A. Código Octave

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function exam
%% SPHERICAL PENDULUM SIMULATION
%%  ISAAC AYALA LOZANO
clear
clc
close all
%% INITIAL CONDITIONS
tspan = [0  10];
b     = 1;  %m
theta   = pi/10;    % rad/s
phi     = pi/5;    % rad/s
Ptheta  = 1;    % kg m /s
Pphi    = 1;    % kg m/s
x0 = [theta Ptheta phi Pphi];
%% Solution
[t,sol] = ode45(@pendulum,tspan,x0);
%% Convert to cartesian
r = b * sin(sol(:,1));
x = r .* cos(sol(:,3));
y = r .* sin(sol(:,3));
z = b .* sin(sol(:,1));
%%% Phase plot theta p_theta
figure(1)
plot(sol(:,1),sol(:,2),'k')
xlabel('$\theta$','Interpreter','latex')
ylabel('$p_{\theta}$','Interpreter','latex')
title('Diagrama fase $\theta - p_\theta$')
set(gcf,'Color',[1 1 1])
print('-dpdflatex', 'img/phaseThetaPTheta.tex', '-S300
    ,250','-mono');
%%% Phase plot phi p_phi
figure(2)
plot(sol(:,3),sol(:,4),'k')
xlabel('$\phi$','Interpreter','latex')
ylabel('$p_{\phi}$','Interpreter','latex')
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35 title('Diagrama fase $\phi - p_\phi$', 'Interpreter',
    'latex')
36 print('-dpdflatex', 'img/phasePhiPPhi.tex', '-S300,200
    ','-mono');
37 %%%3D plot of the pendulum in xyz coordinates
38 figure(3)
39 plot3(x, y, z,'k')
40 xlabel('$x$','Interpreter','latex')
41 ylabel('$y$','Interpreter','latex')
42 zlabel('$z$','Interpreter','latex')
43 title('Trayectoria del péndulo')
44 print('-dpdflatex', 'img/3Dplot.tex', '-S300,250','-
    mono');
45 %%%Time plot of x, y, z
46 figure(4)
47 plot(t, x, 'k', t, y, '--k', t, z, '-*k')
48 xlabel('Tiempo','Interpreter','latex')
49 ylabel('$x,\ y,\ z$','Interpreter','latex')
50 title('Gráfica respecto al tiempo de $x, y, z$', '
    Interpreter', 'latex')
51 legend({' $x$',' $y$', '$ z$'},'Interpreter','latex
    ','location', 'eastoutside', 'orientation', '
    vertical')
52 legend('boxoff')
53 print('-dpdflatex', 'img/timeXYZ.tex', '-S300,180','-
    mono');
54 %%%Time plot of theta, phi
55 figure(5)
56 plot(t, sol(:,1),'k', t, sol(:,3),'--k')
57 xlabel('Tiempo','Interpreter','latex')
58 ylabel('$\theta, \phi$','Interpreter','latex')
59 legend({' $\theta$',' $\phi$'},'Interpreter','latex'
    ,'location', 'east', 'orientation', 'vertical')
60 legend('boxoff')
61 title('Gráfica respecto al tiempo de $\theta, \ \phi$'
    , 'Interpreter', 'latex')
62 print('-dpdflatex', 'img/timeTRhetaPhi.tex', '-S200
    ,200','-mono');
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63 %%%Phase plot theta phi
64 figure(6)
65 plot(sol(:,1), sol(:,3),'k')
66 xlabel('$\theta$','Interpreter','latex')
67 ylabel('$\phi$','Interpreter','latex')
68 title('Diagrama fase de $\theta - \phi$', 'Interpreter
       ', 'latex')
69 print('-dpdflatex', 'img/phaseThetaPhi.tex', '-S300
       ,200','-mono');
70 end
71
72 function dx = pendulum(~,x)
73 %% CONSTANTS
74 b      = 1; %m
75 m      = 1; %kg
76 g      = 9.81;
77 gamma  = 0.01;    %m
78 dx=zeros(4,1);
79 Theta = x(1);
80 pTheta = x(2);
81 Phi = x(3);
82 pPhi = x(4);
83 %% Terms for d_p_theta
84 f1 = ((pTheta^2)*sin(Theta))/(2*m*b*b*((cos(Theta))^3)
       );
85 f2 = ((pPhi^2)*cos(Theta))/(m*b*b*((sin(Theta))^3));
86 f3 = m*g*b*sin(Theta);
87 d_theta   = pTheta/(2*m*b*b*((cos(Theta))^2));
88 d_p_theta = -f1 + f2 - f3;
89 d_phi     = pPhi/(m*b*((sin(Theta))^2));
90 d_p_phi   = 0;
91 dx(1) = d_theta;
92 dx(2) = d_p_theta;
93 dx(3) = d_phi;
94 dx(4) = d_p_phi;
95 end
```