```
function []=Frisbee
%Frisbee Launching Programme
%2 May 2000
%updated 5 June 2003

% define global variables

global rho m c S I hdisc Gravity CLo CDo CLalpha CDalpha;
global CMo CMalpha CMq Alpha0 radius;
global States t
global AlphaWindTunnel CLWindTunnel CDWindTunnel CMWindTunnel % look table
 variables
global CMcontrol CLcontrol
%set up constants
EndTime=5; %sim time span in seconds
g=9.81; % acceleration due to gravity
radius=.1347;   % disc radius(m)
c=2*radius; %root chord
S=0.057;    %disc area (m^2)
WingLoading=0.175*g/S; %N/m^2
rho=1.225;  %air density (kg/m^3)
m=WingLoading*S/g;    %disc  mass (kg). should 0.175kg for frisbee
CruiseVelocity=sqrt(WingLoading/(0.5*rho*.5)); % reference cruise velocity for
 level flight at CL=1

LaunchSpeed=15.0; %2*CruiseVelocity; %m/s % --> 15m/s per ISEA article - mvs
AdvR= 0.29; %advance ratio % 1 --> 0.29 per ISEA article - mvs
DivergenceParameter=WingLoading*AdvR/(0.5*rho*LaunchSpeed^2);
SpinRate=AdvR*LaunchSpeed/radius; % disc spin rate in rad/s
kzz=0.861*radius; %note: radius of gyration for solid disc kzz^2=0.5*r^2,
 kzz=0.71r
Iz=m*kzz^2;
Ix=Iz/2;
Iy=Ix;

I=[Ix 0 0;0 Iy 0;0 0 Iz]'; %Ix Iy Iz

DiscBodyAngularVelocity=[0 0 SpinRate]'; % disc z spin rate in rad/s
hdisc=I*DiscBodyAngularVelocity; % disc momentum vector due to spin
Gravity=[0 0 g]'; % earth gravity vector


%set up Aero linear derivatives
CLo=0.13338;
CDo=0.1069; % zero lift drag coefficient
CLalpha=2.6319; %wing lift curve slope
CDalpha=1.9524; %induced drag approximation - needs improving...
CMo=-0.02; % aircraft zero lift pitching moment coeff (nose up positive)
CMalpha= 0.1436; % change in pitchin moment coeff with alpha
CMeeta=0; % change in pitching moment coeff with elevator deflection (+ve eeta
 is trailing edge up)
CMq=-0.02379; % pitch damping coeff
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```
CYr=0; %side force coeff due to yaw rate
CLxi=0; %Rolling moment coeff due to aileron
CLp=-0.01; %Roll damping

Alpha0=-CLo/CLalpha; %alpha for zero lift

%wind tunnel data for lookup table(if used)
% AlphaWindTunnel=deg2rad([ -100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45
 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
 80 85 90 95 100]);
% CLWindTunnel=[0.150762192 0.078066463 -0.003710301 -0.082749305 -0.152820434
 -0.232348293 -0.307508759 -0.370459819 -0.451363808 -0.507870204 -0.55325323
 -0.58666136 -0.629972439 -0.676394141 -0.640316084 -0.548459792 -0.408897528
 -0.349915069 -0.237808174 -0.080184161 0.118523493 0.437067111 0.730789383
 0.973728456 1.218455606 1.474968425 1.680174357 1.843323286 2.063253791
 2.14512544 1.088061694 1.002551767 0.858051588 0.712625184 0.576326914
 0.433961668 0.282999511 0.138866486 -0.003847719 -0.156353971 -0.297871703];
% CDWindTunnel=[0.822250439 0.843209448 0.851109688 0.829085141 0.812923854
 0.800647891 0.785262096 0.757257913 0.747627731 0.71051867 0.664917562
 0.606092106 0.563885856 0.606203297 0.529796077 0.420099268 0.312967671
 0.228806171 0.16014638 0.095276372 0.093668272 0.151462915 0.253496213
 0.427477977 0.576104485 0.765424978 0.930055057 1.046747219 1.250803494
 1.474386753 1.053032858 1.094576733 1.140686569 1.183168073 1.217424651
 1.244699236 1.266032415 1.271611482 1.291292511 1.283144549 1.273137764];
% CMWindTunnel=[0.030253624 0.011931875 -0.000408519 -0.017544296 -0.033290371
 -0.047948567 -0.060952493 -0.074937851 -0.088136737 -0.09780544 -0.101014497
 -0.105207461 -0.108391399 -0.123400527 -0.13024462 -0.121074706 -0.10541996
 -0.082795771 -0.038575684 -0.021363636 -0.006988333 -0.004016044 0.003319832
 0.020506794 0.042911688 0.075582197 0.110844595 0.151763412 0.200023005
 0.225574384 0.017388352 0.0137404 0.016789607 0.020018008 0.021005287
 0.018780864 0.014442026 0.007442026 0.000442026 -0.008539151 -0.013169381];


%set up turn
% n=1.5; % number of g turn
% CLift=0.5; %Clopt
% LaunchSpeed=sqrt(WingLoading*n/(0.5*rho*CLift))
% Phio=-acos(1/n); %bank angle for turn
% Alphao=CLift/CLalpha-Alpha0
% Thetao=Alphao;
% Psio=0;

% Psidot=-n*g/LaunchSpeed; %turn rate
% p=Psidot*sin(Thetao);
% q=Psidot*sin(Phio);
% CMcontrol=-AdvR*Iz*n*g*sin(Thetao)/(2*rho*LaunchSpeed^2*pi*radius^4);
% CLcontrol=AdvR*Iz*n*g*sin(Phio)/(2*rho*LaunchSpeed^2*pi*radius^4)*2;

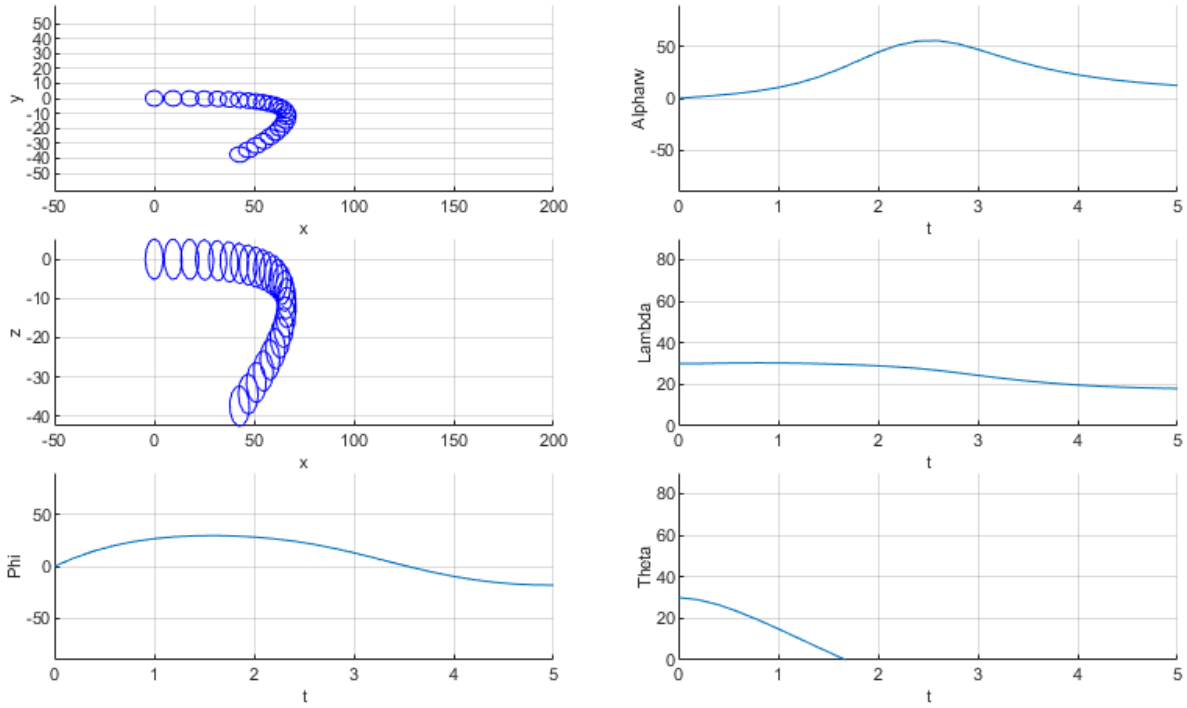
%set up launch normal conditions
%Note that rotations must be applied in the order yaw, pitch roll
%Set up launch attitude
Psio=deg2rad(0);
Thetao=deg2rad(15); % 5 --> 15 per ISEA article - mvs
Phio=deg2rad(0);
```

```
%set alpha
Alphao=deg2rad(0); % launch angle of attack
%Obtain launch relative wind components
uo=LaunchSpeed*cos(Alphao);
wo=LaunchSpeed*sin(Alphao);
vo=0;

%set up initial aircraft state yo

yo(1)=0; %Xe
yo(2)=0; %Ye
yo(3)=0; %Ze
yo(4)=Phio; %phi
yo(5)=Thetao; %theta
yo(6)=Psio; %psi
yo(7)=uo; %u
yo(8)=vo; %v
yo(9)=wo; %w
yo(10)=0; %p
yo(11)=0; %q
yo(12)=SpinRate; %r % 0 --> SpinRate w/AdvR == 0.29 per ISEA article - mvs

dt=.2; %results print interval (s)
tspan=[0:dt:EndTime];
[t,States, Alpharw] = ode23('FrisbeeODE',tspan,yo);
%DisplayFrameDelay=50000; % adjust to change display frame rate
%WorldSize=40; % size of plot world in m
DisplayDisc;
%note that DisplayDisc can be called independently after the simulation has
 finished for repeat viewing
```



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