

ASEN 3128: Homework 1

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Prepare workspace

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

Declare Constants

```
global mass C_d p A W_N W_E W_D  
  
mass = 0.03; % [kg]  
dia = 0.03; % [m], diameter of golf ball  
C_d = 0.6; % Coefficient of drag of golfball  
x_i = 0.0; % [m], initial x-position of the ball  
y_i = 0.0; % [m], initial y-position of the ball  
z_i = 0.0; % [m], initial z-position of the ball  
V_Ni = 0.0; % [m/s], initial velocity in N direction  
V_Ei = 20.0; % [m/s], initial velocity in E direction  
V_Di = -20.0; % [m/s], initial velocity in D direction  
W_N = 0.0; % [m/s], wind initial velocity in N direction  
W_E = 0.0; % [m/s], wind initial velocity in N direction  
W_D = 0.0; % [m/s], wind initial velocity in N direction  
p = 1.225; % [kg/m^3], density of air  
A = 3.1415926 * (dia/2) ^2; % [m^2], cross sectional area of the ball
```

Part A

Preparing for ODE45

```
Initials = [x_i y_i z_i V_Ni V_Ei V_Di]; % Declaring the initial state vector for ODE45  
  
tSpan = 0:0.001:10; % [s], time range for ODE45 plotting  
  
options = odeset('Events', @golfballEventsFcn);
```

Call the ODE

```
[tA, yA, teA, yeA, ieA] = ode45(@golfballFlight, tSpan, Initials, options);  
maxDistance = max(yA(:,2))
```

```
maxDistance = 54.1501
```

The distance the golfball flies is 54.2 meters. From checking with other students, this answer seems to be valid. Additionally, the time of flight of the golfball is approximately 3 seconds. Incorporating aerodynamics drag and an initial horizontal velocity of 20 m/s, 54.2 meters makes logical sense.

Part B

Constants

```
W_N = 1.0;
```

Preparing for ODE45

```
Initials = [x_i y_i z_i V_Ni V_Ei V_Di]; % Declaring the initial state vector for ODE45  
tSpan = 0:0.001:10; % [s], time range for ODE45 plotting  
options = odeset('Events', @golfballEventsFcn);
```

Call the ODE

```
[tB, yB, teB, yeB, ieB] = ode45(@golfballFlight, tSpan, Initials, options);  
windDeflection = max(yB(:,1))
```

```
windDeflection = 2.7068
```

For the initial conditions given for the velocity of the golfball, the landing location varies by 2.71 meters for every 1 meter per second of North wind speed.

Part C

Increasing the Mass

Declaring Constants

```
W_N = 0.0;  
KE_i = 0.5 * mass * norm([V_Ni V_Ei V_Di]);  
mass = 0.05;  
V_mag = KE_i * 2 / mass;  
V_Ei = V_mag * cosd(45);  
V_Di = -V_mag * cosd(45);
```

Preparing for ODE45

```
Initials = [x_i y_i z_i V_Ni V_Ei V_Di]; % Declaring the initial state vector for ODE45  
tSpan = 0:0.001:10; % [s], time range for ODE45 plotting  
options = odeset('Events', @golfballEventsFcn);
```

Call the ODE

```
[tC1, yC1, teC1, yeC1, ieC1] = ode45(@golfballFlight, tSpan, Initials, options);
```

Decreasing the Mass

Declaring Constants

```
KE_i = 0.5 * mass * norm([V_Ni V_Ei V_Di]);  
mass = 0.01;  
V_mag = KE_i * 2 / mass;  
V_Ei = V_mag * cosd(45);  
V_Di = -V_mag * cosd(45);
```

Preparing for ODE45

```
Initials = [x_i y_i z_i V_Ni V_Ei V_Di]; % Declaring the initial state vector for ODE45  
  
tSpan = 0:0.001:10; % [s], time range for ODE45 plotting  
  
options = odeset('Events', @golfballEventsFcn);
```

Call the ODE

```
[tC2, yC2, teC2, yeC2, ieC2] = ode45(@golfballFlight, tSpan, Initials, options);
```

Analysing the Data

```
maxDIncrease = max(yC1(:,2))
```

```
maxDIncrease = 26.2888
```

```
maxDDecrease = max(yC2(:,2))
```

```
maxDDecrease = 72.4692
```

The distance flown by the golfball will increase if the mass is decreased, but the kinetic energy is kept constant.

Plotting Flights

```
figure('Name', 'Golfball Flights');  
  
subplot(1,3,1);  
plot3(yA(:,1), yA(:,2), -yA(:,3));  
title('Golfball Flight');  
xlabel('N (m)');  
ylabel('E (m)');  
zlabel('-D (m)');  
grid on  
  
subplot(1,3,2);  
plot3(yB(:,1), yB(:,2), -yB(:,3));  
title('Wind Deflection')  
xlabel('N (m)');  
ylabel('E (m)');  
zlabel('-D (m)');
```

```
grid on
```

```
subplot(1,3,3);  
plot3(yA(:,1), yA(:,2), -yA(:,3));  
hold on  
plot3(yC1(:,1), yC1(:,2), -yC1(:,3));  
hold on  
plot3(yC2(:,1), yC2(:,2), -yC2(:,3));  
legend({'Same Mass', 'Increased Mass', 'Decreased Mass'}, 'Location', 'best')  
title('Varying Mass')  
xlabel('N (m)');  
ylabel('E (m)');  
zlabel('-D (m)');  
grid on
```

