Contents

Wind Tunnel Lab Sanity Check

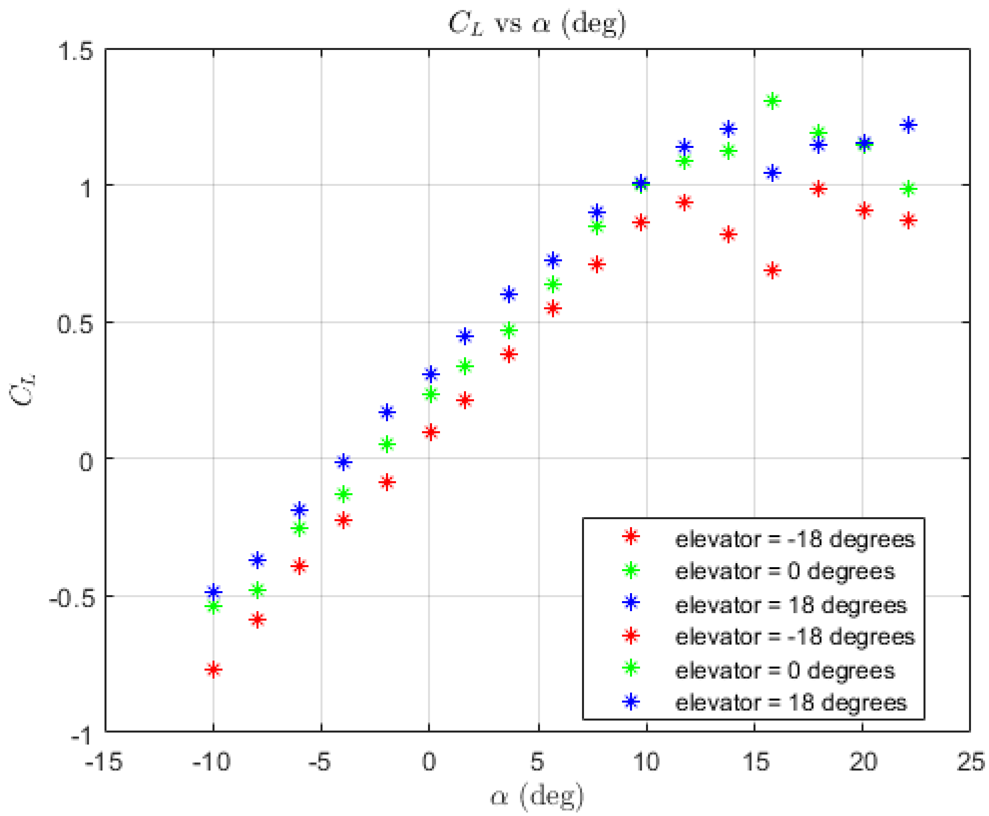
Created 6 Feb 2023, AEM 4303W Updated 16 Mar 2023 Trevor Burgoyne

```
% From CRT_data_parser.m, we generate a .mat file with the following data:

%   Column  1:      Row number
%   Column  2:      Angle of attack (deg)
%   Column  3:      Elevator deflection (deg)
%   Column  4:      Rudder deflection (rad)
%   Column  5:      Air density (kg/m^3)
%   Column  6:      Air speed (m/s)
%   Column  7:      Normal force (N)
%   Column  8:      Standard deviation of normal force (N)
%   Column  9:      Transverse force (N),
%   Column 10:      Standard deviation of transverse force (N)
%   Column 11:      Axial force (N), "X"
%   Column 12:      Standard deviation of axial force (N)
%   Column 13:      Normal Moment (N-m)
%   Column 14:      Standard deviation of normal moment (N-m)
%   Column 15:      Transverse moment (N-m)
%   Column 16:      Standard deviation of transverse moment (N-m)
%   Column 17:      Axial moment (N-m)
%   Column 18:      Standard deviation of axial moment (N-m)

% Hard code actual filename
load("./CRT_data_2023_2_6_11_53.mat"); % 51 rows, 18 col
data = data_matrix; % name of big table when loaded from the .mat file

% Get all elevator deflections
d = data(:,3);  % Elevator deflection (deg)

% Only include rows where d == 0
deflections = [-18, 0, 18];
colors = ["r", "g", "b"];
for i=1:length(deflections)
    data = data_matrix(find(d==deflections(i)),:);
```

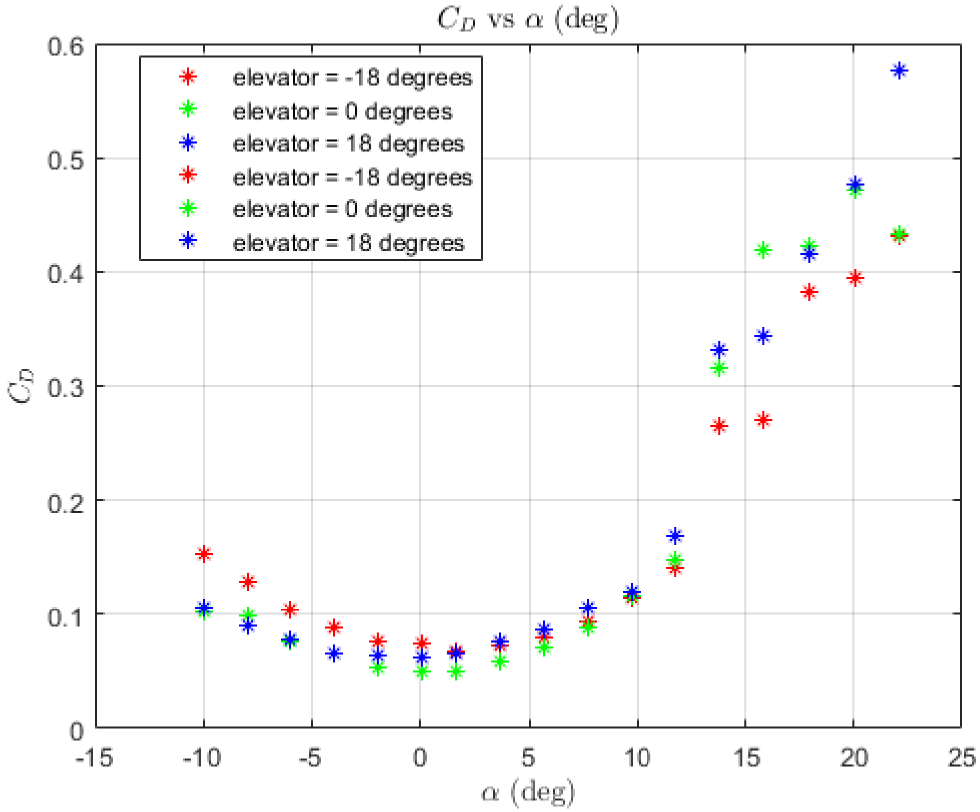
```
% Label data for clarity
a   = data(:,2);   % AoA (deg)
rho = data(:,5);   % Density (kg/m^3)
v   = data(:,6);   % Air speed (m/s)
Z   = -data(:,7);  % Normal Force (N)
X   = -data(:,11); % Axial Force (N)
M_n = data(:,13);  % Normal moment (N*m)
M_t = data(:,15);  % Traverse moment (N*m)

% Ms (sting moments) is the sum of normal and traverse moments
Ms = M_n + M_t; % (N*m)

% Given values:
c    = .2129;               % chord (m)
b_le = .9;                  % Leading edge span (m)
b_te = .985;                % Trailing edge span (m)
S    = .5*c*(b_le + b_te); % Wing area (m^2)
x_cg = .016;                % x location of center of gravity (m)
z_cg = .05;                 % z location of center of gravity (m)

% We want: CL vs a, CL vs CD, and CM vs a
% First, we calculate L, D, M, and q (dynamic pressure) for each alpha.

L = X.*sind(a) - Z.*cosd(a);  % Lift
D = -X.*cosd(a) - Z.*sind(a); % Drag
M = Ms + z_cg*X + x_cg*Z;     % Moment
q = .5*rho.*(v.^2);           % Dynamic pressure (Pa)

% Next, Calculate non-dimensional coefficients
CL = L./(q*S);    % Coefficient of Lift
CD = D./(q*S);    % Coefficient of Drag
CM = M./(q*S*c);  % Moment Coefficient

% Graphs
figure(1) % CL vs a
plot(a, CL, "*", "Color",colors(i), "DisplayName","elevator = " + deflections(i) + " degrees")
title("$C_L$ vs $\alpha$ (deg)","Interpreter","latex");xlabel("$\alpha$ (deg)","Interpreter","latex");ylabel("$C_L$","Interpreter","latex");
legend('show','location','best');
hold on;
grid on;

figure(2) % CD vs a
plot(a, CD, "*","Color",colors(i), "DisplayName","elevator = " + deflections(i) + " degrees")
```

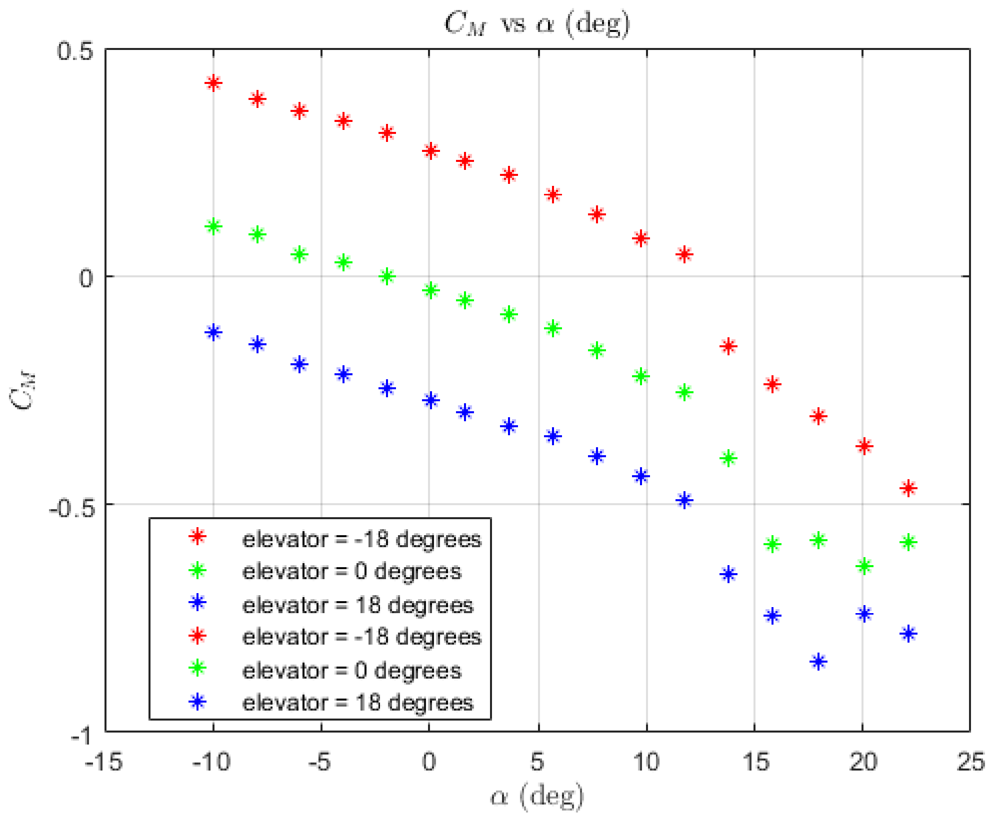
```
title("$C_D$ vs $\alpha$ (deg)","Interpreter","latex");xlabel("$\alpha$ (deg)","Interpreter","latex");ylabel("$C_D$","Interpreter","latex");
legend('show','location','best');
hold on;
grid on;

figure(3) % CM vs a
plot(a, CM, "*","Color",colors(i), "DisplayName","elevator = " + deflections(i) + " degrees")
title("$C_M$ vs $\alpha$ (deg)","Interpreter","latex");xlabel("$\alpha$ (deg)","Interpreter","latex");ylabel("$C_M$","Interpreter","latex");
legend('show','location','best');
hold on;
grid on;

figure(4) % CD vs CL
plot(CL, CD, "*","Color",colors(i), "DisplayName","elevator = " + deflections(i) + " degrees")
title("$C_D$ vs $C_L$","Interpreter","latex");xlabel("$C_L$","Interpreter","latex");ylabel("$C_D$","Interpreter","latex");
legend('show','location','best');
hold on;
grid on;

figure(5) % CM vs CL
plot(CL, CM, "*","Color",colors(i), "DisplayName","elevator = " + deflections(i) + " degrees")
title("$C_M$ vs $C_L$","Interpreter","latex");xlabel("$C_L$","Interpreter","latex");ylabel("$C_M$","Interpreter","latex");
legend('show','location','best');
hold on;
grid on;


% FASER given properties
Sw = 8.28;  % ft^2, wing area
l = 4.31;  % ft, length of fuselage
c = 1.42;  % ft, mean geometric chord
cg = 0.25; % normalized x location of the center of gravity

% conversion
sqft2sqm = .092903; % m^2 per ft^2

% do a linear fit
range = 6:length(CL); % linear regime
p = polyfit(CL(range), CM(range), 1);
slope_test = p(1);       % slope
CM_0 = p(2);             % intercept
np = cg - slope_test;    % neutral point
CL_max = max(CL(range)); % Max CL for this deflection
slope = CM_0/-CL_max;    % theoretical slope for trim at CL_max
```

```
    if deflections(i) == -18
        w_forward  = mean(q)*CL_max*(sqft2sqm*Sw); % N, max weight
        cg_forward = np + slope;
    elseif deflections(i) == 0
        CL_max_0 = CL_max; % save for later
    elseif deflections(i) == 18
        if CM_0 < 0
            cg_aft = np; % There must exist some deflection where CM_0 = 0
        else
            cg_aft = np + slope;
        end
        % Use CL_max at 0 deflection since CM_0 at 0 delections ~= 0
        w_aft  = mean(q)*CL_max_0*(sqft2sqm*Sw);
    end
end
```

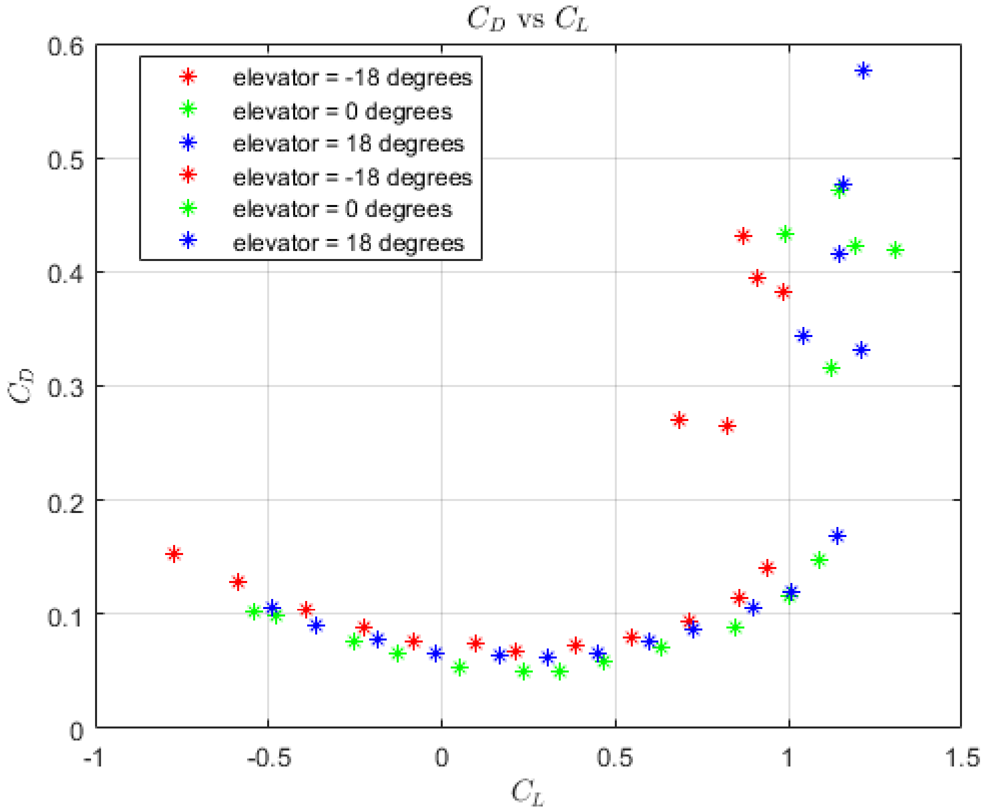


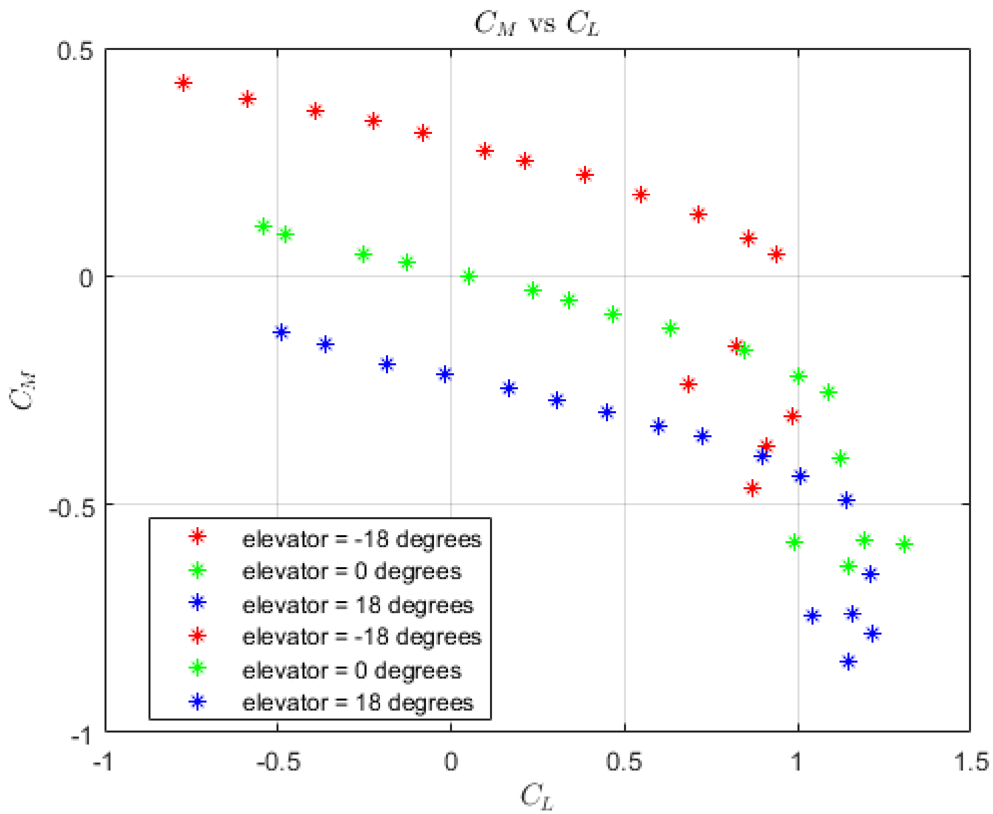
C_L vs α (deg)
1.5
1
0.5
0
-0.5
-1
C_L
-15
-10
-5
0
5
10
15
20
25
α (deg)
elevator = -18 degrees
elevator = 0 degrees
elevator = 18 degrees
elevator = -18 degrees
elevator = 0 degrees
elevator = 18 degrees


C_D vs α (deg)
C_D
α (deg)
elevator = -18 degrees
elevator = 0 degrees
elevator = 18 degrees
elevator = -18 degrees
elevator = 0 degrees
elevator = 18 degrees
0.6
0.5
0.4
0.3
0.2
0.1
0
-15
-10
-5
0
5
10
15
20
25



C_M vs α (deg)
0.5
0
-0.5
-1
C_M
-15
-10
-5
0
5
10
15
20
25
α (deg)
elevator = -18 degrees
elevator = 0 degrees
elevator = 18 degrees
elevator = -18 degrees
elevator = 0 degrees
elevator = 18 degrees


C_D vs C_L
elevator = -18 degrees
elevator = 0 degrees
elevator = 18 degrees
elevator = -18 degrees
elevator = 0 degrees
elevator = 18 degrees
0.6
0.5
0.4
0.3
0.2
0.1
0
C_D
-1
-0.5
0
0.5
1
1.5
C_L



HW 3 Q2: SM from wind tunnel data

```
% Find the forward/aft limits of the center of gravity of FASER.
np          % neutral point
cg_aft      % Aft limit == neutral point (there exists a deflection such that CM_0=0 since CM_0 for 18 degrees is negative)
w_aft       % max weight (N) at aft limit
cg_forward  % forward limit at -18 degrees
w_forward   % max weight (N) at forward limit

% Find the max weight when flying at the forward/aft limits.
```

```
np =

    0.4601
```

```
cg_aft =

    0.4601


w_aft =

   35.1381


cg_forward =

    0.1611


w_forward =

   30.3218
```

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