

MATLAB program to generate the Rocket Car Phase Diagram and the Rocket Car Attainable Set Diagram

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function [ ] = phrocketcar( )
%Written by Elmer G. Wiens June 2019
clear

%set starting values f1, f2
f1 = 2 % -2 % 2
f2 = 1% -1 % 1

syms t v1 v2 r t2 u u1 u2 T w1 w2

A = [0 1; 0 0]
B = [0 1]'

coord1 = 3;
coord2 = 5;
v = [v1; v2];

xn = [ -1/2*t^2; t];
xp = [ 1/2*t^2; -t];

s = linspace(0, coord1, 30);
for i=1:length(s)
    q1(i) = double(subs(xn(1), t, s(i)));
    q2(i) = double(subs(xn(2), t, s(i)));
    q3(i) = double(subs(xp(1), t, s(i)));
    q4(i) = double(subs(xp(2), t, s(i)));
end

figure(1)
hold on;
nxax = -coord2; pxax = coord2; nyax = -coord2; pyax = coord2;
axis([nxax pxax nyax pyax])
plot(zeros(100), linspace(nyax, pyax))
plot(linspace(nxax, pxax), zeros(100))
plot(q1, q2, 'g', 'LineWidth', 3);
plot(q3, q4, 'r', 'LineWidth', 3);

quadn = double(subs(xn, t, 1));
quadp = double(subs(xp, t, 1));

if (f1 == 0)
    if(f2 == 0)
        display ('No trajectories!')
        return
    end
    if (f2 > 0)
        if (quadn(1) < 0)
            u = -1;
        else
            u = 1;
        end
    end
end
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    if (f2 < 0)
        if (quadr(1) < 0)
            u = 1;
        else
            u = -1;
        end
    end
end
end

if (f1 > 0)
    if (quadr(1) > 0)
        e = f1 - xn(1);
        st = max(double(solve(e, 't')));
        xn2 = double(subs(xn(2), t, st));
        if (xn2 < f2)
            u = 1;
        else
            u = -1;
        end
    end
end
if (quadr(1) > 0)
    e = f1 - xp(1);
    st = max(double(solve(e, 't')));
    xp2 = double(subs(xp(2), t, st));
    if (xp2 < f2)
        u = -1;
    else
        u = 1;
    end
end
end
end

if (f1 < 0)
    if (quadr(1) < 0)
        e = f1 - xn(1);
        st = max(double(solve(e, 't')));
        xn2 = double(subs(xn(2), t, st));
        if (xn2 < f2)
            u = -1;
        else
            u = 1;
        end
    end
end
if (quadr(1) < 0)
    e = f1 - xp(1);
    st = max(double(solve(e, 't')));
    xp2 = double(subs(xp(2), t, st));
    if (xp2 < f2)
        u = 1;
    else
        u = -1;
    end
end
end
end
u = u

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x = [ v1+t*v2+1/2*u1*t^2;v2+u1*t];
y = [v1-u1*t^2+2*t*v2+2*u1*t*t^2-1/2*u1*t^2; v2+2*u1*t^2-u1*t];

d2 = [ (-v2-2^(1/2)*(v2^2-2*v1*u1)^(1/2))/u1; ...
      (-v2+2^(1/2)*(v2^2-2*v1*u1)^(1/2))/u1];

d2 = subs(d2,u1,u);
d2 = simple(d2);
d2 = subs(d2, v1, f1);
d2 = double(subs(d2, v2, f2));
d2 = max(d2)

d1 = [-1/2/u1*v2+1/2*d2];
d1 = subs(d1, u1, u);
d1 = double(subs(d1, v2, f2))

x = subs(x, v1, f1);
x = subs(x, v2, f2);
x = subs(x,u1,u);

y = subs(y,u1,u);
y = subs(y, v1, f1);
y = subs(y, v2, f2);
y = simple(y);
y = subs(y,t2,d1);

s = linspace(0, d1, 20);
for i=1:length(s)
    z1(i) = double(subs(x(1), t, s(i)));
    z2(i) = double(subs(x(2), t, s(i)));
end

s1 = linspace(d1, d2, 20);
for i=1:length(s1)
    z3(i) = double(subs(y(1), t, s1(i)));
    z4(i) = double(subs(y(2), t, s1(i)));
end

figure(1)
hold on;
plot(z1,z2,'b', 'LineWidth',3);
plot(z3,z4,'b', 'LineWidth',3);
plot(f1,f2,'y+', 'LineWidth',3);
title('Rocket Car Phase Diagram', 'FontSize',15)
xlabel('x1', 'FontSize',17)
ylabel('x2', 'FontSize',17)

charf1 = num2str(f1);
charf2 = num2str(f2);
charcom= ', ' ;
charbl = '(';
charbr = ')';
charf = [charbl charf1 charcom charf2 charbr];

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text(f1 -.1, f2 + .4, charf, 'FontSize',17)

charu1 = num2str(u);
charu2 = num2str(-u);
chard1 = num2str(d1);
chard2 = num2str(d2);
charl1 = ['u(t) = ' charu1 ' : 0 < t < ' chard1];
charl2 = ['u(t) = ' charu2 ' : ' chard1 ' < t < ' chard2];
text(-4, -3, charl1, 'FontSize',17)
text(-4, -4, charl2, 'FontSize',17)

w1 = u
w2 = w1*(d1 - d2)

y = [v1-u1*t2^2+t*v2+2*u1*t*t2-1/2*u1*t^2; v2+2*u1*t2-u1*t];

y = subs(y, v1, f1);
y = subs(y, v2, f2);
y = subs(y,u2,-u1);

yt = subs(y,u1,-u);
y = subs(y,u1,u);

T = d2 %Terminal time
y1 = subs(y,t,T);
yt1 = subs(yt,t,T);
s = linspace(0, T, 20);
for i=1:length(s)
    az1(i) = double(subs(y1(1), t2, s(i)));
    az2(i) = double(subs(y1(2), t2, s(i)));
    az3(i) = double(subs(yt1(1), t2, s(i)));
    az4(i) = double(subs(yt1(2), t2, s(i)));
end
figure(2)
hold on;
con = 5;
nxax = -con;pxax = con;nyax =-con;pyax = con;
axis([nxax pxax nyax pyax])
axis square
plot(zeros(100),linspace(nyax,pyax))
plot(linspace(nxax,pxax),zeros(100))
plot(az1,az2,'r', 'LineWidth',3);
plot(az3,az4,'b', 'LineWidth',3);
tw1 = [0;w1];
tw2 = [0;w2];
plot(tw1,tw2, 'k', 'LineWidth',3);

title('Rocket Car Attainable Set', 'FontSize',15)
xlabel('x1', 'FontSize',17)
ylabel('x2', 'FontSize',17)

plot(z1,z2,'b', 'LineWidth',3);

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plot(z3,z4,'b', 'LineWidth',3);  
plot(f1,f2,'y+', 'LineWidth',3);  
text(f1 -.1, f2 + .4, charf, 'FontSize',17)  
return  
end
```