Analysis of Engineering Systems – MAE 488

Homework # 1

Spring 2019

Instructions: SHOW YOUR WORK! *If insufficient work is shown, you will receive no credit (even for a correct answer). All handwritten portions of the homework MUST be on standard green engineering paper (available at the bookstore, Staples, Amazon, etc.) If you need some for the first assignment, just let me know. Every problem must have a handwritten portion with: problem number, a brief problem statement, what is given, and the solution (may only be a statement to "see Matlab"). See the example homework!! Note that although the code is provided in the example homework, it is not required.*

As always, be sure to include units where appropriate. All plots should have labels on each axis (with units), a title (e.g. "MAE 488, Homework 1, Problem 1, Part a"), and a legend if more than one plot is in the same figure (except for subplots).

1. The mass of a wheel is 3 slugs.
    a. Calculate the mass in SI units.
    b. Calculate the weight in FPS units.
    c. Calculate the weight in SI units.

2. The displacement of a wheel is given by $y(t) = A\sin(Bt + \phi)$ where t is time in seconds, A = 5 in., B = 12 rad/s, and ϕ = 0.5.
    a. What is the amplitude?
    b. What is the radian frequency?
    c. What is the cyclic frequency in Hz?
    d. What is the period?
    e. What is the phase?
    f. What is the velocity?
    g. What is the acceleration?
    h. Plot the displacement, velocity, and acceleration for 2 seconds (timestep of 0.001 seconds) in a single figure with each plot in a subplot (displacement at the top, acceleration at the bottom). Include axis labels and title the plot "MAE 488, Homework 1, Problem 2, Part h". Use a solid red line for displacement, a dashed greed line for velocity, and a dotted blue line for acceleration. (hint: use the MATLAB commands figure, subplot, plot, xlabel, ylabel, and title). See the example on the next page.

3. Consider the function $f(x) = x\cos x$.
    a. Derive the Taylor series linear approximation to the function at point where $x = \hat{x}$ (where $\hat{x}$ is an arbitrary given value). Write your answer in the form $f(x) \approx mx + b$ where m and b are functions of $\hat{x}$.

b. Calculate the equation of the line approximating the function at $\hat{x}_1 = 3$.
c. Calculate the equation of the line approximating the function at $\hat{x}_2 = 5$.
d. In a single figure, plot the function $f(x) = x\cos x$ from 0 to 10 (solid blue), the equation from part b from $\hat{x}_1 - 1$ to $\hat{x}_1 + 1$ (solid green), the point $[\hat{x}_1, f(\hat{x}_1)]$ (red asterisk), the equation from part c from $\hat{x}_2 - 1$ to $\hat{x}_2 + 1$ (solid magenta), and the point $[\hat{x}_2, f(\hat{x}_2)]$ (green asterisk). See the example on the next page.

4. For each of the following sets of data, plot the data in three subplots: using linear axes for the top subplot, exponential axes for the middle subplot (using MATLAB semilogy command), and power axes for the bottom subplot (using the MATLAB loglog command) and identify the function type (i.e. linear, power, or exponential). See the example on the next page.

a.

x	1	17.5	34	50.5	67	83.5	100
y	0.001	93.79	1336.3	6503.8	20151.1	48612.3	100000

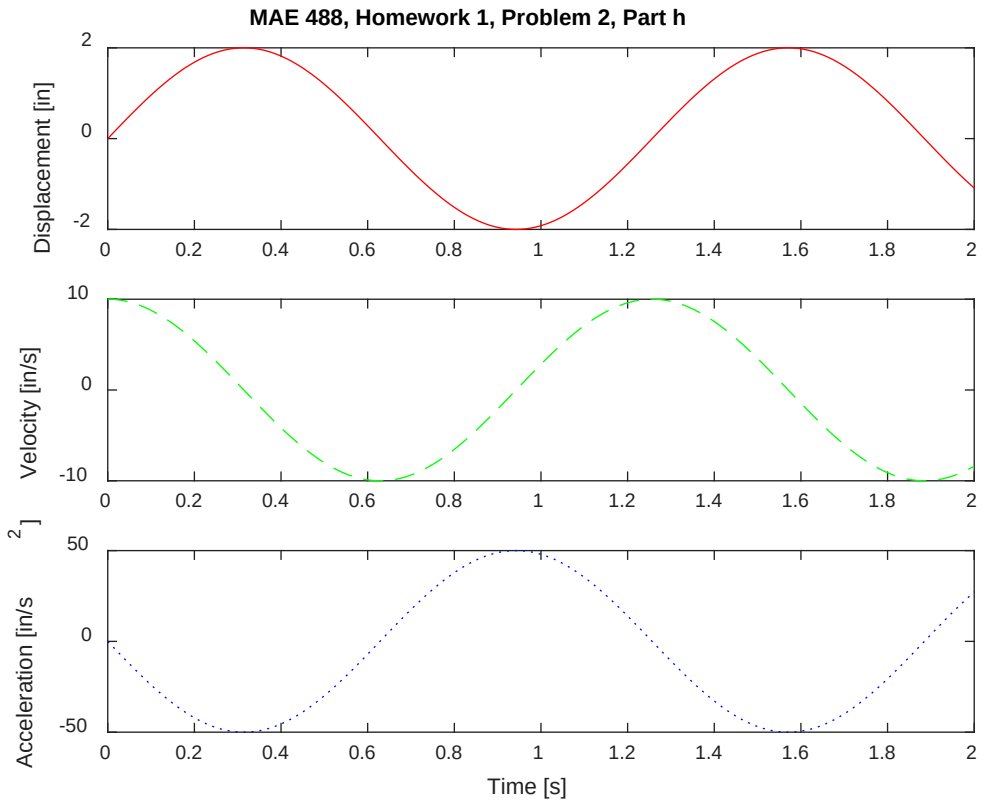
b.

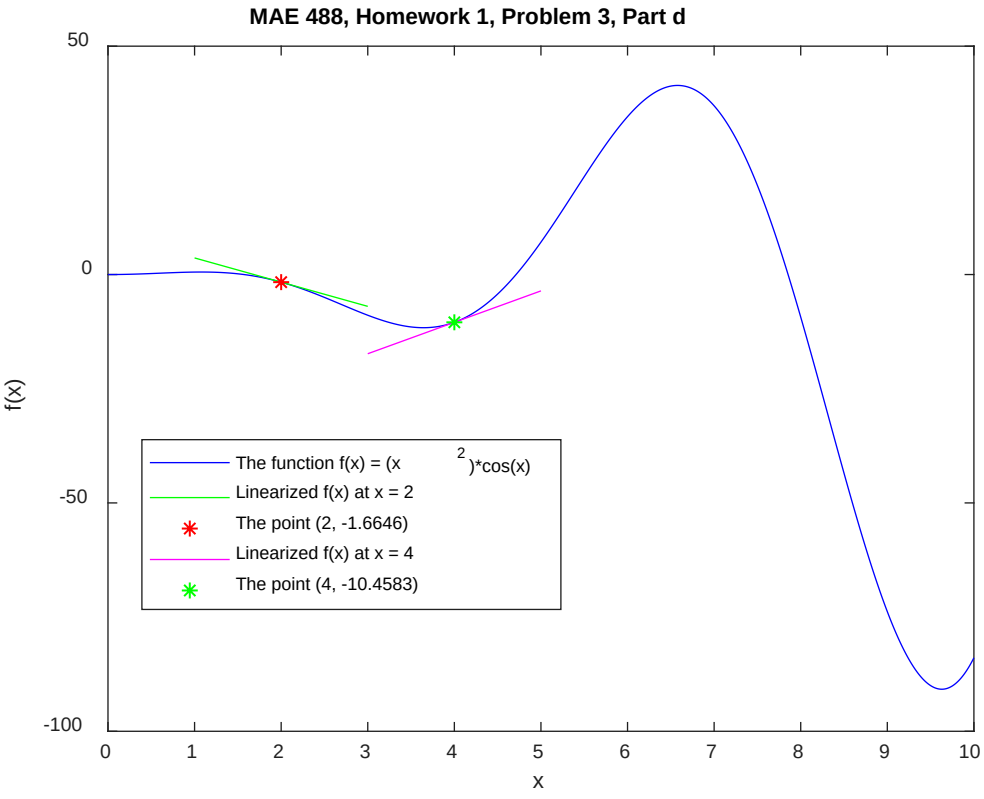
x	14.5	17	19.5	22	24.5	27	29.5
y	0	62.5	125	187.5	250	312.5	375

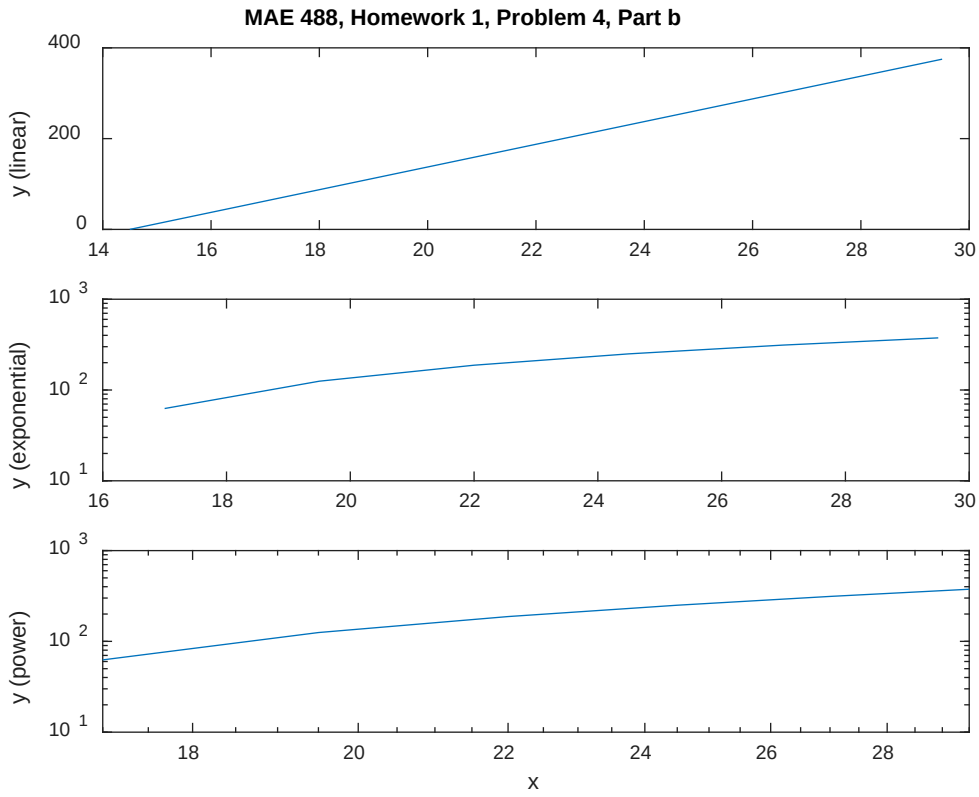
c.

x	0.5	1	1 .5	2	2.5	3	3.5
y	3.115	2.426	1.889	1.471	1.146	0.893	0.695

NOTE: the following examples are provided so that you can see what you need to provide. <u>They are NOT the correct answer</u>.


MAE 488, Homework 1, Problem 2, Part h
Displacement [in]
Velocity [in/s]
Acceleration [in/s 2]
Time [s]


MAE 488, Homework 1, Problem 3, Part d
f(x)
x
The function f(x) = (x 2)*cos(x)
Linearized f(x) at x = 2
The point (2, -1.6646)
Linearized f(x) at x = 4
The point (4, -10.4583)


MAE 488, Homework 1, Problem 4, Part b
y (linear)
400
200
0
14
16
18
20
22
24
26
28
30
y (exponential)
10 3
10 2
10 1
16
18
20
22
24
26
28
30
y (power)
10 3
10 2
10 1
18
20
22
24
26
28
x