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% EMEC 303 Project 1

clear; clc
close all

% Set step size and length of time in seconds
h  = 1;
Lt = 6000;
N  = round(Lt/h);

% Preallocation
height      = zeros(1,N);
den         = zeros(1,N);
t           = zeros(1,N);
phi         = zeros(1,N);
force_r     = zeros(1,N);
force_theta = zeros(1,N);
m           = zeros(1,N);

% Define initial conditions and constants
t_m    = 1.1045;         % Thrust multiplier
t(1)   = 0;              % Initial time
den(1) = rho(0);         % Starting density
r(1)   = 6.378e6;        % Radius of earth
vr(1)  = 0;              % Inital radial velocity
th(1)  = 0;              % Initial angle theta
w(1)   = 7.29e-5;        % Angular velocity of earth
phi(1) = deg2rad(73.8); % Launch angle relative to horizontal
height(1) = 0;           % Initial heigh above ground

% Call force function to determine additional initial conditions
[force_r(1),force_theta(1),m(1)] =...
    force(t(1),den(1),phi(1),vr(1),w(1),r(1),t_m);

% Store dependent variables into y
y = [r,vr,th,w];

% ODEs describing motion of rocket
f = @(t,y,force_r,force_theta,m)...
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    [y(2), force_r/m + y(1)*y(4)^2,...
    y(4),(force_theta/m - 2*y(2)*y(4))/y(1)];

for i = 1:N-1

    % Update height and density
    height(i+1) = y(i,1)-r(1);
    den(i+1) = rho(height(i));

    % Update time
    t(i+1)   = t(i) + h;

    % Update phi based on height
    if height(i) <= 275000
        phi(i+1) = sqrt(phi(1)-phi(1)*(height(i)/275000)^2);
    else
        phi(i+1) = 0;
    end

    % Call force function to update force in r and theta directions
    [force_r(i+1),force_theta(i+1),m(i+1)] = ...
        force(t(i),den(i),phi(i),y(i,2),y(i,4),y(i,1),t_m);

    % Euler update for dependent variables
    y(i+1,:) = y(i,:) + h*f(t(i),y(i,:),force_r(i),force_theta(i),m(i));

end

% Plot results
figure
polarplot((y(:,3)),y(:,1))
hold on
polarplot(0:.01:2*pi,ones(size(0:.01:2*pi))*r(1))
title('Rocket Trajectory in Polar Coordinates')
word1={'Radius (m)'};
text(0,3000000,word1)

figure
subplot(2,2,1)
plot(height,phi)
title ('Rocket Angle Relative to Horizontal')
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ylabel('Angle (rad)')
xlabel('Height (m)')

subplot(2,2,2)
plot(t,height)
title ('Rocket Height vs Time')
ylabel('Height (m)')
xlabel('Time (s)')

subplot(2,2,3)
plot(t,y(:,2))
title ('Radial Velocity vs Time')
ylabel('Speed (m/s)')
xlabel('Time (s)')

subplot(2,2,4)
plot(t,y(:,4).*y(:,1))
title ('Velocity in the Theta Direction vs Time')
ylabel('Speed (m/s)')
xlabel('Time (s)')
```