Rocket Problem

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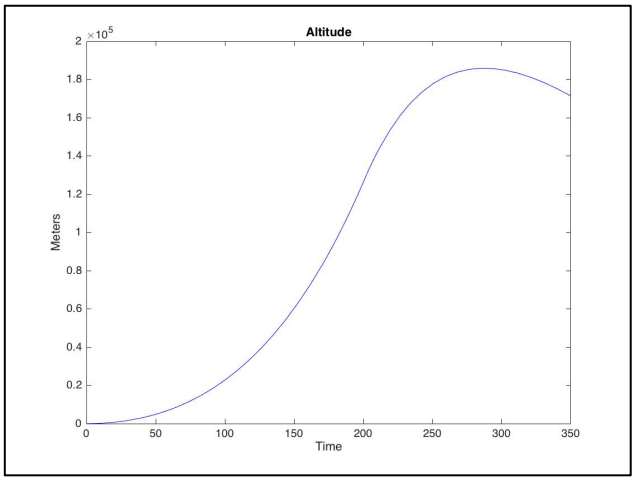
BACKGROUND

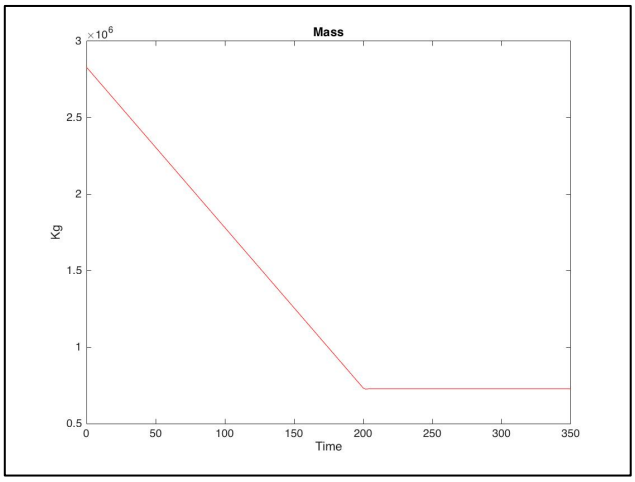
In this problem, we solve several differential equations numerically using MATLAB. These equations describe the time-dependent mass, velocity, and position of a rocket ship during a launch. The associated MATLAB code and output plots are presented below.

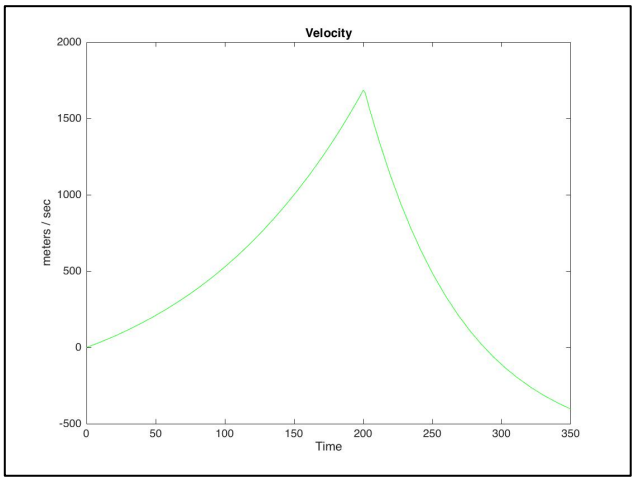
```
% Input Values
Md = 730000; % kg (dry mass)
Mp = 2100000; % kg (propellant mass)

% Initial Conditions:
Y0 = 0; % m (position)
M0 = Md + Mp; % kg (mass)
V0 = 0; % m/s (velocity)

% Time Window:
t0 = 0;
tmax = 350;

% Solve for X0, v0, and M0:
zo=[Y0 M0 V0];

% Call ODE:
[t,z]=ode45('eqns',[t0,tmax],zo);

% Graph:
figure;
plot(t,z(:,1),'b-');
title('Altitude');
xlabel('Time');
ylabel('Meters');

figure;
plot(t,z(:,2),'r-');
title('Mass');
xlabel('Time');
ylabel('Kg');

figure;
plot(t,z(:,3),'g-');
title('Velocity');
xlabel('Time');
ylabel('meters / sec');
```

```
function g = eqns(t,z)

% Input Values
T = 37000000; % N (thrust)
g = 9.8; % m/s/s (acceleration due to gravity)
P0 = 1.2; % kg/m^3 (density)
Cd = 0.0075; % (drag coefficient)
As = pi*10*110; % Surface area (pi*D*H)
Vj = 3528; % m/s (velocity of jet)

% Variables to solve for:
Y = z(1); % position
M = z(2); % mass
V = z(3); % velocity

% Forces:
Fd = .5*(P0)*Cd*As*(V^2)*exp(-Y/7300); % N
(drag force)
Fg = g*M; % N (gravitational pull)

% ODEs:
dYdt = V;

if M > 730000;
dMdt = (-1*T/Vj);
else
dMdt = 0;
end

if M > 730000;
dVdt = (T-Fd-(Fg)-((T/Vj)*V))/M;
else
dVdt = (-Fd-(Fg)-((T/Vj)*V))/M;
end

g = [dYdt dMdt dVdt]';
```

Figure 1, MATLAB code.


Altitude
×10^5
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Meters
0
50
100
150
200
250
300
350
Time


Mass
×10^6
3
2.5
2
1.5
1
0.5
Kg
0
50
100
150
200
250
300
350
Time


Velocity
2000
1500
1000
500
0
-500
meters / sec
0
50
100
150
200
250
300
350
Time