```
clc
clear
close all

velocity_smoothing

% elimate a bunch of zero entries from SMA's
sma_v1 = sma_v1(200:length(sma_v1));
sma_v2 = sma_v2(200:length(sma_v2));
sma_v3 = sma_v3(200:length(sma_v3));
sma_v4 = sma_v4(200:length(sma_v4));

% eliminate a bunch of entries from adjusted SMA's
sma_v1_adj = sma_v1_adj(199:length(sma_v1_adj));
sma_v2_adj = sma_v2_adj(199:length(sma_v2_adj));
sma_v3_adj = sma_v3_adj(199:length(sma_v3_adj));
sma_v4_adj = sma_v4_adj(199:length(sma_v4_adj));

% elimate points prior to 10 seconds for flights
noisy_flight1 = noisy_flight1(200:length(noisy_flight1));
noisy_flight2 = noisy_flight2(200:length(noisy_flight2));
noisy_flight3 = noisy_flight3(200:length(noisy_flight3));
noisy_flight4 = noisy_flight4(200:length(noisy_flight4));


R = 287; % ideal gas constant of air
g0 = 9.8; % gravitational constant
a = -0.0065;
rho_ref = 1.225;
T_ref = 288.15;


% TIME FOR SOME DYNAMICS
t = linspace(10,28,1800);
%t = linspace(18.2,28,2000);
URRG = 728; % URRG start in ft
spaceport = 4595; % spaceport start in ft

starting_data_point = 1;

% dry masses from launches
mtl22 = 91.3;
mcl22 = 98.7;
mtl23 = 127.5;
mcl23 = 134.5;

% temperatures from launches
    % TEMP TL 22 = 292.55 K
    % TEMP CL 22 = 304.85 K
    % TEMP TL 23 = 301.25 K
    % TEMP CL 23 = 313.35 K
% adjusted Reference temperatures
```

```
T_TL22 = 300 + (292.55-295)*4;
T_CL22 = 300 + (304.85-295)*4;
T_TL23 = 300 + (301.25-295)*4;
T_CL23 = 300 + (313.35-295)*4;

status = 0;

S = pi*0.25^2; % cross sectional area of rocket in ft^2
[t1,x1] = ode45(@(t,X) pic(t,X,URRG,mtl22,T_TL22,S,status),t,
[noisy_flight1(starting_data_point+1);sma_v1_adj(starting_data_point+1)]);
[t2,x2] = ode45(@(t,X) pic(t,X,spaceport,mcl22,T_CL22,S,status),t,
[noisy_flight2(starting_data_point+1);sma_v2_adj(starting_data_point+1)]);
[t3,x3] = ode45(@(t,X) pic(t,X,URRG,mtl23,T_TL23,S,status),t,
[noisy_flight3(starting_data_point+1);sma_v3_adj(starting_data_point+1)]);
[t4,x4] = ode45(@(t,X) pic(t,X,spaceport,mcl23,T_CL23,S,status),t,
[noisy_flight4(starting_data_point+1);sma_v4_adj(starting_data_point+1)]);

status = 1;

%S = S + ((1.43*(1/12))*(2.75*(1/12))*4); % add new area
[t1a,x1a] = ode45(@(t2,X) pic(t,X,URRG,mtl22,T_TL22,S,status),t,
[noisy_flight1(starting_data_point+1);sma_v1_adj(starting_data_point+1)]);
[t2a,x2a] = ode45(@(t2,X) pic(t,X,spaceport,mcl22,T_CL22,S,status),t,
[noisy_flight2(starting_data_point+1);sma_v2_adj(starting_data_point+1)]);
[t3a,x3a] = ode45(@(t,X) pic(t,X,URRG,mtl23,T_TL23,S,status),t,
[noisy_flight3(starting_data_point+1);sma_v3_adj(starting_data_point+1)]);
[t4a,x4a] = ode45(@(t,X) pic(t,X,spaceport,mcl23,T_CL23,S,status),t,
[noisy_flight4(starting_data_point+1);sma_v4_adj(starting_data_point+1)]);


figure
plot(t1,x1(:,1))
hold on
plot(t1a,x1a(:,1))
xlabel('Time into Flight','FontSize',16)
ylabel('Altitude','FontSize',16)
title("Airbrakes' Effects on TL 2022",'FontSize',16)
legend('No Airbrakes','Airbrakes
 Deployed','Location','southeast','FontSize',16)
hold off


figure
plot(t2,x2(:,1))
hold on
plot(t2a,x2a(:,1))
xlabel('Time into Flight','FontSize',16)
ylabel('Altitude','FontSize',16)
title("Airbrakes' Effects on CL 2022",'FontSize',16)
legend('No Airbrakes','Airbrakes
 Deployed','Location','southeast','FontSize',16)
hold off
```

```
figure
plot(t3,x3(:,1))
hold on
plot(t3a,x3a(:,1))
xlabel('Time into Flight','FontSize',16)
ylabel('Altitude','FontSize',16)
title("Airbrakes' Effects on TL 2023",'FontSize',16)
legend('No Airbrakes','Airbrakes
 Deployed','Location','southeast','FontSize',16)
hold off


figure
plot(t4,x4(:,1))
hold on
plot(t4a,x4a(:,1))
xlabel('Time into Flight','FontSize',16)
ylabel('Altitude','FontSize',16)
title("Airbrakes' Effects on CL 2023",'FontSize',16)
legend('No Airbrakes','Airbrakes
 Deployed','Location','southeast','FontSize',16)
hold off

% for i = 3:length(noisy_flight1)-1
%     starting_data_point = i;
%     [t,x] = ode45(@(t,X) pic(t,X,URRG,mtl22,T_TL22,S),t,
[noisy_flight1(starting_data_point+1);sma_v1_adj(starting_data_point)]);
%     predictions(i) = max(x(:,1));
% end
%


predictions1 = [];
predictions2 = [];
predictions_diff = [];

for i = 3:length(noisy_flight2)-1
    starting_data_point = i;

    S = pi*0.25^2;
    status = 0;
    [t5,x5] = ode45(@(t5,X5) pic(t,X5,spaceport,mcl22,T_CL22,S,status),t,
[noisy_flight2(starting_data_point+1);sma_v2_adj(starting_data_point)]);
    predictions1(i) = max(x5(:,1));

    %S = S + ((1.43*(1/12))*(2.75*(1/12))*4);
    status = 1;
    [t6,x6] = ode45(@(t6,X6) pic(t,X6,spaceport,mcl22,T_CL22,S,status),t,
[noisy_flight2(starting_data_point+1);sma_v2_adj(starting_data_point)]);
    predictions2(i) = max(x6(:,1));

    predictions_diff(i) = predictions2(i) - predictions1(i);

end
```

```
% for i = 3:length(noisy_flight3)-1
%     starting_data_point = i;
%     [t3,x3] = ode45(@(t,X) pic(t,X,URRG,mtl23,T_TL23,S),t,
[noisy_flight3(starting_data_point+1);sma_v3_adj(starting_data_point)]);
%     predictions3(i) = max(x3(:,1));
% end
%
% for i = 3:length(noisy_flight4)-1
%     starting_data_point = i;
%     [t4,x4] = ode45(@(t,X) pic(t,X,spaceport,mcl23,T_CL23,S),t,
[noisy_flight4(starting_data_point+1);sma_v4_adj(starting_data_point)]);
%     predictions4(i) = max(x4(:,1));
% end
%
%
%
% predictions = predictions';
predictions2 = predictions2';
% predictions3 = predictions3';
% predictions4 = predictions4';
%
%
%
% predictions = predictions(3:length(predictions));
predictions2 = predictions2(3:length(predictions2));
% predictions3 = predictions3(3:length(predictions));
% predictions4 = predictions4(3:length(predictions));
%
% predictions_residuals = 10707 - predictions;
predictions2_residuals = 10350 - predictions2;
% predictions3_residuals = 12315 - predictions3;
% predictions4_residuals = 10067 - predictions4;
%
%
%
%
% v1 = sma_v1_adj';
v2 = sma_v2_adj';
% v3 = sma_v3_adj';
% v4 = sma_v4_adj';
%
% v1 = v1(3:1800);
v2 = v2(3:1800);
% v3 = v3(3:1800);
% v4 = v4(3:1800);
%
%
figure
% plot(v1,predictions_residuals)
% hold on
plot(v2(3:length(v2)-100),predictions_diff(3:length(predictions_diff)-2-100),'LineWidth',1
% plot(v3(3:length(v3)),predictions3_residuals)
% plot(v4(3:length(v4)),predictions4_residuals)
```

```
%
xlabel('Velocity at Airbrake Deployment (ft/s)','FontSize',16)
ylabel('Apogee Reduction (ft)','FontSize',16)
title("Airbrakes' Effect on Apogee for Varying Speeds",'FontSize',16)
% legend('TL22 (10,707 ft)','CL22 (10,350 ft)','TL23 (12,315 ft)','CL23
 (10,067 ft)','FontSize',16)
%
% hold off

figure
plot(t2(3:length(t2)-140),predictions_diff(3:length(predictions_diff)-140),'LineWidth',1.5
xlabel('Time of Airbrake Deployment (s)','FontSize',16)
ylabel('Apogee Reduction (ft)','FontSize',16)
title("Aibrakes' Effect on Apogee for Varying Times of Deployment (Competition
 Launch 2022)",'FontSize',16)


function Xdot = pic(t,X,xstart,m,T_ref,S,status)
    x = X(1);
    xdot = X(2);
    R = 287;
    %R = 85;
    g0 = 9.81;
    g = 32.17; % ft/s
    a = -0.0065;
    rho_ref = 1.225;
    %rho_ref = 1.6;
    %T_ref = 288.15;
    %T_ref = 400;
    Cd = 0.536; % coefficient of drag as predicted on open rocket
    S_flaps = ((1.43*(1/12))*(2.75*(1/12))*4);


    % MASSES
    % DRY MASS TL 22 = 91.3 lbm
    % DRY MASS CL 22 = 98.7 lbm
    % DRY MASS TL 23 = 127.5 lbm
    % DRY MASS CL 23 = 134.5 lbm

    % TEMPERATURES
    % TEMP TL 22 = 292.55 K
    % TEMP CL 22 = 304.85 K
    % TEMP TL 23 = 301.25 K
    % TEMP CL 23 = 313.35 K



    beta = 0.5*Cd*S;


    rho = (1/16.0185)*(rho_ref*(1+(a*((x+xstart)*0.3048)/T_ref)).^((-g0/
(a*R))-1)); % ft/lb^3
```

```
    %T = 80 - 0.00649*(x+xstart);
    %p = 101.29*((T+273.1)/288.08)^5.256;
    %rho = p / (0.2869*(T+273.1));
    %rho = rho*(1/16.0185);

    if status == 1
        % incoroprate additional drag coefficient and area if airbrakes are
        % deployed
        xdoubledot = -g - beta/m*rho*xdot^2 - (0.5*1.28*S_flaps)/m*rho*xdot^2;
        Xdot = [xdot; xdoubledot];
    else
        % do not incorporate additional area or draf coefficient if
        % airbrakes are rettracted
        xdoubledot = -g - beta/m*rho*xdot^2;
        Xdot = [xdot; xdoubledot];
    end

end
```

Warning: Column headers from the file were modified to make them valid MATLAB identifiers before creating variable names for the table. The original column headers are saved in the VariableDescriptions property. Set 'VariableNamingRule' to 'preserve' to use the original column headers as table variable names.