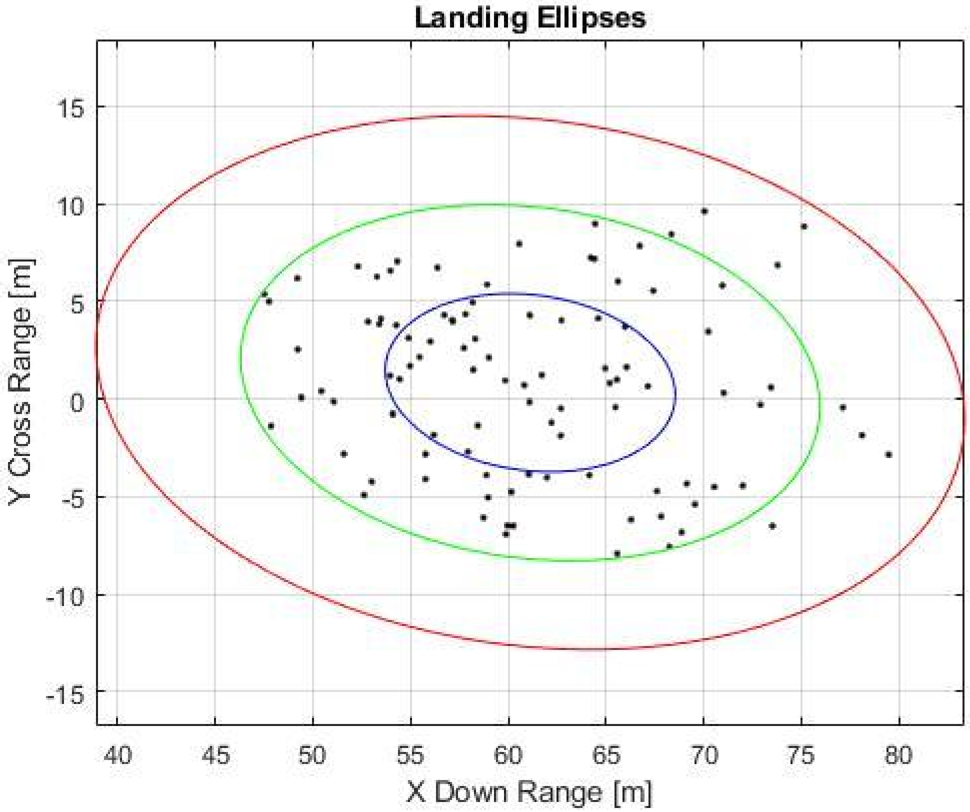
Zak Reichenbach
4/11/2021
ASEN 2004



<u>Estimated Landing Zone (x,y):</u> (61,1) [m]

Table of Contents


```
%Rocket Equation calculations for a Rocket
%Zak Reichenbach
%4/5/2021
```

House Keeping

```
clc;
clear all;
close all;
```

Monte Carlo loop

```
%How many simulations?
simulations = 100;

for k = 1:simulations
```

Uncertainties in Values

```
SigmaLA = -1:.25:1;                    %Launch Angle [deg]
SigmaWater = -.0005:.000075:.0005;         %Water Mass    [kg]
SigmaDrag = -.1:.025:.1;               %Drag Coeff.
SigmaDir = -3:.5:3;                    %XY launch angle (40 deg from
 north to west with 3deg variation)

%Random Value Selection
Picker = randi([1 9],1,1);
DeltaLA = SigmaLA(Picker);
Picker = randi([1 14],1,1);
DeltaWater = SigmaWater(Picker);
Picker = randi([1 9],1,1);
DeltaDrag = SigmaDrag(Picker);
Picker = randi([1 13],1,1);
DeltaDir = SigmaDir(Picker);
```

Values pulled from static test stand report

```
ISP = [1.421 1.866 1.187 1.582 1.338 1.401 1.511 1.251 1.473 1.457
 1.531 1.680 1.352 1.783 1.593 1.740 1.682];
ISP_Avg = mean(ISP);
ISP_Sigma = std(ISP);
%Error in ISP?
INeg = round((ISP_Avg - ISP_Sigma),1);
IPos = round((ISP_Avg + ISP_Sigma),1);
%Random Value Selection
ISP_Range = linspace(INeg,IPos);
Picker = randi([1 100],1,1);
ISP_Avg = ISP_Range(Picker);
```

Initial Values

```
BottleDiameter = 10.5; %cm
mdry = .128; %[kg]
mp = 1.001 + DeltaWater; %[kg]
mwet = mdry+mp; %[kg]
Cd = 0.38 + DeltaDrag;
LaunchAngle = 45 + DeltaLA; %[deg]
% % p0 = 40; %[psi]
% % Temp = 63; %[deg]
g = 9.81; %[m/s^2]

%Passable Constant Struct
Values =
 num2cell([g;0.961;1000;2.1;10.5;mdry;Cd;0.0;LaunchAngle;0.0;0.25;0.5]);
Names
 =["g","RoeAmb","RoeWat",'Dt','Db','MBot','CD','V0','Theta','X0','Z0','L']';
C = cell2struct(Values,Names,1);  %Create Struct of Constants

%Bottle Area for Drag
Ab = pi/4*((C.Db*10^-2))^2;

%Initial velocity
Delta_V = ISP_Avg*g*log(mwet/mdry);

%Initial velocity componentsm
VX = Delta_V*cosd(LaunchAngle)*cosd(DeltaDir);
VZ = Delta_V*sind(LaunchAngle);
VY = Delta_V*sind(DeltaDir);


%Wind Factor
theta = -11.25:.25:11.25;
theta0 =355;                %[deg]
theta = theta+theta0;
w =randi([1,91],1,1);
WindX = 1.34112*cosd(theta(w));
WindY = 1.34112*sind(theta(w));
```

ODE45 Start

```
% Intial State of the rocket to enter into ODE45
Properties0 = [C.Z0 C.X0 0 VZ VX VY];

tspan = [0 10];

terminalCond = odeset('Events', @hitGround);

[t,Properties] = ode45(@(t,s) Rocket(t,s,C,Ab,WindX,WindY), tspan,
 Properties0, terminalCond);

Q{k} = Properties;

end
```

Landing Points

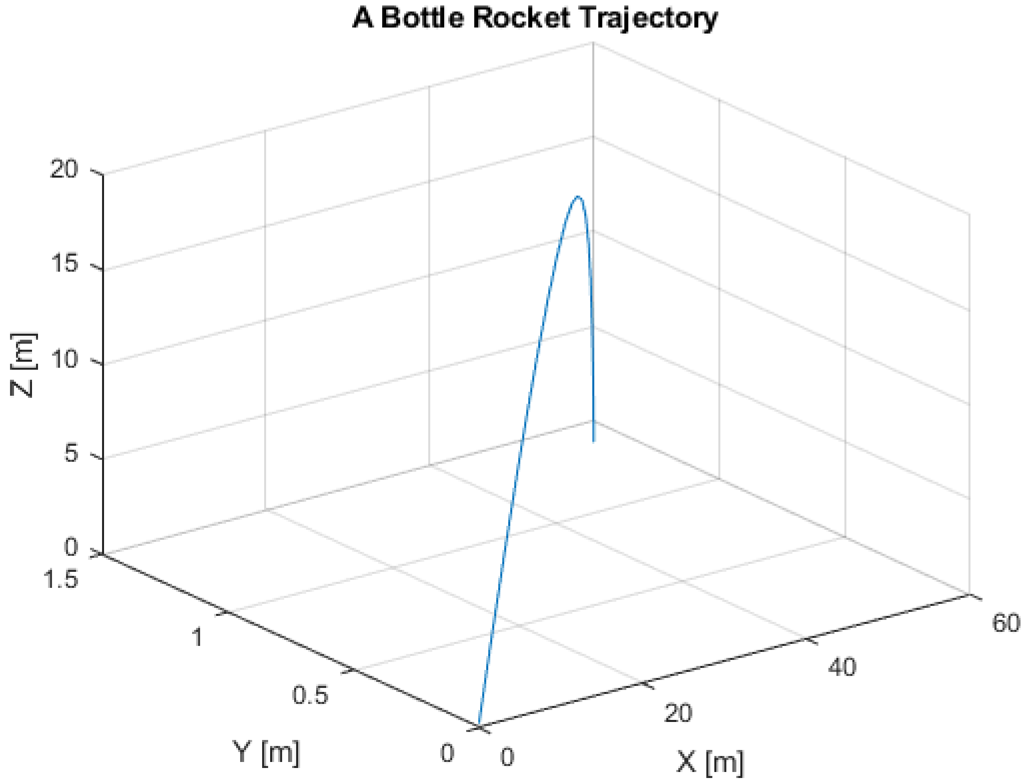
```
for i =1:simulations
   Zs{i} = Q{i}(:,1);
   Xs{i} = Q{i}(:,2);
   Ys{i} = Q{i}(:,3);
end

for j = 1:simulations

    Xf(j) = Xs{j}(end)';
    Yf(j) = Ys{j}(end)';

end
```

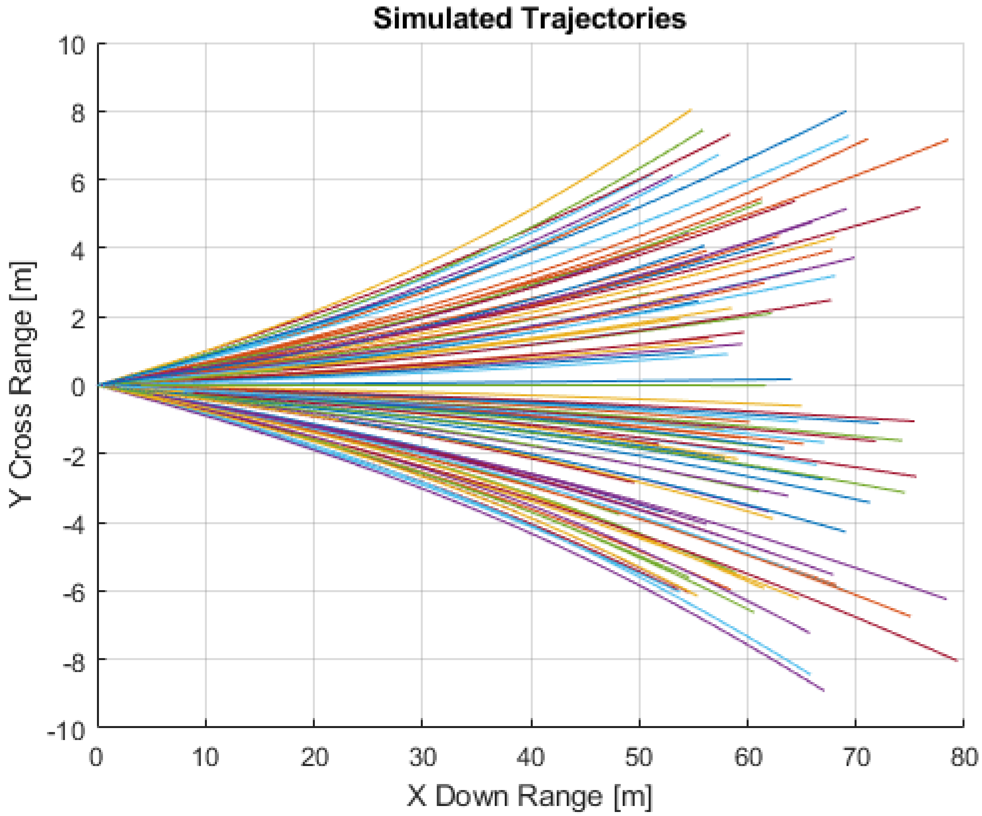
Plot

```
figure(1)
plot3(Properties(:,2),Properties(:,3),Properties(:,1))
grid on
title('A Bottle Rocket Trajectory')
xlabel('X [m]')
ylabel('Y [m]')
zlabel('Z [m]')

save('landingPoints.mat','Xf','Yf','simulations')

figure(2)
for i = 1:simulations
    hold on
plot3(Q{i}(:,2),Q{i}(:,3),Q{i}(:,1))

end
title('Simulated Trajectories')
ylabel('Y Cross Range [m]')
```

```
xlabel('X Down Range [m]')
grid on
hold off

function state = Rocket(t,state_i,C,AreaBottle,WindX,WindY)


 %State Vector
 state = zeros(4,1);
 Z = state_i(1);                         %Z position [m]
 X = state_i(2);                         %X position [m]
 Y = state_i(3);
 V_Z = state_i(4);                       %Velocity [m/s]
 V_X = state_i(5);                       %Velocity [m/s]
 V_Y = state_i(6);
%Heading Calculations
 Velocity = sqrt(V_Z^2+V_X^2+V_Y^2);            %[m/s]
%Heading position
if (sqrt((X-C.X0)^2+(Z-C.Z0)^2) < C.L)   %Launch angle 45 deg
    hz = sind(C.Theta);
    hx = cosd(C.Theta);
    hy = 0;
else
    hz = V_Z/Velocity;                   %sin(theta)
    hx = V_X/Velocity;                   %cos(theta)
    hy = V_Y/Velocity;
end

q_z = (1/2)*C.RoeAmb*V_Z^2;              %Dynamic Pressure
q_x = (1/2)*C.RoeAmb*V_X^2;
q_y = (1/2)*C.RoeAmb*V_Y^2;
Drag_Z = q_z*C.CD*AreaBottle;            %Drag
Drag_X = q_x*C.CD*AreaBottle;
Drag_Y = q_y*C.CD*AreaBottle;
%%%%%%%%%CALCULATE THETA_DOT HERE

            Sum_FX = - Drag_X*hx;
            Sum_FY = - Drag_Y*hy;
            Sum_FZ = - Drag_Z*hz - C.MBot*C.g;
            %Calculate the X and Y accelerations
            Accel_X = Sum_FX /C.MBot;
            Accel_Y = Sum_FY /C.MBot;
            Accel_Z = Sum_FZ /C.MBot;



%Outputing the derivative of things on top of our state vectors
state(1) = V_Z;             %[m/s]
state(2) = V_X - WindX;             %[m/s]
state(3) = V_Y - WindY;
state(4) = Accel_Z;         %[m/s^2]
state(5) = Accel_X;         %[m/s^2]
state(6) = Accel_Y;
```

```
end


%This stops the ODE45 call when the rocket would hit the ground
function [value, isterminal, direction] = hitGround(t,state)
value  =(state(1) <= 0);
isterminal = 1;
direction =  0;
end
```





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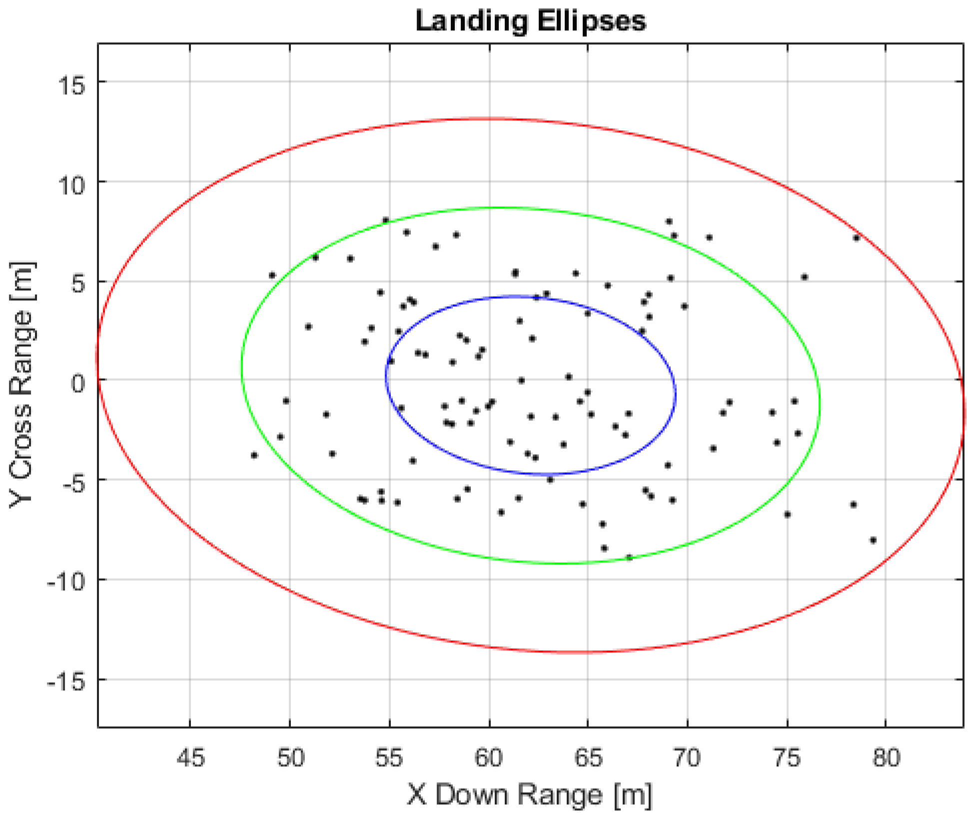
```
clc; clear all; close all;
```

Replace this section of code with your real data

Simulate and plot 100 data points, (YOU SHOULD USE REAL DATA HERE!)

```
load('landingPoints.mat')

N = simulations; % Number of points to simulate
x = Xf; % Data From ISP Rocket Model
y = Yf;

figure; plot(x,y,'k.','markersize',6)
axis equal; grid on; xlabel('X Down Range [m]'); ylabel('Y Cross Range
 [m]'); title('Landing Ellipses'); hold on;

% Calculate covariance matrix
P = cov(x,y)
mean_x = mean(x);
mean_y = mean(y);

% Calculate the define the error ellipses
n=N; % Number of points around ellipse
p=0:pi/n:2*pi; % angles around a circle

[eigvec,eigval] = eig(P); % Compute eigen-stuff
xy_vect = [cos(p'),sin(p')] * sqrt(eigval) * eigvec'; % Transformation
x_vect = xy_vect(:,1);
y_vect = xy_vect(:,2);

% Plot the error ellipses overlaid on the same figure
plot(1*x_vect+mean_x, 1*y_vect+mean_y, 'b')
plot(2*x_vect+mean_x, 2*y_vect+mean_y, 'g')
plot(3*x_vect+mean_x, 3*y_vect+mean_y, 'r')
```

```
P =

   52.9444   -3.3892
   -3.3892   20.0208
```



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