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## Problem 6

```
clear all; close all; clc

ri = [22000 -103000 -15000]; % initial state vectors
vi = [0.91 -4.5 -2.5];
mu = 398600;
dt = 3600*2; % time change in seconds
r_mag = norm(ri); % magnitude
v_mag = norm(vi);
vr = dot(ri,vi)/r_mag;
alpha = 2/r_mag - v_mag^2/mu;
a = 1./alpha; % semi major axis, if negative = hyperbolic
chi_guess = sqrt(mu)/abs((a))*dt; % Chobotov approx

chi = fzero('UniAn',chi_guess); % fzero to brute force solution
% universal anomaly equations
z = alpha*chi^2;
C_stu = (cosh(sqrt(-z)) - 1)/(-z);
S_stu = abs((sinh(sqrt(-z))-sqrt(-z))/(-z^(-1/3)));
%lagrange coefficients
f = 1-chi^2/r_mag*C_stu;
g = dt-1/sqrt(mu)*chi^3*S_stu;
%new vectors per lagrange
r_new = f*ri+g*vi;
r_new_mag = norm(r_new);
fdot = sqrt(mu)/(r_mag*r_new_mag)*(alpha*chi^3*S_stu-chi);
gdot = 1-chi^2/r_new_mag*C_stu;
v_new = fdot*ri +gdot*vi;

fprintf('Universal Anomaly: %0.2f \n', chi)
fprintf('Position: [%0.f, %0.f, %0.f] km \n', r_new)
fprintf('Velocity: [%0.2f, %0.2f, %0.2f] km/s \n', v_new)

Universal Anomaly: 36.92
Position: [28410, -134736, -32903] km
Velocity: [0.87, -4.32, -2.46] km/s
```

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```

function func = UniAn(chi)
ri = [22000 -103000 -15000];
vi = [0.91 -4.5 -2.5];
mu = 398600;
dt = 3600*2;
r_mag = norm(ri);
v_mag = norm(vi);
vr = dot(ri,vi)/r_mag;

alpha = 2./r_mag - v_mag.^2/mu;
a = 1./alpha;
h = cross(ri,vi);
z = alpha*chi^2;
C_stu = (cosh(sqrt(-z)) - 1)/(-z);
S_stu = abs((sinh(sqrt(-z))-sqrt(-z))/(sqrt(-z)^3));
func = r_mag*vr/sqrt(mu)*chi^2*C_stu + ...
    (1-alpha*r_mag)*chi^3*S_stu+r_mag*chi - sqrt(mu)*dt;
end

```