*** Q-3, Location of Neutral point ***

Problem

Find the location of Neutral Point from nose of the projectile.

PROCEDURE

Step 1: Find the values of C_{My} fordifferent values of x (center of gravity).

Step 2: Plot C_{My} v/s α for different values of x.

Step 3: The location of x for which the plot has zero slope is the location of Neutral point.

Step 4: Considering SM = +15% find CG of bomb.

Step 5: Use the value of x (location of cg) to find the plots of question-01.

MATLAB code

(1) Body alone case

```
%% Neutral Point estimation for Body alone configuration

clc
clear all
close all

% Geometrical data (constant)
q = 974.329545;        % for 1st vaelocity
S = 0.009677;
l = 0.884;
Q1 = 1/q/S;
Q2 = 1/q/S/l;

% Balance center location(m)
% x = -0.465;
y = 0;
z = 0;

% Measured Voltage signal
CM = [63.080043     0.144499     -0.206795     1.354260     1.630051     4.275882
-0.123649     150.309342     0.592082     -0.725847     0.030856     0.393628
0.024098     -0.689773     151.831777     0.096597     -0.571799     -4.414537
```

```
0.152944	-2.334107	0.037781	77.595997	0.445712	5.841784
-0.006030	0.114642	-0.574072	-0.065800	79.176337	0.322466
0.047415	0.466131	0.099431	0.208017	0.190935	44.877349];

% No wind data
% NW = [-0.001023; 0.001298; 0.001474; -0.000501; -0.000191; -0.000147];
NW = [-0.001023 0.001298 0.001474 -0.000501 -0.000191 -0.000147];
NW = NW';

% k = [Pitch af	n1	n2	s1	s2	rm]
% Data for 40 m/s
k = [-9.9479170.002673	-0.006420	0.005058	-0.001114	0.000491	-0.000003
-8.052083	0.002539	-0.004903	0.004606	-0.000981	0.000274	-0.000041
-6.052083	0.002434	-0.003329	0.003960	-0.000981	0.000253	-0.000068
-4.062500	0.002377	-0.001724	0.003177	-0.000968	0.000107	-0.000071
-2.052083	0.002325	-0.000170	0.002245	-0.000885	0.000153	-0.000090
-0.052083	0.002249	0.001322	0.001340	-0.000831	0.000072	-0.000128
0.052083	0.002201	0.001334	0.001344	-0.000864	0.000120	-0.000131
1.947917	0.002324	0.002779	0.000499	-0.000783	0.000108	-0.000153
3.947917	0.002385	0.004320	-0.000380	-0.000745	-0.000003	-0.000158
5.947917	0.002458	0.005940	-0.001250	-0.000692	-0.000010	-0.000191
7.947917	0.002611	0.007523	-0.001939	-0.000602	-0.000087	-0.000206
9.947917	0.002765	0.009013	-0.002427	-0.000612	-0.000136	-0.000233
11.947917	0.002850	0.010588	-0.002839	-0.000578	-0.000102	-0.000257
13.947917	0.002862	0.012207	-0.003176	-0.000626	-0.000078	-0.000250
15.937500	0.002895	0.013871	-0.003436	-0.000631	-0.000056	-0.000280
17.937500	0.002860	0.015556	-0.003610	-0.000583	-0.000413	-0.000303
19.947917	0.002808	0.017221	-0.003662	-0.000535	-0.000676	-0.000332
21.947917	0.002689	0.018903	-0.003702	-0.000579	-0.000642	-0.000360
23.947917	0.002521	0.020650	-0.003677	-0.000634	-0.000730	-0.000392
```

```
25.947917	0.002294	0.022447	-0.003645	-0.000538	-0.001077	-
0.000409];

a = transpose(k);
v = [a(2,:); a(3,:); a(4,:); a(5,:); a(6,:); a(7,:)];	% a = [af; n1;	n2;	s1;	s2;	rm]
(6x20)

alpha_dummy = [];
Cmy_dummy1=[];
Cmy_dummy2=[];
Cmy_dummy3=[];
Cmy_dummy4=[];
Cmy_dummy5=[];
Cmy_dummy6=[];
Cmy_dummy7=[];
Cmy_dummy8=[];
Cmy_dummy9=[];
Cmy_dummy10=[];

x = [-0.465:0.093:(0.465-0.093)];	% The CG is varied from 0.45 to -0.45 to find NP of
configuration

    y1 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(1) 0 1 0; -y x(1) 0 0 0 1];
    y2 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(2) 0 1 0; -y x(2) 0 0 0 1];
    y3 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(3) 0 1 0; -y x(3) 0 0 0 1];
    y4 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(4) 0 1 0; -y x(4) 0 0 0 1];
    y5 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(5) 0 1 0; -y x(5) 0 0 0 1];
    y6 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(6) 0 1 0; -y x(6) 0 0 0 1];
    y7 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(7) 0 1 0; -y x(7) 0 0 0 1];
    y8 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(8) 0 1 0; -y x(8) 0 0 0 1];
    y9 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(9) 0 1 0; -y x(9) 0 0 0 1];
    y10 = [-1 0 0 0 0 0; 0 1 0 0 0 0; 0 0 -1 0 0 0; 0 -z y 1 0 0; z 0 -x(10) 0 1 0; -y x(10) 0 0 0
1];

for i = 1:1:20

  af = v(1,i);
  n1 = v(2,i);
  n2 = v(3,i);
  s1 = v(4,i);
  s2 = v(5,i);
  rm = v(6,i);

  a = [af; n1; n2; s1; s2; rm];
  alpha = k(:,1);

  A = CM*[a - NW];	% A=[Ax;N1;N2;S1;S2;Rm] in kg and kg-m
  Af = A(1);
  N1 = A(2);
  N2 = A(3);
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```
S1 = A(4);
S2 = A(5);
Rm = A(6);

% Transform the forces and moments to the body axis
% FM = [fx; fy; fz; mx; my; mz]
FM = [Af; (S1+S2); (N1+N2); Rm; (N1-N2)*0.065; (S1-S2)*0.065]*9.81;

% Transform the forces and moments to the C.G the flight vehicle
% CG = [Fx Fy Fz Mx My Mz] @cg
CG1 = y1*FM;
CG2 = y2*FM;
CG3 = y3*FM;
CG4 = y4*FM;
CG5 = y5*FM;
CG6 = y6*FM;
CG7 = y7*FM;
CG8 = y8*FM;
CG9 = y9*FM;
CG10 = y10*FM;

% Mxyz = [Mx My Mz]
Mxyz1 = CG1(4:6,1);
Mxyz2 = CG2(4:6,1);
Mxyz3 = CG3(4:6,1);
Mxyz4 = CG4(4:6,1);
Mxyz5 = CG5(4:6,1);
Mxyz6 = CG6(4:6,1);
Mxyz7 = CG7(4:6,1);
Mxyz8 = CG8(4:6,1);
Mxyz9 = CG9(4:6,1);
Mxyz10 = CG10(4:6,1);

% Cmxyz = [Cmx Cmy Cmz]
Cmxyz1 = (1/(q*S*l))*Mxyz1;
Cmxyz2 = (1/(q*S*l))*Mxyz2;
Cmxyz3 = (1/(q*S*l))*Mxyz3;
Cmxyz4 = (1/(q*S*l))*Mxyz4;
Cmxyz5 = (1/(q*S*l))*Mxyz5;
Cmxyz6 = (1/(q*S*l))*Mxyz6;
Cmxyz7 = (1/(q*S*l))*Mxyz7;
Cmxyz8 = (1/(q*S*l))*Mxyz8;
Cmxyz9 = (1/(q*S*l))*Mxyz9;
Cmxyz10 = (1/(q*S*l))*Mxyz10;

Cmy1 = Cmxyz1(2);
Cmy2 = Cmxyz2(2);
Cmy3 = Cmxyz3(2);
Cmy4 = Cmxyz4(2);
Cmy5 = Cmxyz5(2);
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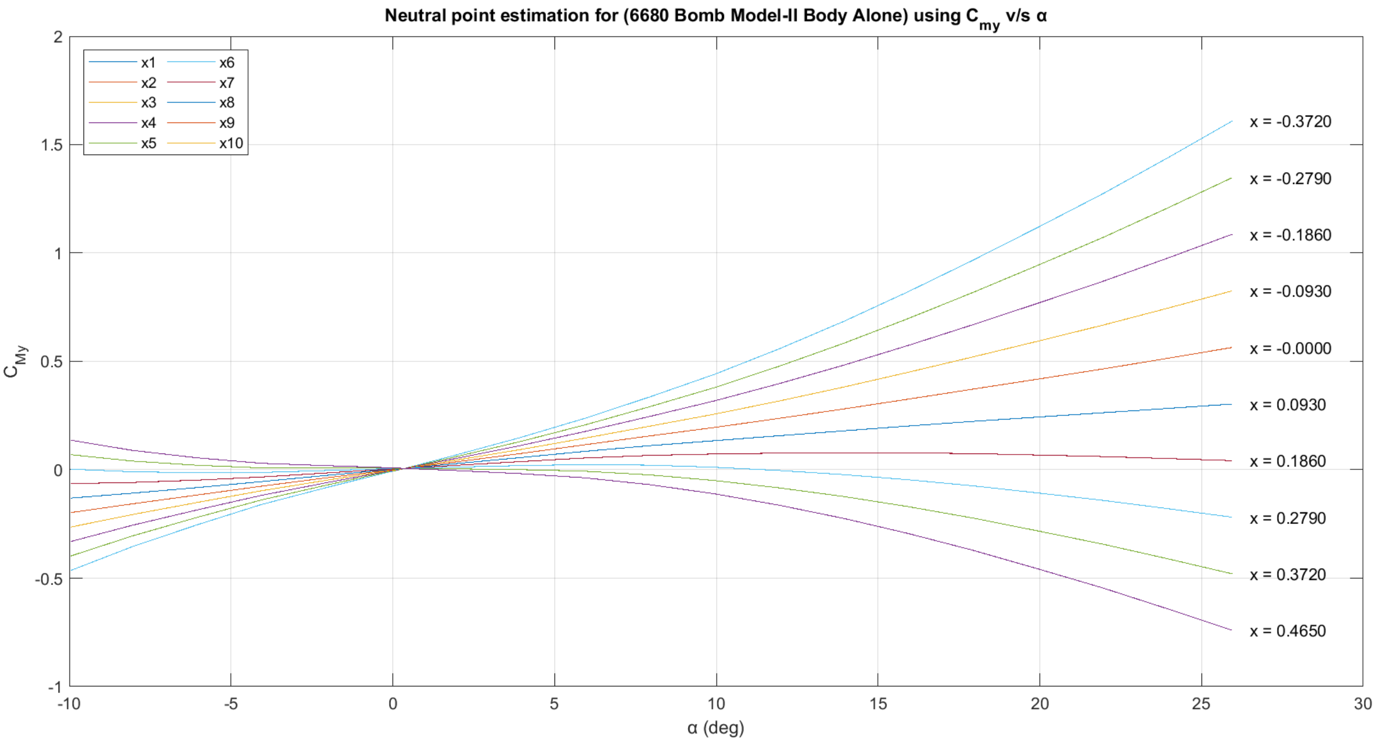
```
    Cmy6 = Cmxyz6(2);
    Cmy7 = Cmxyz7(2);
    Cmy8 = Cmxyz8(2);
    Cmy9 = Cmxyz9(2);
    Cmy10 = Cmxyz10(2);

    Cmy_dummy1 = [Cmy_dummy1, Cmy1];
    Cmy_dummy2 = [Cmy_dummy2, Cmy2];
    Cmy_dummy3 = [Cmy_dummy3, Cmy3];
    Cmy_dummy4 = [Cmy_dummy4, Cmy4];
    Cmy_dummy5 = [Cmy_dummy5, Cmy5];
    Cmy_dummy6 = [Cmy_dummy6, Cmy6];
    Cmy_dummy7 = [Cmy_dummy7, Cmy7];
    Cmy_dummy8 = [Cmy_dummy8, Cmy8];
    Cmy_dummy9 = [Cmy_dummy9, Cmy9];
    Cmy_dummy10 = [Cmy_dummy10, Cmy10];

    alpha_dummy = [alpha_dummy, alpha];

end

figure('Name','Neutral Point estimation for Bomb Model-II_Body Alone','NumberTitle','off')
plot(alpha_dummy,Cmy_dummy1)
hold on
plot(alpha_dummy,Cmy_dummy2)
hold on
plot(alpha_dummy,Cmy_dummy3)
hold on
plot(alpha_dummy,Cmy_dummy4)
hold on
plot(alpha_dummy,Cmy_dummy5)
hold on
plot(alpha_dummy,Cmy_dummy6)
hold on
plot(alpha_dummy,Cmy_dummy7)
hold on
plot(alpha_dummy,Cmy_dummy8)
hold on
plot(alpha_dummy,Cmy_dummy9)
hold on
plot(alpha_dummy,Cmy_dummy10)
hold off
title('Neutral point estimation for (6680 Bomb Model-II Body Alone) using C_m_y v/s α')
grid on
xlabel('α (deg)')
ylabel('C_M_y')
legend({'x1','x2','x3','x4','x5','x6','x7','x8','x9','x10'},'Location','northwest','NumColumns',2)

y_text_location = [Cmy_dummy1(20), Cmy_dummy2(20), Cmy_dummy3(20),
Cmy_dummy4(20), Cmy_dummy5(20),...
```

```
    Cmy_dummy6(20), Cmy_dummy7(20), Cmy_dummy8(20), Cmy_dummy9(20),
Cmy_dummy10(20)]

for i=1:10
    j = i-1;
    x(i) = -0.465 + i*0.093
    textString = sprintf('x = %.4f', x(i));
    text(26.5, y_text_location(i), textString, 'FontSize', 10);
    hold on;
end
```

Output Plot

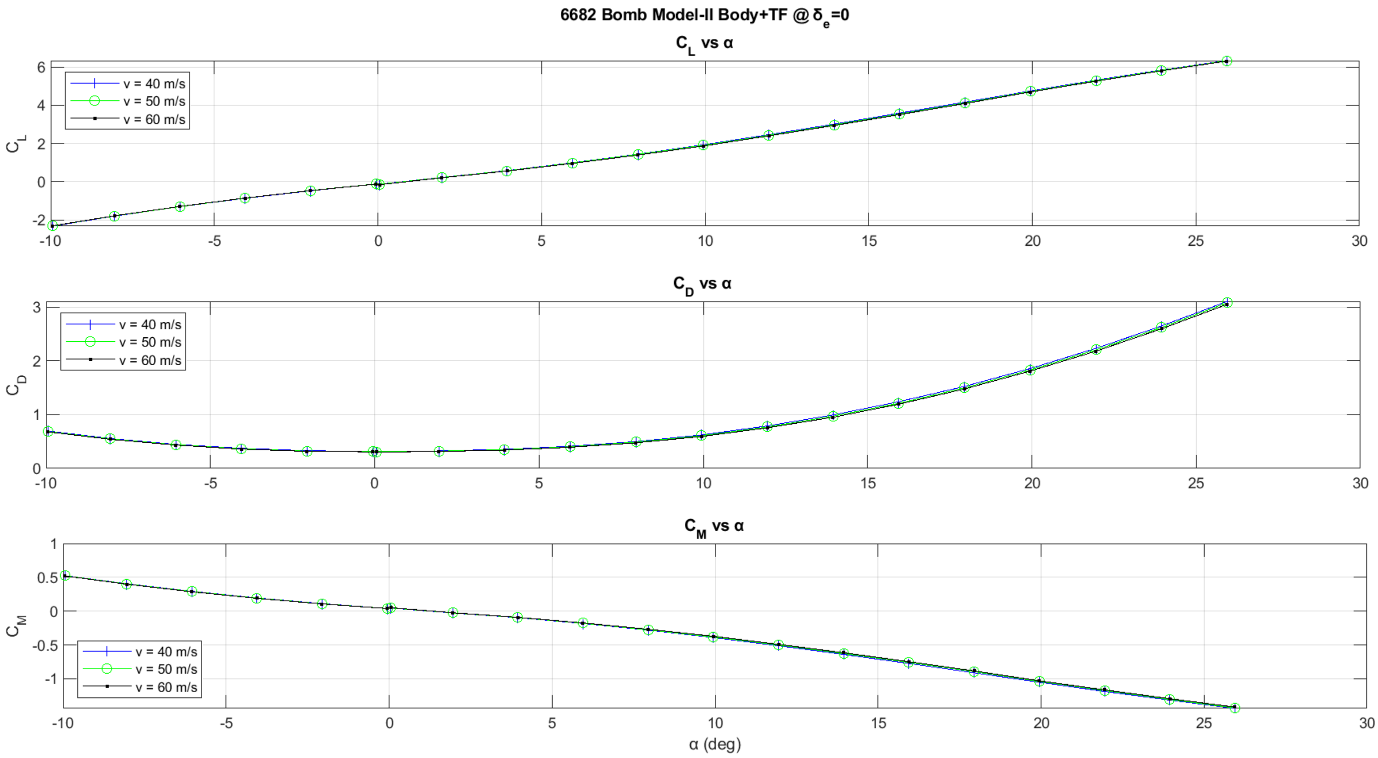


C_{My} v/s α for different locations of CG (Body alone)

(2) Body + Tail fin

- The MATLAB code is similar as shown for Body alone configuration, Only No wind data, Wind tunnel data and dynamic head will change.

Output Plot

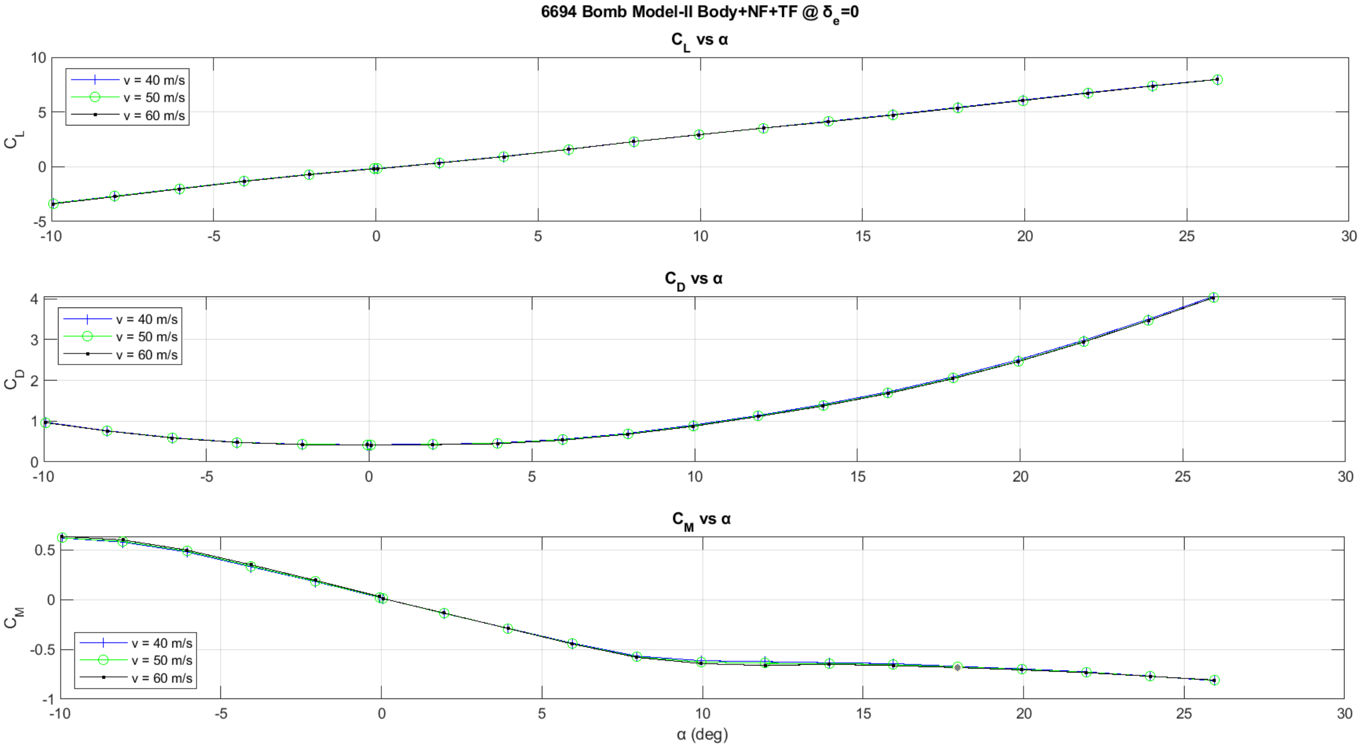


C_{My} v/s α for different locations of CG (Body alone + TF)

(3) Body + Nose fin + Tail fin

- The MATLAB code is similar as shown for Body alone configuration, Only No wind data, Wind tunnel data and dynamic head will change.

Output Plot



C_{My} v/s α for different locations of CG (Body alone + NF + TF)

Observations

1. 6680_Bomb Model-II_Body Alone

==> CMy v/s α curve is fairly flat (i.e Slope is zero) within range of NP [0.186, 0.279].

Approximate location of **NP** from balance load center is 0.2325m. (i.e 0.465-0.2325 = **0.2325 behind nose**).

==> Considering SM of +15%, the CG shold lie at 0.01665 m ahead of NP.

(i.e. 0.24915 m from balance load center and 0.21585 m behind nose)

x = -0.24915 m

2. 6682_Bomb Model-II_Body_TF_0

==> Cmy v/s alpha curve is fairly flat (i.e Slope is zero) within range of NP [-0.093, 0].

Approximate location of **NP** from balance load center is -0.0465m

(i.e 0.465-(-0.0465) = **0.5115 behind nose**).

==> Considering SM of +15%, the CG shold lie at 0.01665 m ahead of NP.

(i.e. -0.02985 m from balance load center and 0.49485 m behind nose)

x = 0.02985 m

3. 6694_Bomb Model-II_Body_NF_TF_0

==> Cmy v/s alpha curve is fairly flat (i.e Slope is zero) at NP location of 0.093.

Approximate location of **NP** from balance load center is 0.093m

(i.e 0.465-0.093 = **0.372 m behind nose**).

==> Considering SM of +15%, the CG shold lie at 0.01665 m ahead of NP.

(i.e. 0.10965 m from balance load center and 0.35535 m behind nose)