AE332-MODELLING AND ANALYSIS LAB

SESSION 3

SIMULATION OF ROCKETS AND SHELL

Aditya Kumar Shahi

SC21B005

PROBLEM 1:SIMULATION OF ARTILARY SHELL IN ATMOSPHERE

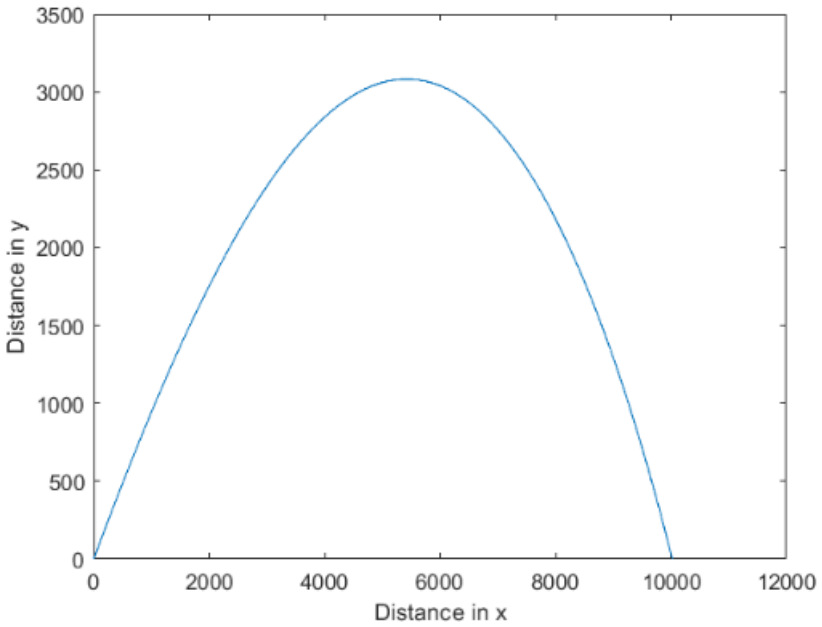
FUNCTION WRITTEN IN MATLAB

```
function z1=shell(t,z,m,A,T,D,M,CN_alpha,C_p,MAjoff_array,hAjoff_array,CAmatrix_joff)
g=9.81;
L=1.115;
x_CoM=0.70769;
I=4.29;
Rnom=0.101/2;
S=pi*Rnom^2;
temp=interp1(A,T,z(2,1)/1000);
density=interp1(A,D,z(2,1)/1000);
a=sqrt(1.4*287*temp);
mach=sqrt(z(4,1)^2+z(5,1)^2)/a;
CN_alpha=interp1(M,CN_alpha,mach);
cop=interp1(M,C_p,mach);
alpha=z(3,1)-atan(z(5,1)/z(4,1));
C_N=CN_alpha*alpha;
C_A=interp2(hAjoff_array,MAjoff_array,CAmatrix_joff,z(2,1)/1000,mach);
x_cp=cop*L;
a_x=x_cp-x_CoM;
F_N=0.5*C_N*S*density*(z(4,1)^2+z(5,1)^2);
F_A=0.5*C_A*S*density*(z(4,1)^2+z(5,1)^2);
z1(1,1)=z(4,1);
z1(2,1)=z(5,1);
z1(3,1)=z(6,1);
z1(4,1)=-(F_N/m)*sin(z(3,1))-(F_A/m)*cos(z(3,1));
z1(5,1)= (F_N/m)*cos(z(3,1))-(F_A/m)*sin(z(3,1))-g;
z1(6,1)= -F_N*abs(a_x)/I;
end
```

CODE WRITTEN IN MATLAB

```
tspan=0:0.001:50;
v=442.8;
theta=pi/4;
run('shell.mlx')
A=atmsphr(:,1);
T=atmsphr(:,2);
P=atmsphr(:,3);
D=atmsphr(:,4);
m=40;
M=NrmlFrc(:,1);
CN_alpha=NrmlFrc(:,2);
C_p=NrmlFrc(:,3);
tol=odeset('RelTol',1e-12,'AbsTol',1e-12);
z0=[0;0;pi/4;v*cos(theta);v*sin(theta);0];
[t,z]=ode45(@(t,z) shell(t,z,m,A,T,D,M,CN_alpha,C_p,MAjoff_array,hAjoff_array,CAmatrix_joff),tspan,z0,tol);
x=z(:,1);
y=z(:,2);
plot(x,y);
xlabel('Distance in x');
ylabel('Distance in y');
range=max(x)
```

GRAPH:



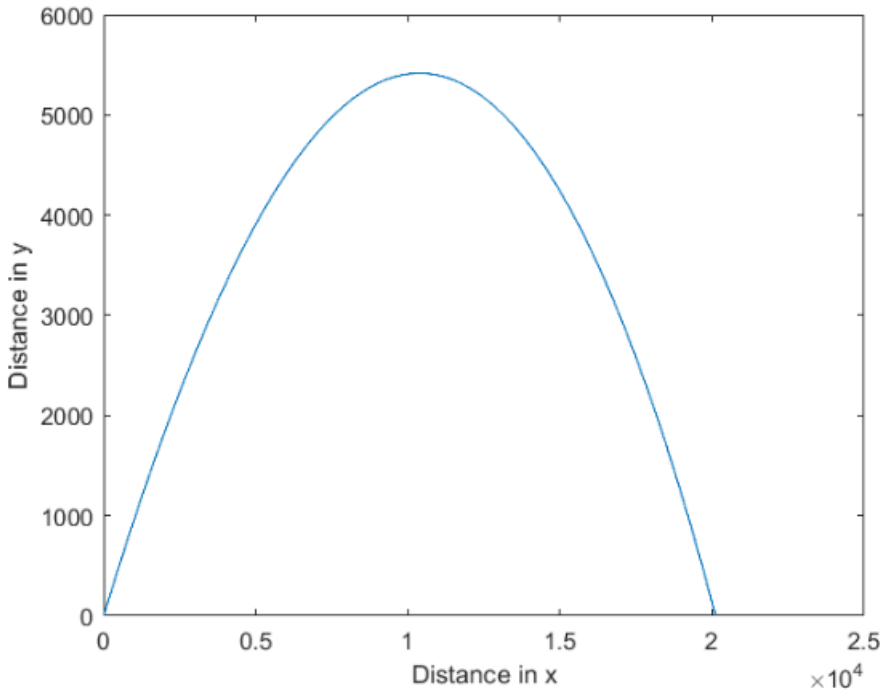
RANGE=10,022m

ACHIEVING 20 KM:

CODE

```
tspan=0:0.01:100;
m=275;
v=490;
run('shell.mlx')
tol=odeset('RelTol',1e-12,'AbsTol',1e-12);
z0=[0;0;pi/4;v*cos(theta);v*sin(theta);0];
[t,z]=ode45(@(t,z) shell(t,z,m,A,T,D,M,CN_alpha,C_p,MAjoff_array,hAjoff_array,CAmatrix_joff),tspan,z0,tol);
x=z(:,1);
y=z(:,2);
plot(x,y);
xlabel('Distance in x');
ylabel('Distance in y');
range=max(x)
```

GRAPH




```
range = 2.0114e+04
```

PROBLEM 2: SIMULATION OF ROCKET IN ATMOSPHERE

FUNCTION WRITTEN IN MATLAB:

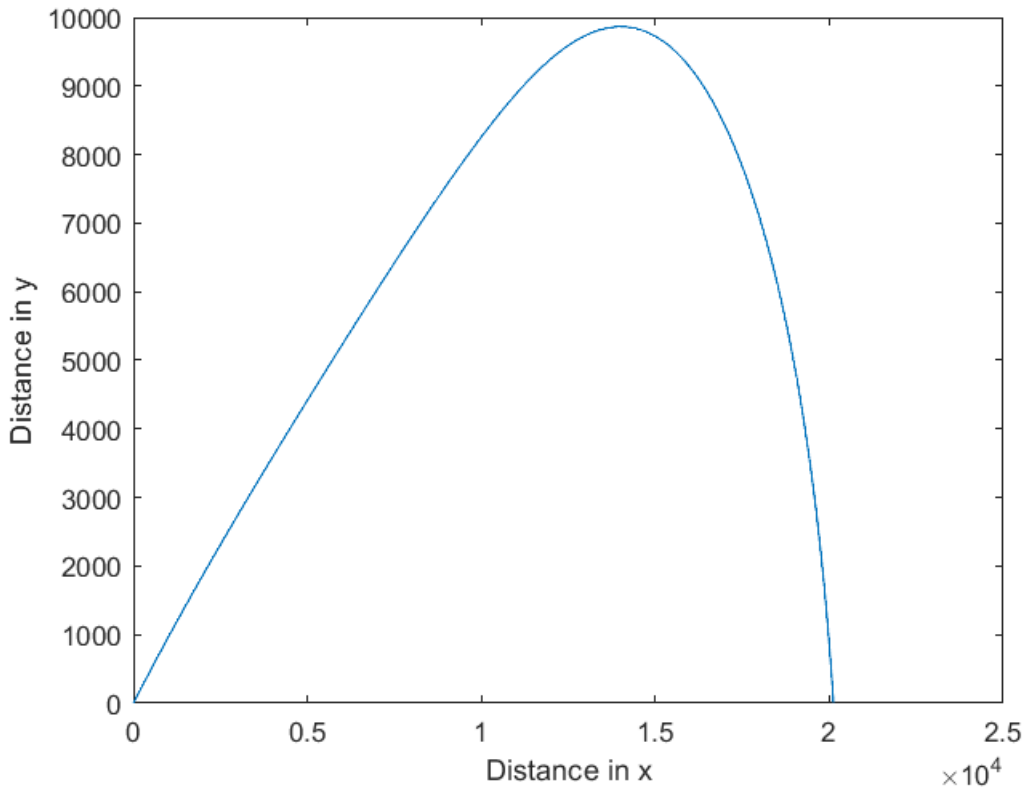
```
function z1=rocket(t,z,A,T,D,M,P,CN_alpha,C_P,MAjoff_array,hAjoff_array,CAmatrix_joff,MAjon_array,hAjon_array,CAmatrix_jon,tm_array,thrustKN_array,massexpelled_array)
SRL=2.277;
StructuralMass=39.229;
InitialpropellantMass=48.771;
%ipar=[43.681 1.4735 16.318 1.1135 0.0979]
g=9.81;
Rnom=0.207/2;
S=pi*Rnom^2;
R_E=0.125/2;
A_E=pi*R_E^2;
t_thrusting=11.778;
alpha=z(3,1)-atan(z(5,1)/z(4,1));
temp=interp1(A,T,z(2,1)/1000);
density=interp1(A,D,z(2,1)/1000);
p_a=interp1(A,P,z(2,1)/1000);
a=sqrt(1.4*287*temp);
mach=sqrt(z(4,1)^2+z(5,1)^2)/a;
CN_alpha=interp1(M,CN_alpha,mach);
C_N=CN_alpha*alpha;
cop=interp1(M,C_P,mach);
x_cp=cop*SRL;
C_A1=interp2(hAjoff_array,MAjoff_array,CAmatrix_joff,z(2,1)/1000,mach);
C_A2=interp2(hAjon_array,MAjon_array,CAmatrix_jon,z(2,1)/1000,mach);
F_N=0.5*C_N*S*density*(z(4,1)^2+z(5,1)^2);
if(t<=t_thrusting)
T_vaccum=interp1(tm_array,thrustKN_array,t)*1000;
massexp=interp1(tm_array,massexpelled_array,t);
m_p=InitialpropellantMass-massexp;
m=StructuralMass+m_p;
```

```
x_com=(43.681+1.4735*m_p)/(39.229+m_p);
I=16.318+39.229*(1.1135-x_com).^2+(0.0979+(1.4735-x_com).^2).*m_p;
C_A=C_A2;
T=T_vaccum-p_a*A_E;
else
    C_A=C_A1;
    T=0;
    x_com=1.1135;
    m=StructuralMass;
    I=16.318;
end
a_x=x_cp-x_com;
F_A=0.5*C_A*S*density*(z(4,1)^2+z(5,1)^2);

z1(1,1)=z(4,1);
z1(2,1)=z(5,1);
z1(3,1)=z(6,1);
z1(4,1)=-(F_N/m)*sin(z(3,1))-(F_A/m)*cos(z(3,1))+(T*cos(z(3,1)))/m;
z1(5,1)=(F_N/m)*cos(z(3,1))-(F_A/m)*sin(z(3,1))+(T*sin(z(3,1)))/m-g;
z1(6,1)=-F_N*abs(a_x)/I;




end
```

CODE:

```
t_span=0:0.01:200;
v=442.8;
theta=pi/4;
run('sounding.mlx')
A=atmsphr(:,1);
T=atmsphr(:,2);
P=atmsphr(:,3);
D=atmsphr(:,4);
M=NrmlFrc(:,1);
CN_alpha=NrmlFrc(:,2);
C_P=NrmlFrc(:,3);
tol=odeset('RelTol',1e-12,'AbsTol',1e-12);
z0=[0;0;pi/4;v*cos(theta);v*sin(theta);0];
[t,z]=ode45(@(t,z)rocket(t,z,A,T,D,M,P,CN_alpha,C_P,MAjoff_array,hAjoff_array,CAmatrix_joff,MAjon_array,hAjon_array,CAmatrix_jon,tm_array, ...
    thrustKN_array,massexpelled_array),t_span,z0,tol);
x=z(:,1);
y=z(:,2);
plot(x,y);
xlabel('Distance in x');
ylabel('Distance in y');
maxm_y=max(z(:,2));
maxm_x=max(z(:,1));
```

GRAPH AT THETA=PI/4



GRAPH AT THETA=PI/2.47