Name : ______________ © Jeffrey A. Anderson **Class Number**: ______

Engr 11: Introduction to MATLAB
Sample Exam 2

How long is this exam?

- This exam is scheduled for a 110 minute period.
- Make sure you have 5 sheets of paper (10 pages front and back) including this cover page.
- There are a total of 7 separate questions on this exam including:
  - 6 Free-response questions (40 points)
  - 1 Optional, extra credit challenge problem (5 points)

How will your written work be graded on these questions?

- Your work should show evidence of original thought and deep understanding. Work that too closely resembles the ideas presented in Jeff's lesson notes will likely NOT earn top scores. Work that does not demonstrate individualized, nuanced understanding will likely NOT earn top scores.
- Read the directions carefully. Your work will be graded based on what you are being asked to do.
- In order to earn a top score, please show all your work. In most cases, a correct answer with no supporting work will NOT earn top scores. What you write down and how you write it are the most important means of getting a good score on this exam.
- Neatness and organization are IMPORTANT! Do your best to make your work easy to read.
- You will be graded on accurate use of the notation we studied in this class.

What can you use on this exam?

- You may use less-than or equal to SIX double-sided note sheets (or 12 singled-sided sheets).
- Each note sheet is to be no larger then 11-inches by 8.5-inches (standard U.S. letter-sized paper).
- You may write on both sides of your note sheets.
- Your note sheet must be handwritten.
- PLEASE SUBMIT ALL OF YOUR NOTE SHEETS WITH YOUR EXAM.
- You are allowed to use calculators for this exam. Examples of acceptable calculators include TI 83, TI 84, and TI 86 calculators. You are not allowed to use any calculator with a Computer Algebra System including TI 89 and TI NSpire. If you have a question, please ask your instructor about this.

What other rules govern your participation during this exam?

- PLEASE DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO!
- It is a violation of the Foothill Academic Integrity Code to, in any way, assist another person in the completion of this exam. Please keep your own work covered up as much as possible during the exam so that others will not be tempted or distracted. Thank you for your cooperation.
- No notes (other than your note sheets), books, or classmates can be used as resources for this exam.
- Please turn off your cell phones during this exam. No cell phones will be allowed on your desk.

Table 1: Various Powers of Two

n	2^n	=	Decimal
0	2^0	=	1
1	2^1	=	2
2	2^2	=	4
3	2^3	=	8
4	2^4	=	16
5	2^5	=	32
6	2^6	=	64
7	2^7	=	128
8	2^8	=	256
9	2^9	=	512
10	2^{10}	=	$1,024$
11	2^{11}	=	$2,048$
12	2^{12}	=	$4,096$
13	2^{13}	=	$8,192$
14	2^{14}	=	$16,384$
15	2^{15}	=	$32,768$
16	2^{16}	=	$65,536$
22	2^{22}	=	$4,194,304$
23	2^{23}	=	$8,388,608$
31	2^{31}	=	$2,147,483,648$
32	2^{32}	=	$4,294,967,296$
52	2^{52}	=	$4,503,599,627,370,496$
53	2^{53}	=	$9,007,199,254,740,992$
63	2^{63}	=	$9,223,372,036,854,775,808$
64	2^{64}	=	$18,446,744,073,709,551,616$

Table 2: Hexadecimal Nibble Chart

Decimal	4-bit binary niblbe	Lowercase Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	a
11	1011	b
12	1100	c
13	1101	d
14	1110	e
15	1111	f

1. (6 points) Consider the following snippet of code:

```
x = single(-214.6);
y = -214.6;
format hex
x, y
```

Show the output that MATLAB will produce in the Command Window after we execute this code. Note, you can assume that MATLAB rounds up.

2. (6 points) Using the "chop" rule for rounding (literally chop off the extra bits), set

$$x_1 = \texttt{ufixed8}_{2(5,3)}\left(\frac{181}{16}\right) \qquad \text{and} \qquad x_2 = \texttt{ufixed8}_{2(4,4)}\left(\frac{181}{16}\right)$$

Then, calculate the absolute error $|x_1 - x_2|$ and explain why your answer makes sense?

3. (10 points) Consider the following raw, uninterpreted 8-bit binary word

$$B = 1110\ 1011$$

What decimal value does the B have if:

A. (2 points) we interpret this number as an unsigned binary integer?

B. (2 points) we interpret this number as a signed integer in signed-magnitude representation?

C. (2 points) we interpret this number as a signed integer in twos complemment representation?

D. (2 points) we interpret this number as a $\texttt{ufixed8}_{2(3,5)}$ representation?

E. (2 points) we interpret this number as a `binary8` representation?

4. (6 points) In this problem, we study the exact range for the $\texttt{ufixed8}_{2(\ell,f)}$ data format. For each of your answers, please write BOTH the decimal representation and the corresponding raw, uninterpreted binary word that encodes this representation in the stated format.

   A. (2 points) What is the smallest positive number that can be encoded in $\texttt{ufixed8}_{2(6,2)}$?

   B. (2 points) What is the largest number that can be encoded in $\texttt{ufixed8}_{2(6,2)}$?

   C. (2 points) Let $\ell, f \in \mathbb{Z}$ be nonnegative integers with $\ell + f = 8$. What is the range of $x \in \mathbb{Q}_I$ that can be stored exactly in the data format $\texttt{ufixed8}_{2(\ell,f)}$.

5. (6 points) In this problem, we study the exact range for positive, normalized numbers in the `binary8` data format. For each of your answers, please write BOTH the decimal representation and the corresponding raw, uninterpreted binary word that encodes this representation in the stated format.

   A. (3 points) What is the smallest, normalized positive number that can be encoded in `binary8`?

   B. (3 points) What is the largest, normalized positive that can be encoded in `binary8`?

6. (6 points) Consider the integers $p = 812$ and $q = 2^{24}$. Define the type I numbers

$$x = \frac{p}{q}$$

Assuming $x = \texttt{binary16}(B)$, find the 16−bit raw, uninterpreted binary word that encodes x in the `binary16` data format.

Challenge Problem

7. (Optional, Extra Credit, Challenge Problem: 5 points) In this class, we've studied a few different algorithms for converting finite decimal expansions into binary expansions. Let's return to one of these algorithms by studying the number

$$0.390625 = \frac{25}{64} = \frac{16+8+1}{64}$$

We can find the equivalent binary representation of this number with the following steps

$$
\begin{aligned}
2 \cdot 0.390625 = 0.78125 \quad &\implies \quad 0.78125 = 0.78125 + 0 \\
2 \cdot 0.78125 = 1.5625 \quad &\implies \quad 1.5625 = 0.5625 + 1 \\
2 \cdot 0.5625 = 1.125 \quad &\implies \quad 1.125 = 0.125 + 1 \\
2 \cdot 0.125 = 0.25 \quad &\implies \quad 0.25 = 0.25 + 0 \\
2 \cdot 0.25 = 0.5 \quad &\implies \quad 0.5 = 0.5 + 0 \\
2 \cdot 0.5 = 1.0 \quad &\implies \quad 1.0 = 0.0 + 1
\end{aligned}
$$

Then, we use this to conclude that $(0.390625)_{10} = (0.011001)_2$. With this in mind, let $n \in \mathbb{N}$ and suppose we have an $n-$digit, finite decimal expansion given by

$$x = 0.d_1 d_2 ... d_n = \frac{d_1 d_2 ... d_n}{10^n}$$

where $0 < x < 1$. Prove that the algorithm described above will produce the binary representation of x.

Use for Scratch Work