ME 481 – H13 **Name ________________________**

1) Develop a Working Model (WM) simulation of a simple pendulum as shown in Notes_07_03 with angular motion of ±10 degrees of swing. Use m = 0.46 lbm, a = 3.7 inches and J_G = 1.5 lbm.in^2. Provide MATLAB graphs of angular position, velocity and acceleration as a function of time for at least 5 oscillations. Attach a screen shot of your mechanism. Determine period of oscillation from your graphs and calculate period of oscillation using Notes_07_03.

τ_{WM} __________________ τ_{CALC} ___________________

2) Produce a MATLAB phase plane plot of angular velocity as a function of angular position. Discuss the shape of this plot.

3) Provide a MATLAB FFT plot of frequency content for angular acceleration of your pendulum simulation using angular motion of ±10 degrees. Determine natural frequency and the period of oscillation from the FFT. Show your work.

f_N _________________ τ_{FFT} _________________

4) Repeat part 3) for ±80 degrees of pendulum motion. Discuss the difference in the FFT plots.

f_N _________________ τ_{FFT} _________________

EXTRA CREDIT
Provide a MATLAB plot of frequency content for piston acceleration from H03. Discuss where you would expect peaks in this plot.

ME 481 – H13 Name ________________________

```matlab
% test_fft.m - example use of FFT
% HJSIII - 20.04.06

clear

% read time domain data here
% must also define time step h

% alternately create synthetic signal for testing
% synthetic - 30 Hz sine, +/- 5 mm, 0.001 sec time step
h = 0.001;                                    % time step [sec]
f_synthetic = 30;                             % synthetic frequency [Hz]
x_max = 5;                                    % size synthetic signal [mm]
t = [ 0:(1999) ]' * h;                        % synthetic time [sec]
x = x_max * sin( 2 * pi * f_synthetic * t );  % synthetic signal [mm]
% bottom - creating synthetic signal

% synthetic square wave
%x = sign( x );

% find number of samples and sampling frequency
n = length( x );  % number of samples
fs = 1 / h;       % sampling frequency [Hz]

% FFT
% MATLAB FFT must be scaled by 2/n - DC component must be scaled scaled by 1/n
a = fft(x) * 2 / n;                   % complex number - units [mm]
a(1) = a(1) / 2;                      % offset at frequency of 0 Hz [mm]
amp = abs( a );                       % amplitude at each frequency [mm]
phase = angle( a ) * 180 / pi;        % phase angle [deg]
df = fs / n;                          % frequency resolution between spectral bands [Hz]
freq = [ 0:(n-1) ]' * df;             % all frequencies [Hz]

% find peaks and list
[ peaks, i_locations ] = findpeaks( amp, 'MinPeakHeight', 0.01 );  % ignore tiny values
disp( ' ' )
disp( ' freq [Hz] peak [mm]' )
disp( [ freq(i_locations) peaks ] )    % units [Hz] [mm]

% plot time domain, amplitude, phase
figure( 1 )
subplot( 3,1,1 )
  plot( t, x )
  xlabel( 'Time (sec)' )
  ylabel( 'Signal [mm]' )

subplot( 3,1,2 )
  plot( freq, amp )
  xlabel( 'Frequency [Hz]' )
  ylabel( 'Amplitude [mm]' )

subplot( 3,1,3 )
  plot( freq, phase )
  xlabel( 'Frequency [Hz]' )
  ylabel( 'Phase [deg]' )

% bottom - test_fft
```