ECE 298JA **NS #1 – Version 1.06 September 5, 2017** **Fall 2017**

Univ. of Illinois **Due Mon, Sept 5, 2017** **Prof. Allen**

Topic of this homework: Introduction to MATLAB (see the *Matlab tutorial* for help).
Items in blue represent corrections. Deliverable: Print outs of plots and answers to questions.

1 Plotting complex quantities in Matlab

Plot real, imaginary, magnitude and phase quantities.

1. Consider the functions $f(s) = s^2 + 6s + 25$ and $g(s) = s^2 + 6s + 5$.
   (a) Find the zeros of functions $f(s)$ and $g(s)$ using the command `roots`.
   (b) On a single plot, show the roots of $f(s)$ as red circles, and the roots of $g(s)$ as blue plus signs. The x-axis should display the real part of each root, and the y-axis should display the imaginary part. Use `hold on` and `grid on` when plotting the roots.
   (c) Give your figure the title 'Complex Roots of f(s) and g(s)' using the command `title`. Label the x-axis 'Real Part' and the y-axis 'Imaginary Part' using `xlabel` and `ylabel`. Type `ylim([-10 10])` and `xlim([-10 10])`, to expand the axes.
2. Consider the function $h(t) = e^{j2\pi ft}$ for $f = 5$ and `t=[0:0.01:2]`
   (a) Use `subplot` to show the real and imaginary parts of $h(t)$ as two graphs in one figure. Label the x-axes 'Time (s)' and the y-axes 'Real Part' and 'Imaginary Part'.
   (b) Use `subplot` to plot the magnitude and phase parts of $h(t)$. Use the command `angle` or `unwrap(angle())` to plot the phase. Label the x-axes 'Time (s)' and the y-axes 'Magnitude' and 'Phase (radians)'.

2 Prime numbers, infinity, etc. in Matlab

1. Prime numbers in Matlab
   (a) Use the Matlab function `factor` to find the prime factors of 123, 248, 1767, and 999,999.
   (b) Use the Matlab function `isprime` to check if 2, 3 and 4 are prime numbers. What does the function `isprime` return when a number is prime, or not prime? Why?
   (c) Use the Matlab function `primes` to generate prime numbers between 1 and 10^6 and save them in a vector `x`. Plot this result using the command `hist(x)`.
   (d) Now try `[n,bin_centers] = hist(x)`. Use `length(n)` to find the number of bins.
   (e) Set the number of bins to 100 by using an extra input argument to the function `hist`. Show the resulting figure and give it a title and axes labels.
2. `Inf`, `NaN` and logarithms in Matlab
   (a) Try `1/0` and `0/0` in the command window. What are the results? What do these 'numbers' mean in Matlab?
   (b) In Matlab, the natural logarithm $\ln(\cdot)$ is computed using the function `log` ($\log_{10}$ and $\log_2$ are computed using `log10` and `log2`). Try `log(0)` in the command window.

(c) Try `log(-1)` in the command window. Do you get what you expect for $\ln(-1)$? Show how Matlab arrives at the answer by considering $-1 = e^{i\pi}$.

(d) (*not graded*) What is a decibel? Look up decibels on the internet.

3. Find the largest prime number that can be stored on an Intel 64 bit computer, which we call $\pi_{\texttt{max}}$. Hint: As explained in the Matlab/Octave command `help flintmax`, the largest positive integer is 2^{53}, however the largest integer that can be factored is $2^{32} = \sqrt{2^{64}}$. Explain the logic of your answer. Hint: help isprime().

```
%Matlab code to find the largest prime in IEEE-floating point
clear variables; close all
clc
format long;
N=2^32; %flintmax says this is the largest integer
disp(sprintf('N %g',N));
 %
for n=1:20
p=isprime(N-n);
if p
    F=factor(N-n)
disp(sprintf('n= %g, N=%g; Factor: %d',n,N,factor(N-n)))
end
end
```

4. Suppose you are interested in primes that are greater than $\pi_{\texttt{max}}$. How can you find them on an Intel computer (i.e., one using IEEE-floating point)?

   (a) Hint 1: Since every prime number greater than 2 is odd, there is no reason to check the even numbers. Thus consider a sieve containing only odd numbers, starting from 3 (not 2). Thus odd integers $n_{\text{odd}} \in \mathbb{N}/2$ contain all the primes other than 2.

5. The following idenity is interesting:

$$\begin{aligned} 1 &= 1^2 \\ 1+3 &= 2^2 \\ 1+3+5 &= 3^2 \\ 1+3+5+7 &= 4^2 \\ 1+3+5+7+9 &= 5^2 \\ &\cdots \\ \sum_{n=0}^{N-1} 2n+1 &= N^2. \end{aligned}$$

   Can you find a proof?[1]

[1]This problem came from an exam problem for Math 213, Fall 2016.