```matlab
clear
close all

% Ronan Gissler January 2023

% This file is used to analyze the data from the experiments Sakthi
% and I ran with the 1 DOF flapper robot outfitted with
% Polydimethylsiloxane (PDMS) and Carbon Black (CB) wings on December
% 2nd 2022. We tested flapping speeds between 1 Hz and 3 Hz (or so we
% thought, this was set by adjusting the speed command to the motor).
% It doesn't appear that the flapper got much faster than 1.5 Hz
% though and for large portions of the recorded data the flapper is
% accelerating up to the set speed since we used a small acceleration
% value to reduce stress on the system. During part of the wingbeat
% which corresponds to a full rotation of the bevel gears, the gears
% make a grinding noise. There seemed to be a resonant frequency of
% the system that amplified this grinding making it painful to listen
% to. This peak in grinding occurred twice for most tests leading me
% to believe this was as a result of the system hitting the resonant
% frequency once on acceleration and once on deceleration.

% Next steps:
% - Can I monitor actual wingbeat occurence from stepper code (rather
% than frequency analysis of force data as I'm doing now)?
% - Why are wings not beating at the prescribed frequency? I think the
% acceleration is much too slow. With the current setup it would take
% 80 seconds to accelerate to 3 Hz, so the flapper starts decelerating
% back to zero long before then given the relatively short measurement
% period. So either I increase the acceleration or the measurement
% period.
% - What can I do to mitigate the grinding? Would it help if I mounted
% a rubber pad to the system to dissipate vibrations?
% - How is the speed and noise affected if I try running fast
% frequency tests without wings attached?

% -------------------------------------------------------------
% ----------------------Plot All Data--------------------------
% -------------------------------------------------------------

files =
 ["12_02_2022_benchtop_test/1Hz_25cycles_PDMSwing_experiment_120222.csv"

  "12_02_2022_benchtop_test/1Hz_100cycles_CBwing_2000acc_experiment_120222.csv"

  "12_02_2022_benchtop_test/2.5Hz_50cycles_PDMSwing_2000acc_experiment_120222.csv"

  "12_02_2022_benchtop_test/2.5Hz_100cycles_CBwing_2000acc_experiment_120222.csv"

  "12_02_2022_benchtop_test/2.5Hz_100cycles_PDMSwing_2000acc_experiment_120222.csv

  "12_02_2022_benchtop_test/2Hz_50cycles_PDMSwing_4000acc_experiment_120222.csv"

  "12_02_2022_benchtop_test/2Hz_50cycles_PDMSwing_experiment_120222.csv"
```

```matlab
        "12_02_2022_benchtop_test/2Hz_100cycles_CBwing_2000acc_experiment_120222.csv"

       "12_02_2022_benchtop_test/3Hz_100cycles_CBwing_2000acc_experiment_120222.csv"

       "12_02_2022_benchtop_test/3Hz_100cycles_PDMSwing_2000acc_experiment_120222.csv"]

    for i = 1:length(files)

        % Get case name from file name
        case_name = erase(files(i),
    ["12_02_2022_benchtop_test/", "_experiment_120222.csv"]);
        case_name = strrep(case_name,'_',' ');

        % Get data from file
        data = readmatrix(files(i));

        times = data(1:end,1);
        force_vals = data(1:end,2:7);

        % Open a new figure.
        f = figure;
        f.Position = [200 50 900 560];

        % Create three subplots to show the force time histories.
        subplot(2, 3, 1);
        plot(times, force_vals(:, 1));
        title("F_x");
        xlabel("Time (s)");
        ylabel("Force (N)");
        subplot(2, 3, 2);
        plot(times, force_vals(:, 2));
        title("F_y");
        xlabel("Time (s)");
        ylabel("Force (N)");
        subplot(2, 3, 3);
        plot(times, force_vals(:, 3));
        title("F_z");
        xlabel("Time (s)");
        ylabel("Force (N)");

        % Create three subplots to show the moment time histories.
        subplot(2, 3, 4);
        plot(times, force_vals(:, 4));
        title({"M_x" ""});
        xlabel("Time (s)");
        ylabel("Torque (N m)");
        subplot(2, 3, 5);
        plot(times, force_vals(:, 5));
        title({"M_y" ""});
        xlabel("Time (s)");
        ylabel("Torque (N m)");
        subplot(2, 3, 6);
        plot(times, force_vals(:, 6));
```
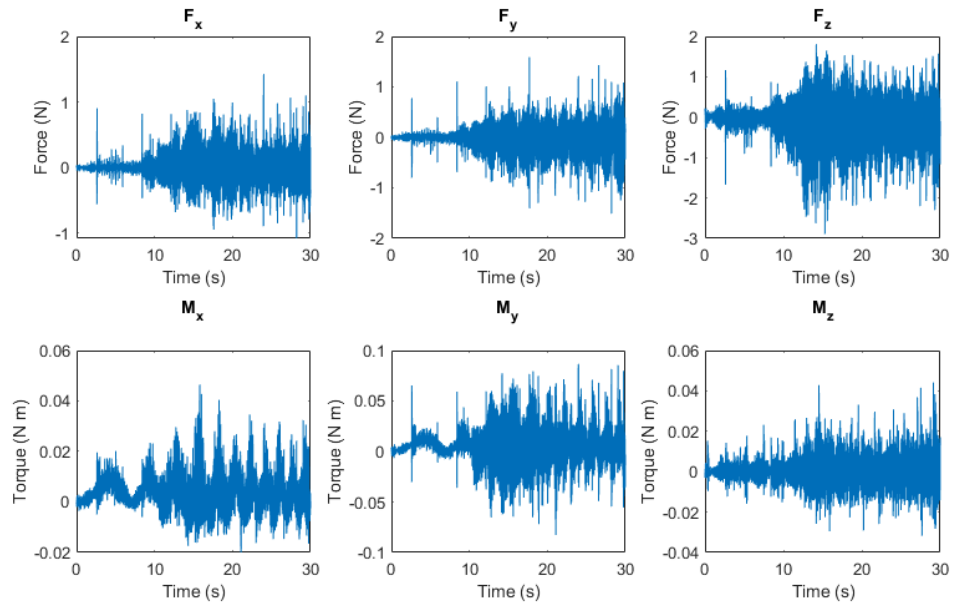
```matlab
title({"M_z" ""});
xlabel("Time (s)");
ylabel("Torque (N m)");

% Label the whole figure.
sgtitle("Force Transducer Measurement for " + case_name);
```
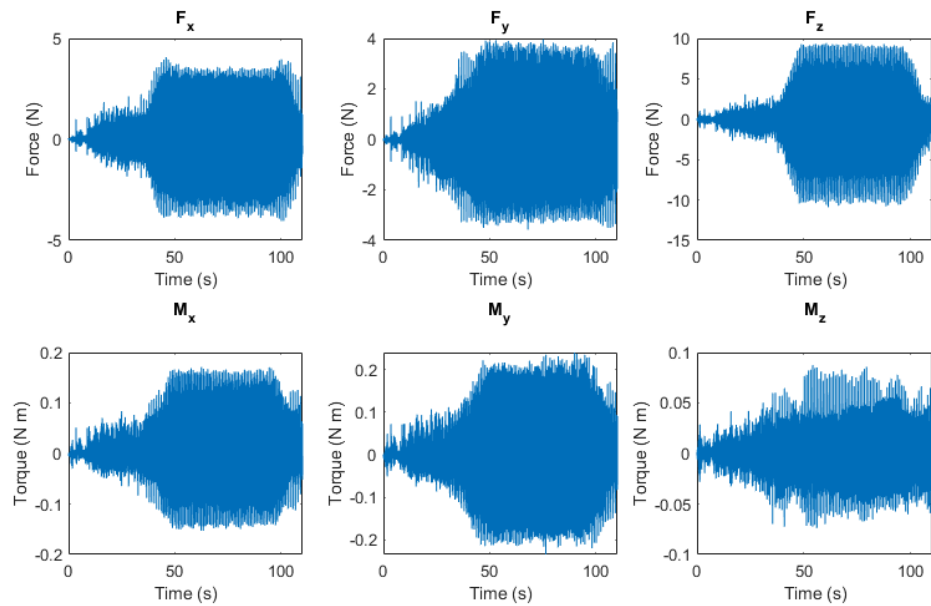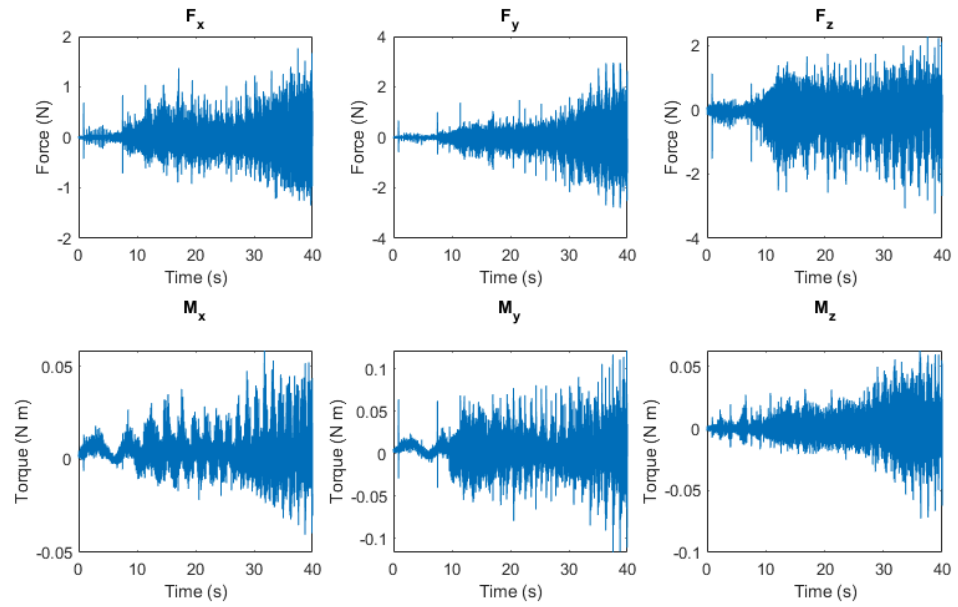

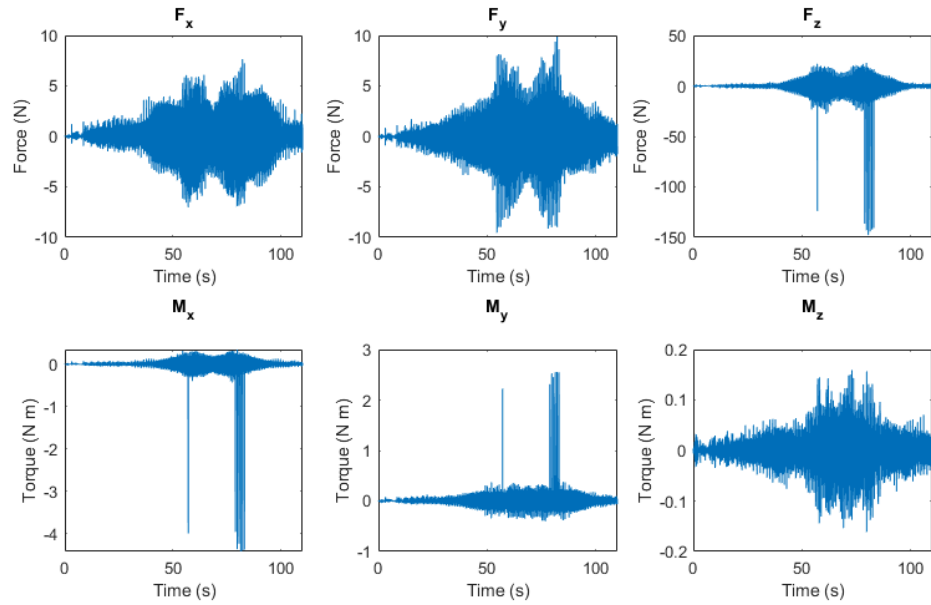Force Transducer Measurement for 1Hz 25cycles PDMSwing

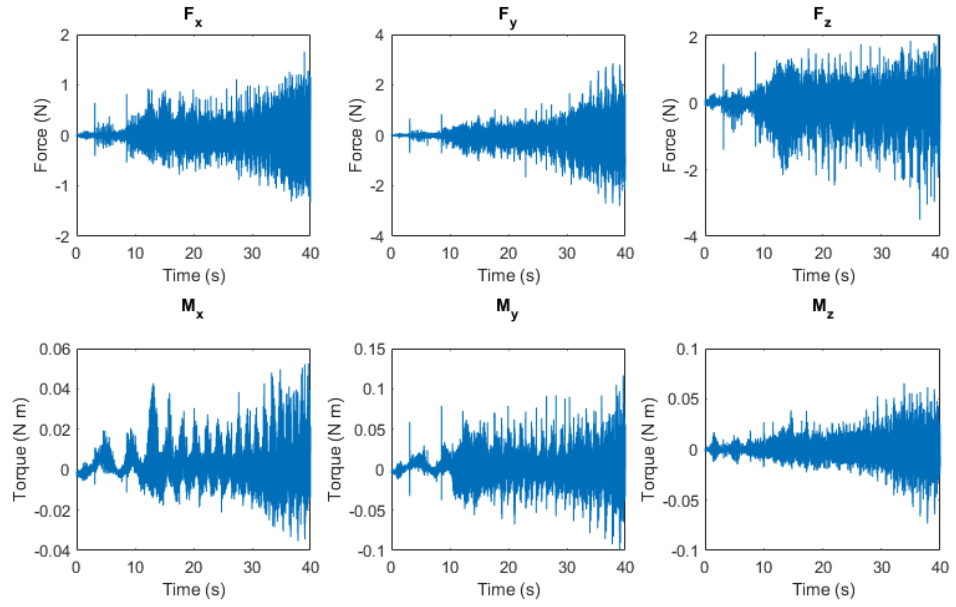Force Transducer Measurement for 1Hz 100cycles CBwing 2000acc

Force Transducer Measurement for 2.5Hz 50cycles PDMSwing 2000acc
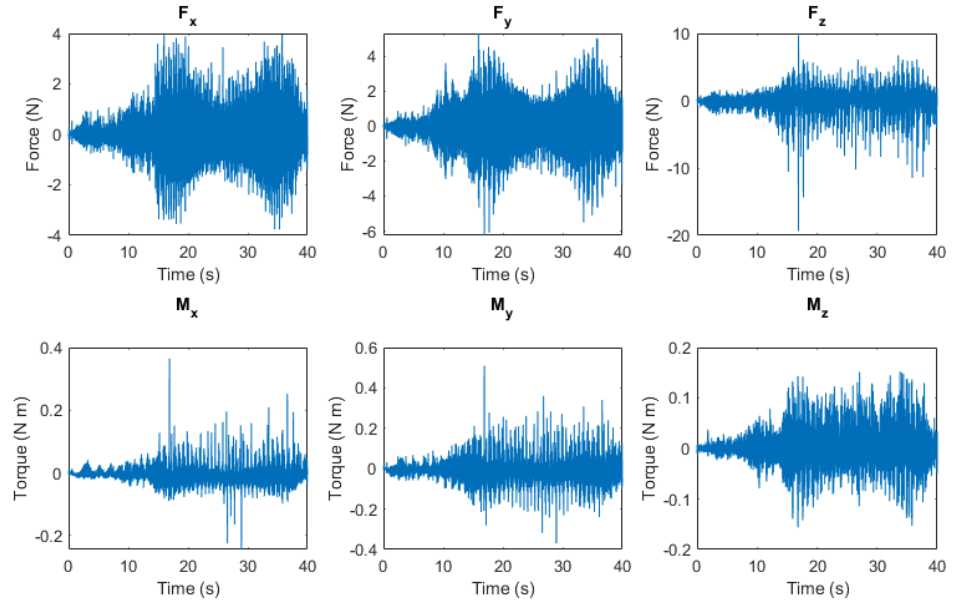

Force Transducer Measurement for 2.5Hz 100cycles CBwing 2000acc
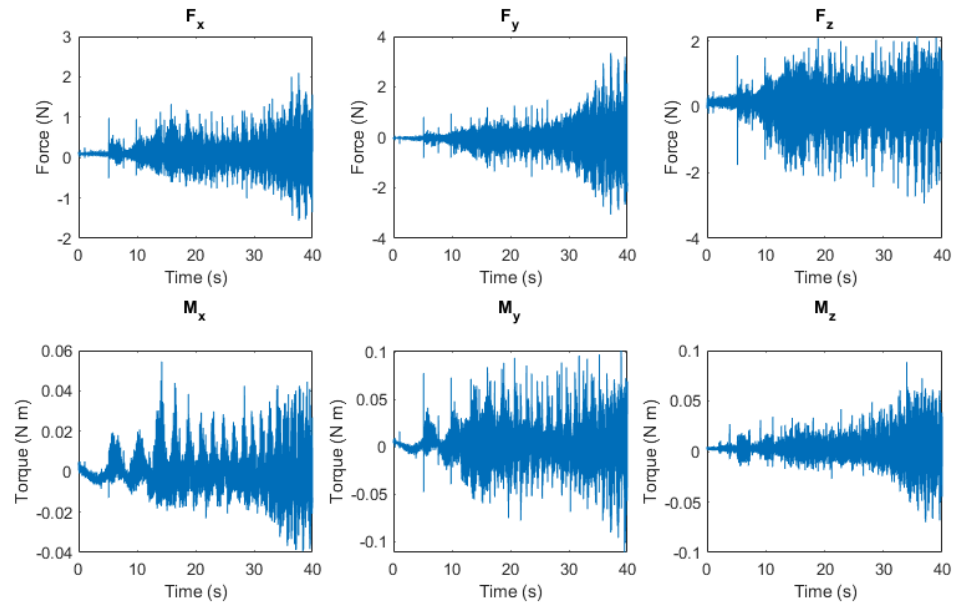
Force Transducer Measurement for 2.5Hz 100cycles PDMSwing 2000acc
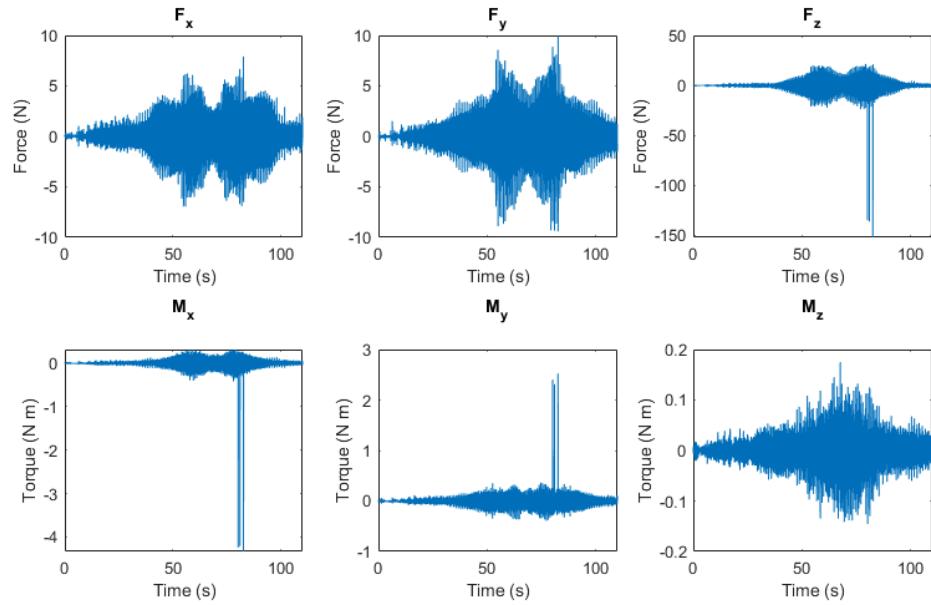

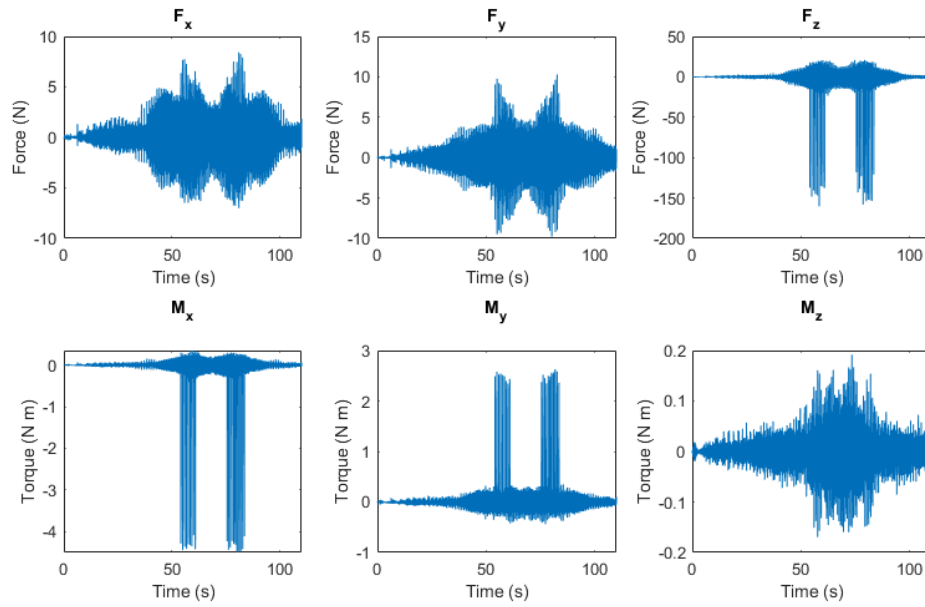Force Transducer Measurement for 2Hz 50cycles PDMSwing 4000acc

Force Transducer Measurement for 2Hz 50cycles PDMSwing

Force Transducer Measurement for 2Hz 100cycles CBwing 2000acc

Force Transducer Measurement for 3Hz 100cycles CBwing 2000acc

Force Transducer Measurement for 3Hz 100cycles PDMSwing 2000acc
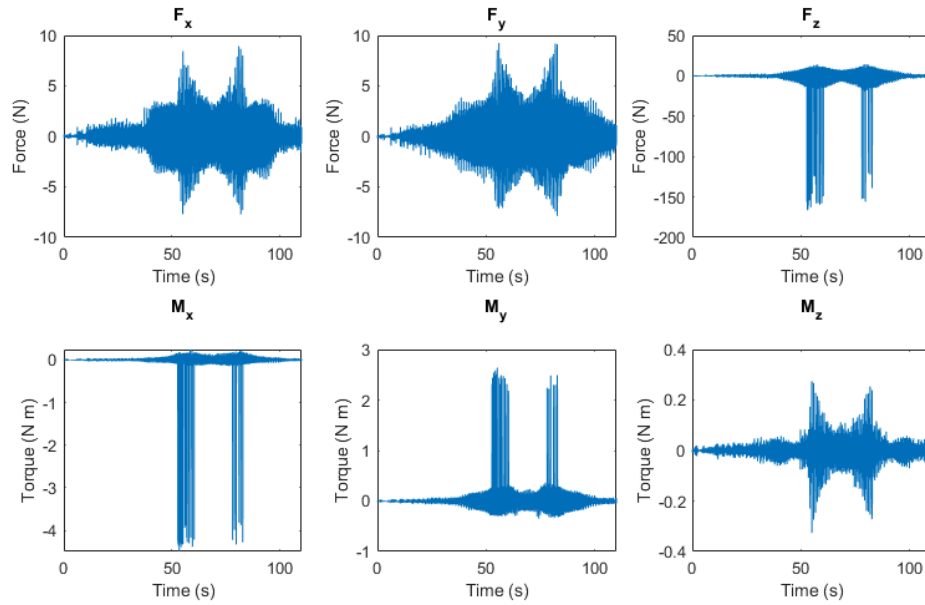

```matlab
end

% --------------------------------------------------------------
% --------------------Plot Carbon Black Data-------------------
% -----during perceived speed peak between 34 and 38 seconds------
% --------determined by watching video of 3 Hz CB trial-----------
% --------------------------------------------------------------
```

```matlab
files = 
 ["12_02_2022_benchtop_test/3Hz_100cycles_CBwing_2000acc_experiment_120222.csv"

  "12_02_2022_benchtop_test/2.5Hz_100cycles_CBwing_2000acc_experiment_120222.csv"

  "12_02_2022_benchtop_test/2Hz_100cycles_CBwing_2000acc_experiment_120222.csv"

  "12_02_2022_benchtop_test/1Hz_100cycles_CBwing_2000acc_experiment_120222.csv"];

% files = 
 ["12_02_2022_benchtop_test/3Hz_100cycles_CBwing_2000acc_experiment_120222.csv"];
% files = 
 ["12_02_2022_benchtop_test/1Hz_25cycles_PDMSwing_experiment_120222.csv"
%
 "12_02_2022_benchtop_test/2.5Hz_50cycles_PDMSwing_2000acc_experiment_120222.csv"
%
 "12_02_2022_benchtop_test/2.5Hz_100cycles_PDMSwing_2000acc_experiment_120222.csv"
%
 "12_02_2022_benchtop_test/2Hz_50cycles_PDMSwing_4000acc_experiment_120222.csv"
%
 "12_02_2022_benchtop_test/2Hz_50cycles_PDMSwing_experiment_120222.csv"
%
 "12_02_2022_benchtop_test/3Hz_100cycles_PDMSwing_2000acc_experiment_120222.csv"];

% Open a new figure.
f = figure;
f.Position = [200 50 900 560];
title("Lift Force (z-direction)");
xlabel("Time (s)");
ylabel("Force (N)");
hold on

for i = 1:length(files)
    % Get case name from file name
    case_name = erase(files(i), 
 ["12_02_2022_benchtop_test/", "_experiment_120222.csv"]);
    case_name = strrep(case_name,'_',' ');

    % Get data from file
    data = readmatrix(files(i));
    data = data(34*1000:38*1000,:);

    times = data(1:end,1);
    force_vals = data(1:end,2:7);

    % Plot lift force
    plot(times, force_vals(:, 3), 'DisplayName', 
 case_name, "LineWidth",3);
end
legend("Location","Southwest");
```

Lift Force (z-direction)

Legend:
- 3Hz 100cycles CBwing 2000acc
- 2.5Hz 100cycles CBwing 2000acc
- 2Hz 100cycles CBwing 2000acc
- 1Hz 100cycles CBwing 2000acc

X-axis: Time (s)
Y-axis: Force (N)

```matlab
% ---------------------------------------------------------------
% ----------------Plot FILTERED Carbon Black Data----------------
% -----during perceived speed peak between 34 and 38 seconds------
% --------determined by watching video of 3 Hz CB trial-----------
% ---------------------------------------------------------------

% Open a new figure.
f = figure;
f.Position = [200 50 900 560];
title("Filtered Lift Force (z-direction)");
xlabel("Time (s)");
ylabel("Force (N)");
hold on

for i = 1:length(files)
    % Get case name from file name
    case_name = erase(files(i),
 ["12_02_2022_benchtop_test/", "_experiment_120222.csv"]);
    case_name = strrep(case_name,'_',' ');

    % Get data from file
    data = readmatrix(files(i));
    data = data(34*1000:38*1000,:);

    times = data(1:end,1);
    force_vals = data(1:end,2:7);

    % Filtering force transducer data with a butterworth filter
    fc = 3; % cutoff frequency
    fs = 1000; % sample frequency
```
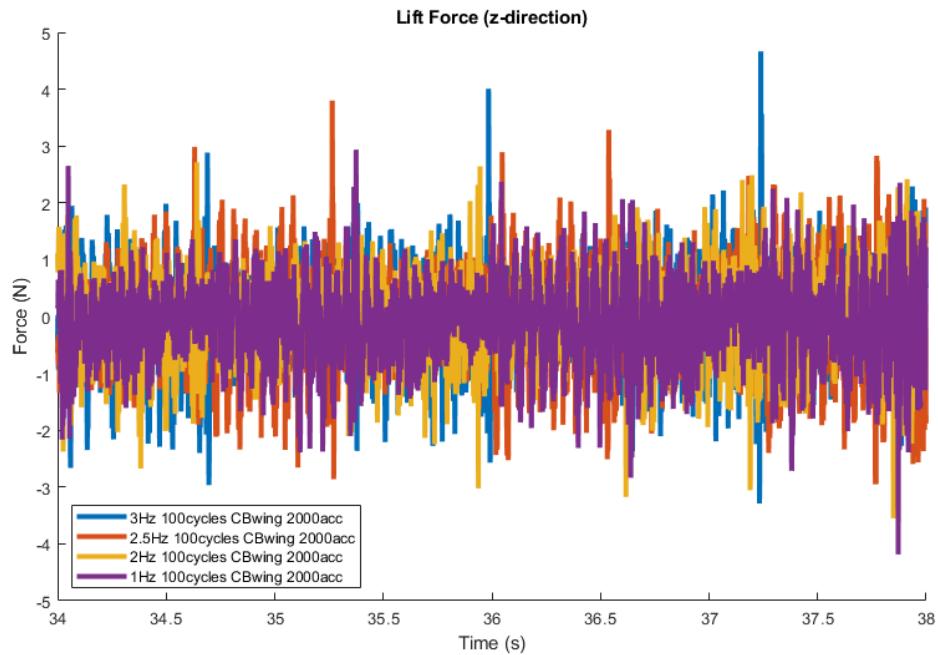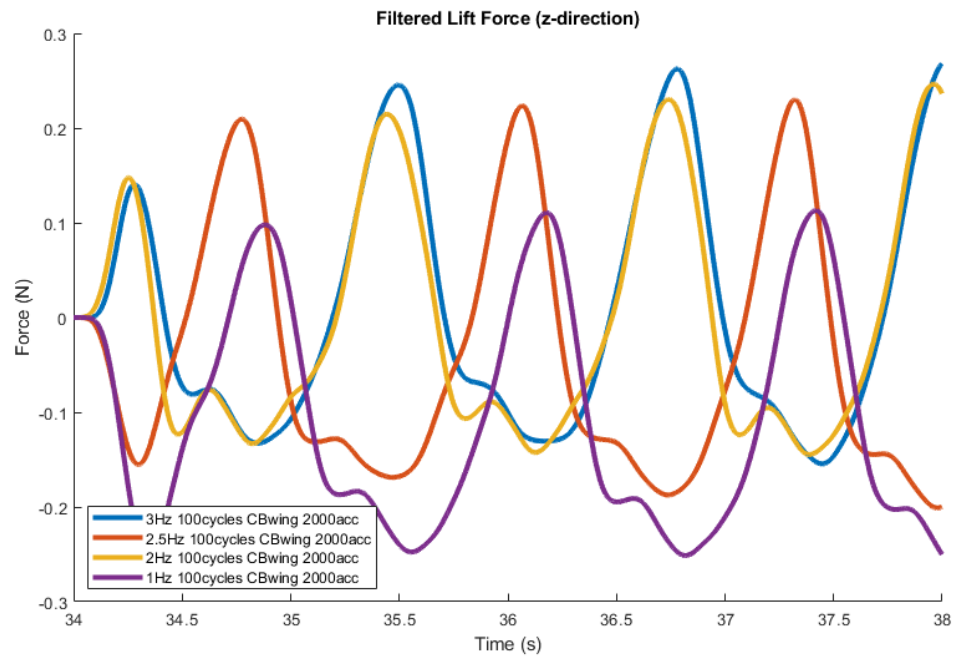
```matlab
        [b,a] = butter(6,fc/(fs/2)); % 6th order
        force_vals = filter(b, a, force_vals);

        % Plot lift force
        plot(times, force_vals(:, 3), 'DisplayName',
    case_name, "LineWidth",3);
    end
    legend("Location","Southwest");
```


Filtered Lift Force (z-direction)

```matlab
% ----------------------------------------------------------------
% -------------------------Trashed Code-------------------------
% ----------------------------------------------------------------

% Fast Fourier Transform stuff I was looking at for a bit...

% f = figure;
% f.Position = [200 50 900 560];
% %instfreq(force_vals(:, 3),fs)
% Y = fft(force_vals(:, 3));
% L = 2000;
% P2 = abs(Y/L);
% P1 = P2(1:L/2+1);
% P1(2:end-1) = 2*P1(2:end-1);
%
% freqs = fs*(0:(L/2))/L;
% plot(freqs,P1)
% title("Single-Sided Amplitude Spectrum of Force Transdcuer Data")
% xlabel("f (Hz)")
% ylabel("|P1(f)|")
% xlim([0,10])
```

```matlab
% instantaneous frequency stuff I was trying...

% % Open a new figure.
% f = figure;
% f.Position = [200 50 900 560];
% title("Filtered Lift Force (z-direction)");
% xlabel("Time (s)");
% ylabel("Force (N)");
% hold on
%
% for i = 1:length(files)
%     % Get case name from file name
%     case_name = erase(files(i), ["12_02_2022_benchtop_test/",
% "_experiment_120222.csv"]);
%     case_name = strrep(case_name,'_',' ');
%
%     % Get data from file
%     data = readmatrix(files(i));
%
%     times = data(1:end,1);
%     force_vals = data(1:end,2:7);
%
%     % Filtering force transducer data with a butterworth filter
%     fc = 3; % cutoff frequency
%     fs = 1000; % sample frequency
%
%     [b,a] = butter(6,fc/(fs/2)); % 6th order
%     force_vals = filter(b, a, force_vals);
%
% %     stft(force_vals(:,
% 3),fs,Window=kaiser(256,5),OverlapLength=220,FFTLength=512);)
%
% %     instfreq(force_vals(:, 3),fs);
% %     ylim([0,5]);
% end
```

Published with MATLAB® R2020b