SESSION 2

SIMULATING A CANNONBALL IN VACUUM AND ATMOSPHERE

1 PROBLEM 1

SIMULATING A CANNONBALL IN VACUUM

1.1 CODE

```
g = 9.81;
f = @(t, z) [z(3,1); z(4,1); 0; -g];
hori0 = 0;
vy0 = 470 * sin(45);
vert0 = 0;
vx0 = 470 * cos(45);
z0 = [hori0; vert0; vx0; vy0];
t = 0:0.01:81.8;
[t, z] = ode45(f, t, z0);
i=1;
z1=z(:,1);
z2=z(:,2);
horizontal_position=zeros;
altitude=zeros;
```

FIGURE 1. CODE WRITTEN IN MATLAB

1.2 CODE

```
while(z2(i)>=0)
    horizontal_position(i)=z1(i);
    altitude(i)=z2(i);
    i=i+1;
end
Range = max(horizontal_position);
disp(['Range of the cannonball: ' num2str(Range) ' meters']);
clf();
plot(horizontal_position, altitude);
xlabel('Horizontal Position (m)');
ylabel('Altitude (m)');
title('Cannonball Trajectory in Vacuum');
```
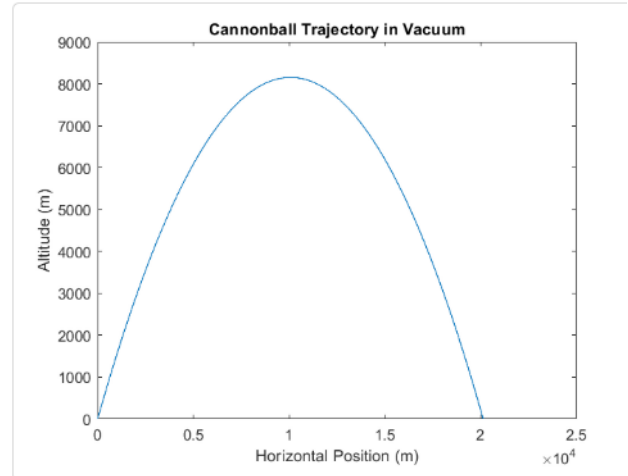
FIGURE 2. CODE WRITTEN IN MATLAB

FIGURE 3. GRAPH

2   PROBLEM 2

SIMULATING A CANNONBALL IN ATMOSPHERE

```matlab
v_0=442.7;
theta=pi/4;
whos("atmscale.m","atmosphere","A","T","P","D");
A=atmosphere(:,1);
T=atmosphere(:,2);
D=atmosphere(:,4);
```

FIGURE 4.   CODE WRITTEN IN MATLAB

```matlab
[t,z]=ode45(@(t,z) f(t,z,A,T,D),(0:0.001:100),[0 0 v_0*cos(theta) v_0*sin(theta)]);
%[t,y]=ode45(@f2,(0:0.001:100),[0 v0*sin(theta)]);
i=1;
z1=z(:,1);
z2=z(:,2);
x_new=zeros;
y_new=zeros;
while(z2(i)>=0)
    x_new(i)=z1(i);
    y_new(i)=z2(i);
    i=i+1;
end
plot(x_new,y_new)
```
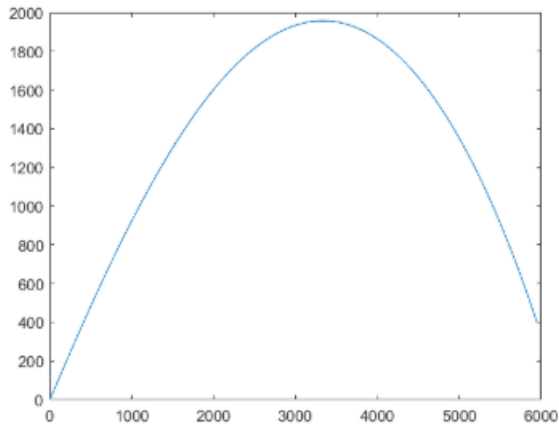
FIGURE 5.   CODE WRITTEN IN MATLAB

```
function zdot=f(~,z,A,T,D)
    rho=7750;%kg/m^3
    m=40;%kg
    d=0.22;%diameter in m
    s=(pi*d^2)/4;%surface area
    temp=interp1(A,T,z(2,1)/1000);
    density=interp1(A,D,z(2,1)/1000);
    mu=(1.458e-06*temp^1.5)/(temp+110.4);
    Re=density*(sqrt(z(3,1)^2+z(4,1)^2))*d/mu;
    R=log(Re);
    M=sqrt(z(3,1)^2+z(4,1)^2)/(sqrt(1.4*287*temp));
    c = [0.0000641, -0.0006166, -0.0075524, 0.1175224, -0.0009032, 0.0136069, 0.0086353, -1.0093621, 0.0041238, -0.0858483,0.4289429,
        1.5431515, -0.0064570, 0.1778755, -1.5559375, 4.0394577];
    Cd = c(1)*M^3*R^3 + c(2)*M^3*R^2 + c(3)*M^3*R + c(4)*M^3 + c(5)*M^2*R^3 + c(6)*M^2*R^2 + c(7)*M^2*R + c(8)*M^2
    + c(9)*M*R^3 + c(10)*M*R^2 + c(11)*M*R + c(12)*M + c(13)*R^3 + c(14)*R^2 + c(15)*R +c(16);
    zdot(1,1)=z(3,1);
    zdot(2,1)=z(4,1);
    zdot(3,1)=-0.5*(density/m)*s*Cd*(sqrt(z(3,1)^2+z(4,1)^2))*z(3,1);
    zdot(4,1)=-9.81-0.5*(density/m)*s*Cd*(sqrt(z(3,1)^2+z(4,1)^2))*z(4,1);
```

FIGURE 6.   CODE WRITTEN IN MATLAB

FIGURE 7.   GRAPH DRAWN IN MATLAB