*** Q-1, DYNAMICS OF GUIDED PROJECTILE ***

INITIAL CONDITIONS ASSUMED

Bomb cell is launched at 3000 m, with velocity of 20 m/s at different launch angles 0, 5 & 10 degrees.
Mass of Bomb cell is 160 kg.

MATLAB code

>> MAIN_Q1.m

```
%% MAIN_Q1

close all
clear all
clc

v0 = 20; % m/s
x0 = 0; % m
y0 = 3000; % m

launch_all = [0 , 5, 10];

for i = 1:3
    launch = launch_all(i);
    gamma_0 = deg2rad(launch); % rad

states0 = [v0, gamma_0, x0, y0];

[t,y] = RK4(@pointMassModel, 50, 0.01, states0);

figure(i);

subplot(4,1,1);
plot(t,y(:,3),'r');
% xlim([0 25])
ylabel('x');
grid on

subplot(4,1,2);
plot(t,y(:,4),'r');
% xlim([0 25])
ylabel('y');
grid on
```

```
subplot(4,1,3);
plot(t,y(:,1),'r');
% xlim([0 25])
ylabel('v');
grid on

subplot(4,1,4);
plot(t,y(:,2),'r');
% xlim([0 25])
ylabel('\gamma');
xlabel('t');
grid on

% figure(i);
%
% if i==1
%     title("\gamma_0 = 0^\circ");
% else if i==2
%         title("\gamma_0 = 5^\circ");
% else
%     title("\gamma_0 = 10^\circ");
% end

end
```

>> DENSITY.m

```
function rho = DENSITY(hg)

hg1=0;              % Gradient layer 1-2 (0 to 11 km)
T1=288.16;
a1=-0.0065;

p1=101325;  % in pascal at MSL (Mean Sea Level)
d1=1.225;   % in kg/m3 at MSL
g0=9.81;    %gravitational acceleration at MSL
R=287;      %in J/kgK

r=6371000;                          % Radius of earth

h=(r*hg)/(r+hg);                     % Calculation for Geopotential altitude
h1=(r*hg1)/(r+hg1);                  % Geo potential ALT CALC
T=T1+(a1*delh);                     % TEMP CALC
d=d1*((T/T1)^((-g0/(a1*R))-1));         % DENS CALC

rho = d;

end
```

>> POINTMASSMODEL.m

```
%% POINT MASS MODEL

function dstates = pointMassModel(~,states)

v = states(1);
gamma = states(2);
x = states(3);
y = states(4);

rho = DENSITY(y);

S = 0; % m^2 (Assuming Point mass)
cd0 = 0.302;
m = 160; % kg
g = 9.81; % m/s

D = 0.5*rho*v^2*S*cd0;

v_dot = -(D + m*g*sin(gamma))/m;
gamma_dot = -g*cos(gamma)/v;
x_dot = v*cos(gamma);
y_dot = v*sin(gamma);

dstates = [v_dot; gamma_dot; x_dot; y_dot];
end
```

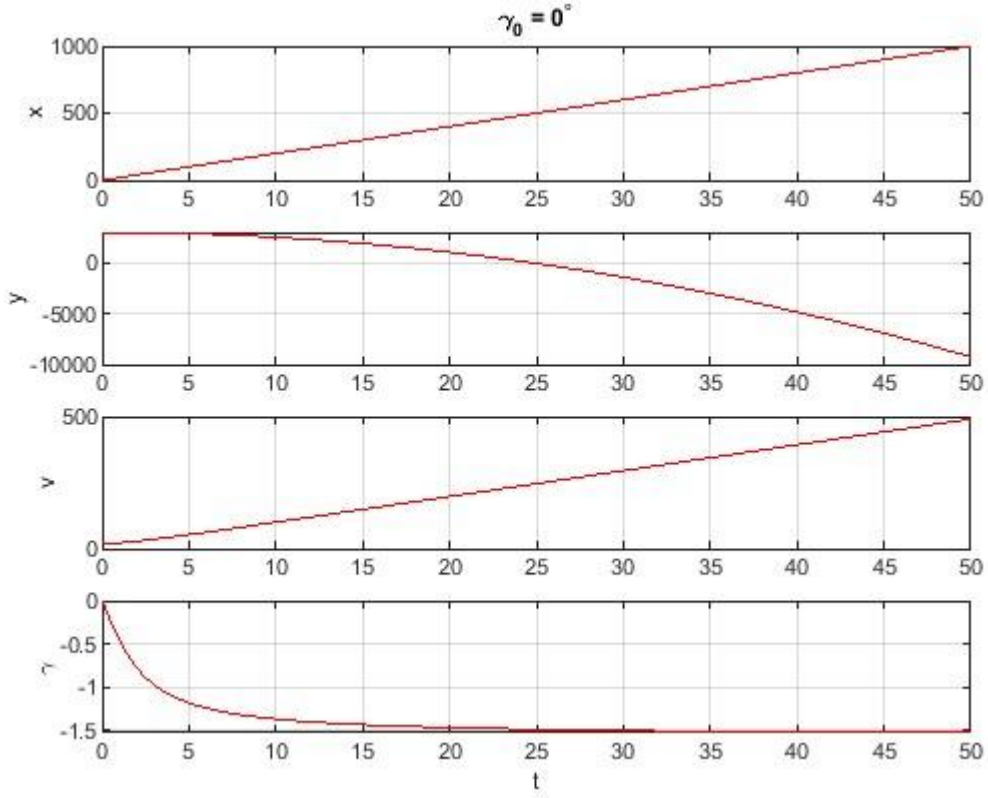
>> RK4.m

```
%% RK4

function [t,y] = RK4(dydt, tf, h, y0)
% reshape y0 to column vector
y0 = reshape(y0, [], 1);

n = tf/h;
d = size(y0,1);

t = zeros(n,1);
y = zeros(n,d);

tn = 0;
yn = y0;

t(1,:) = tn;
y(1,:) = yn';
```

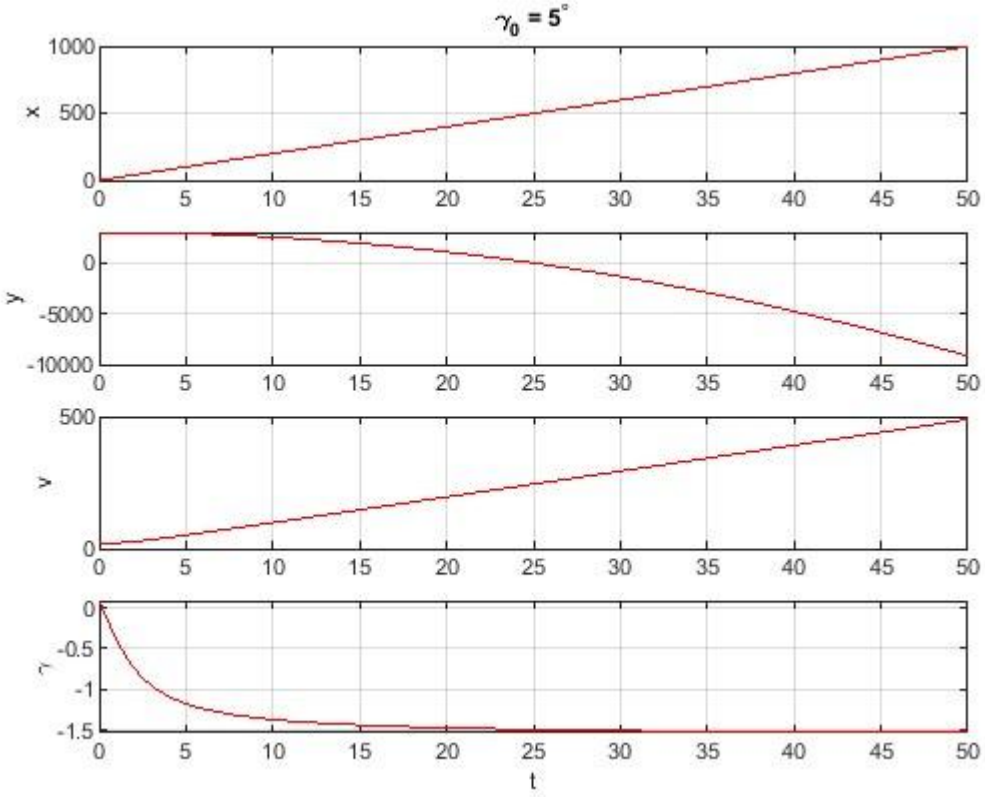
```
for i=2:n+1
k1 = dydt(tn, yn);
k2 = dydt(tn + h/2, yn + h*k1/2);
k3 = dydt(tn + h/2, yn + h*k2/2);
k4 = dydt(tn + h, yn + h*k3);

yn = yn + (k1 + 2*k2 + 2*k3 + k4)*h/6;
tn = tn + h;

t(i) = tn;
y(i,:) = yn';
end
end
```

Output (PLOTS)

>> Launch angle = 0°



>> Launch angle = 5°



>> Launch angle = 10°