of gate voltage (V_G). The resulting "characteristic curves" are plotted on the same graph, similar to Figure 2.
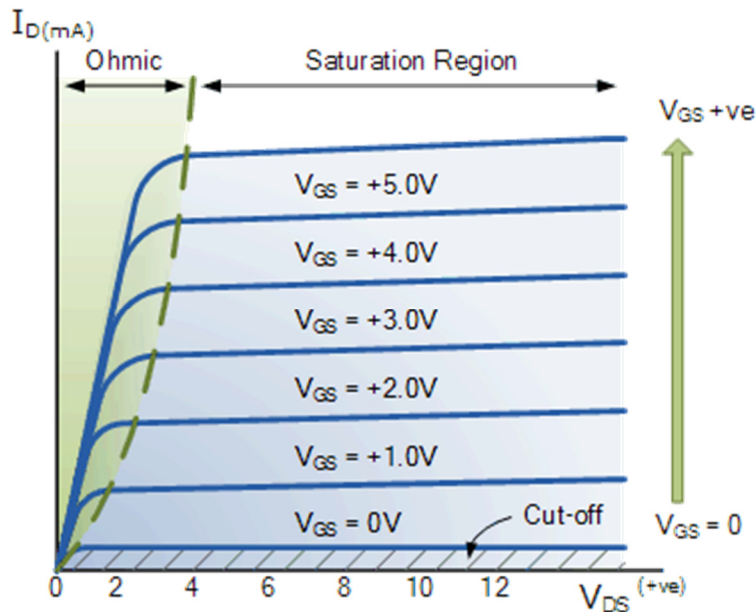

Figure 2: NMOS characteristic curves[1]

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[1] http://www.electronics-tutorials.ws/transistor/tran_6.html

Task

Write a MATLAB program that meets these specifications:

- Prompts the user to enter a file name.
  (The file with this name should contain measured I_D-V_{DS} data.)

- Reads the raw data from the file and stores it in appropriate arrays.
  (*Hint:* Consider whether multiple 1-D arrays or a single 2-D array is more efficient.)

- Plots the characteristic curves on a graph, which should have these features:
    - The 1st line of the title should be "I_D-V_{DS} Characteristic Curves".
    - The 2nd line of the title should contain the name of the file.
    - The *x*-axis label should be "Drain voltage V_{DS} (V)".
    - The y-axis label should be "Drain current I_D (mA)".
    - The legend should say "V_{GS} = xx V", where xx is one of the gate voltage values.
    - Hint: You can create *cell arrays* to hold multiple strings for the title and legend.

  Attach a printout of your graph that uses data from *SSOI2_NMOS_r12c11_50u_450.txt*.

  Upload your MATLAB program to the appropriate D2L dropbox.

Important:

- Your program should have a title block and reasonable in-line comments.

- Your graph must look as similar to the instructor's graph style as possible. This includes marker symbols, font sizes, colors, labels, subscripts in labels, title, legend, etc.

- Your program should work for *any* data file that follows the format described below.
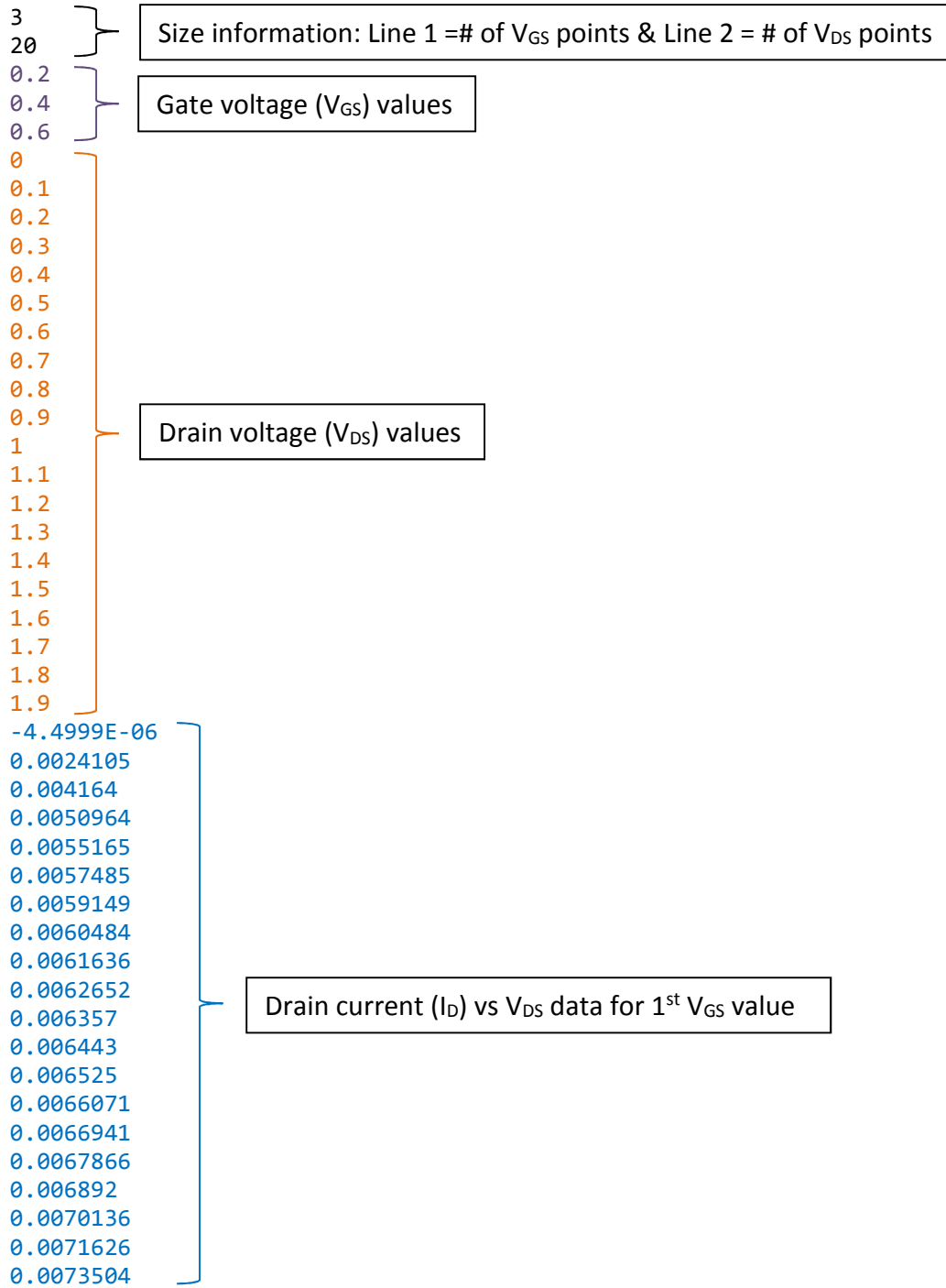

File Format

You are given two data files to use for testing:
- SSOI2_NMOS_r12c11_50u_450.txt   (full set of actual measured values)
- reduced_data.txt   (a subset of the SSOI2 file to make it easier for you to experiment with)

The internal organization of each file looks like this:
- The first line always states the number of V_{GS} points.
- The second line always states the number of V_{DS} points.
- The next block lists the gate-source voltage values (one per line).
- The next block lists of the drain-source voltage values (one per line).
- Following those are consecutive blocks of I_D data values (one for each V_{DS}) for a given V_{GS}.

Hint: Look at the reduced_data.txt file. Once the raw data is read via `dlmread`, think about the array indices that mark the beginning and ending of each block. Since the file tells you the number of V_{GS} and V_{DS} points, see if you can find a general pattern for determining the indices of each block. You can then extract the desired data using the indices with the colon range operator.

Organization of data inside the file *reduced_data.txt*:

```
3
20
```
Size information: Line 1 =# of V_{GS} points & Line 2 = # of V_{DS} points

```
0.2
0.4
0.6
```
Gate voltage (V_{GS}) values

```
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
```
Drain voltage (V_{DS}) values

```
-4.4999E-06
0.0024105
0.004164
0.0050964
0.0055165
0.0057485
0.0059149
0.0060484
0.0061636
0.0062652
0.006357
0.006443
0.006525
0.0066071
0.0066941
0.0067866
0.006892
0.0070136
0.0071626
0.0073504
```
Drain current (I_D) vs V_{DS} data for 1st V_{GS} value

```
-4.5975E-06
0.003075
0.0058515
0.0080576
0.009469
0.010198
0.010575
0.010805
0.010965
0.01109
0.011195
0.01128
0.011355
0.011425
0.01149
0.011555
0.011625
0.011705
0.011795
0.011915
```

Drain current (I_D) vs V_{DS} data for 2nd V_{GS} value

```
-5.2319E-06
0.003409
0.0066636
0.0096126
0.01204
0.013765
0.014775
0.01531
0.0156
0.015775
0.01589
0.015975
0.016035
0.01608
0.01612
0.01615
0.016175
0.016211
0.016245
0.01629
```

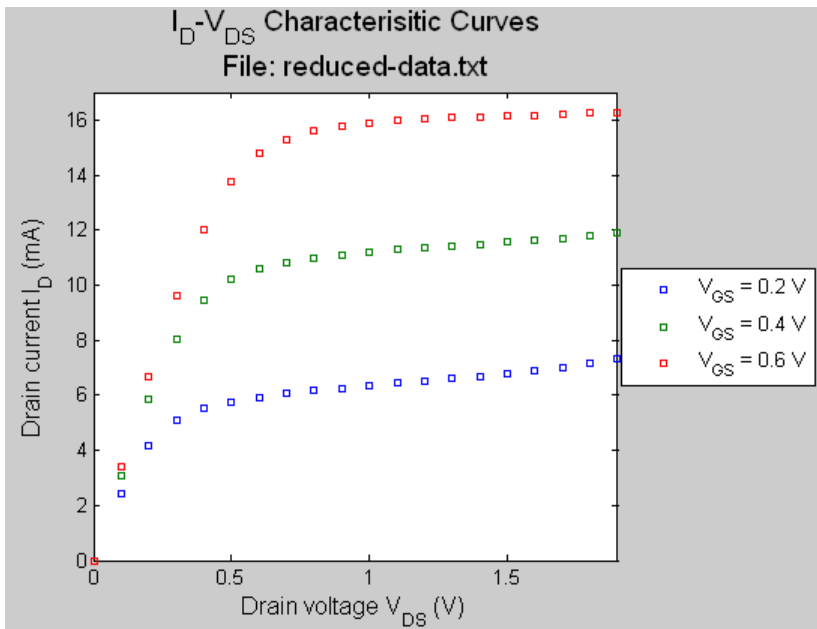Drain current (I_D) vs V_{DS} data for 3rd V_{GS} value

Figure 3: Sample MATLAB plot – Your output should mimic this.

Problem #3

Find two examples of "badly" designed graphs from outside sources. They can be from a magazine article, a book, a research paper, or a website. If the source is printed material, you can cut out the actual page, or photocopy it, or scan it. If it is from a website, you can print it out or do a screen capture.

Perform these tasks:

a) For each graph, list what is wrong with the graph.

b) Choose just *one* of your "bad" graphs and <u>re-do it</u> either on graph paper or via a graphing program (e.g., MATLAB). Fix all of the things that are wrong with the original graph. You may change the type of graph if that enhances understanding of the data.

Here are additional requirements:

- Each graph should be from a different source, e.g., one from a book and another from a website.
- Only submit graphs that are substantially bad! Each graph should have *at least* two major things wrong with it. The worse, the better!