```
% launch to orbit

% shoot to orbit
clear
r2d = 180/pi;
d2r = pi/180;

G=6.7e-11;                % gravitational constant
mEarth = 5.9742e24;       % mass of the earth
rEarth = 6.378e6;         % radius of the earth

EarthRate = 2*pi/(24*60*60);


% Delta IV first stage
Thrust1 = 3212000;
Length1 = 70;
Mass1 = 250000;
Fuel1 = 150000;
BurnTime1 = 260;




% Delta IV second stage
Thrust2 = 300000;
Length2 = 70;
Mass2 = 50000;
Fuel2 = 25000;
BurnTime2 = 850;


t(1) = 0;                 % start time
dt=1;
n = 5000;

% initial parameters for rocket

xR(1) = rEarth;                 % initial x position
yR(1) = 0;                      % initial y position at alt. 300km
vxR(1) = 0;                     % initial x velocity
vyR(1) = rEarth * EarthRate;    % initial i velocity
alpha(1) = 0;                   % initial orientation
valpha(1) = EarthRate;          % initial orientation rate
vR(1) = vyR(1);

theta=zeros(1,n);
for i=100:109
   theta(i) = -0.015*d2r;    % 100 seconds in

   theta(i+100) = 0.0055*d2r;    % 200 seconds in
end



for i=2:n
   t(i) = t(i-1) + dt;          % time at start of interval i

   xR(i) = xR(i-1) + vxR(i-1)*dt;  % x at start of interval i
   yR(i) = yR(i-1) + vyR(i-1)*dt;  % y at start of interval i
   alpha(i) = alpha(i-1) + valpha(i-1)*dt;
```

```
   Rr = sqrt(xR(i-1)^2+yR(i-1)^2);  % R at start of interval i-1

   Agr = G*mEarth/Rr^2;             % gravity accel at start of interval i-1
   Agx = -Agr*xR(i-1)/Rr;
   Agy = -Agr*yR(i-1)/Rr;


   if (t(i-1) <= BurnTime1)    % First stage ?

      % yes
       Thrust = Thrust1;
       Mass = Mass1 - t(i-1)/BurnTime1*Fuel1;
       Length = Length1;

   elseif (t(i-1) <= BurnTime1 + BurnTime2)    % Second stage ?

       % yes
       Thrust = Thrust2;
       Mass = Mass2 - (t(i-1)- BurnTime1)/BurnTime2*Fuel2;
       Length = Length2;


   else
       % flyout stage
       Thrust = 0;



   end
   thetaa = theta(i-1);

   Thrustcm = Thrust*cos(thetaa);

   Thrustx = Thrust*cos(alpha(i-1)+thetaa);
   Thrusty = Thrust*sin(alpha(i-1)+thetaa);

   Torque = -Thrust*sin(thetaa)*Length/2;

   I = Mass*Length^2/12;


   vxR(i)= vxR(i-1) + dt*(Agx + Thrustx/Mass);
   vyR(i)= vyR(i-1) + dt*(Agy + Thrusty/Mass);

   vR(i) = sqrt(vxR(i)^2 + vyR(i)^2);

   vangle(i) = acos(vxR(i) / vR(i));  % error when vangle crosses 90

   AoA(i) = vangle(i) - alpha(i);

   valpha(i) = valpha(i-1) + dt*Torque/I ;

end


plot(xR, yR);

% here we draw a circle for the earth
for i2=1:101
   ang=2*pi*(i2-1)/100;
   xE(i2)= rEarth*cos(ang);
```

```
   yE(i2)= rEarth*sin(ang);
end
hold on
plot(xE,yE)                          % draw the earth
hold off
axis equal
```