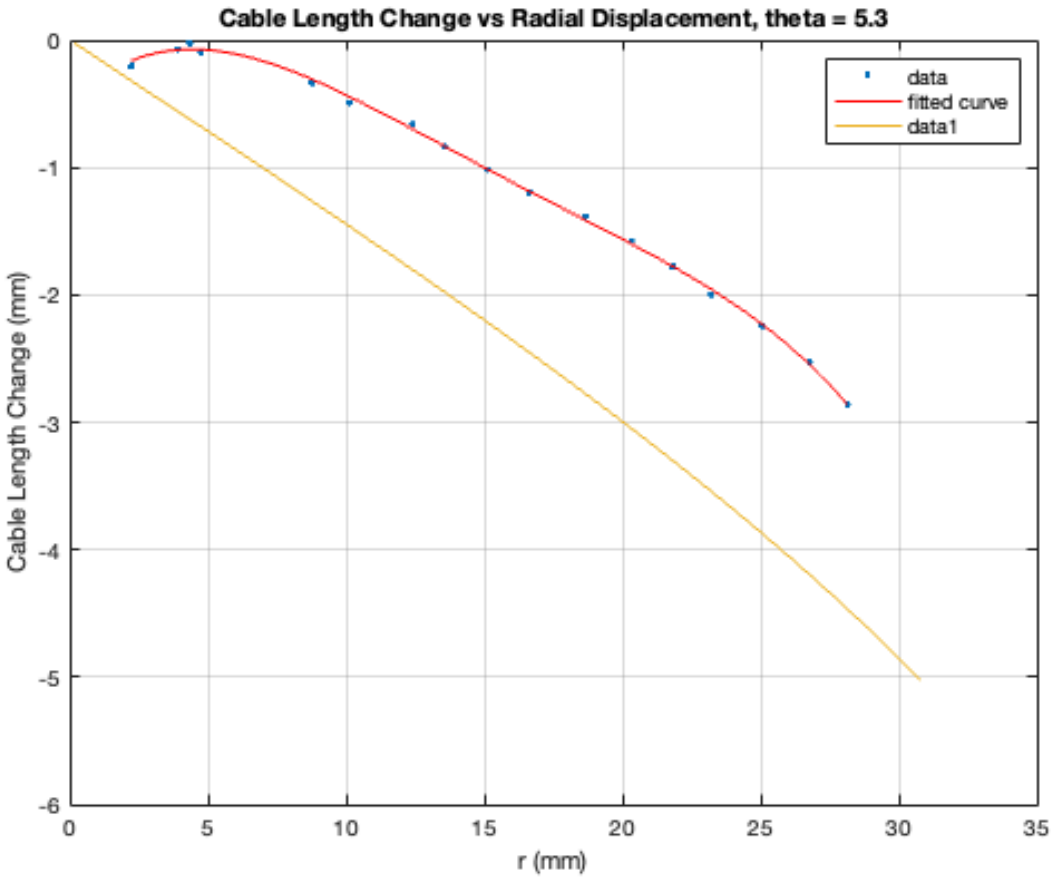
```
clear; close all;

%load full circle data history
points_record_tab = readtable('points_record_curvefit_test.csv');
points_record_2D = table2array(points_record_tab);
x_coeffs_tab = readtable('x_coeffs_full.csv');
x_coeffs = table2array(x_coeffs_tab);

dl_all_iterations_Q1_tab = readtable("dl_all_iterations_Q1.csv");
dl_all_iterations_Q1 = table2array(dl_all_iterations_Q1_tab);
dl_all_iterations_Q2_tab = readtable("dl_all_iterations_Q2.csv");
dl_all_iterations_Q2 = table2array(dl_all_iterations_Q2_tab);
dl_all_iterations_Q3_tab = readtable("dl_all_iterations_Q3.csv");
dl_all_iterations_Q3 = table2array(dl_all_iterations_Q3_tab);
dl_all_iterations_Q4_tab = readtable("dl_all_iterations_Q4.csv");
dl_all_iterations_Q4 = table2array(dl_all_iterations_Q4_tab);

dl2D = [dl_all_iterations_Q1 dl_all_iterations_Q2 dl_all_iterations_Q3
 dl_all_iterations_Q4];

%physical system parameters
L = 56; % (mm) from spine architecture
d = 4;  % (mm) "
disk_diameter = 15; % (mm) diameter of the disk
PWMrange = 500-100;
setmid = 350;

%set frequency of sampling
res_curve = 18;
res_theta = 40;
iterations = 3;

%initiate vars
points_record = zeros(7,res_curve,iterations,res_theta);
r = zeros(res_curve*iterations,res_theta);
x = zeros(res_curve*iterations,res_theta);
y = zeros(res_curve*iterations,res_theta);
z = zeros(res_curve*iterations,res_theta);
u1 = zeros(res_curve*iterations,res_theta);
dl1 = zeros(res_curve*iterations,res_theta);
dlplane = zeros(res_curve,iterations,res_theta);
zfits5 = zeros(6,res_theta);
xfits = zeros(5,res_theta);

%values to be used in calcs
mid = ones(res_curve*iterations,1)*setmid;
theta = [linspace(0,pi/2,10) linspace(pi/2,pi,10) linspace(pi,3*pi/2,10)
 linspace(3*pi/2,2*pi,10)];

dl = zeros(57,res_theta);

for i = 1:10
```

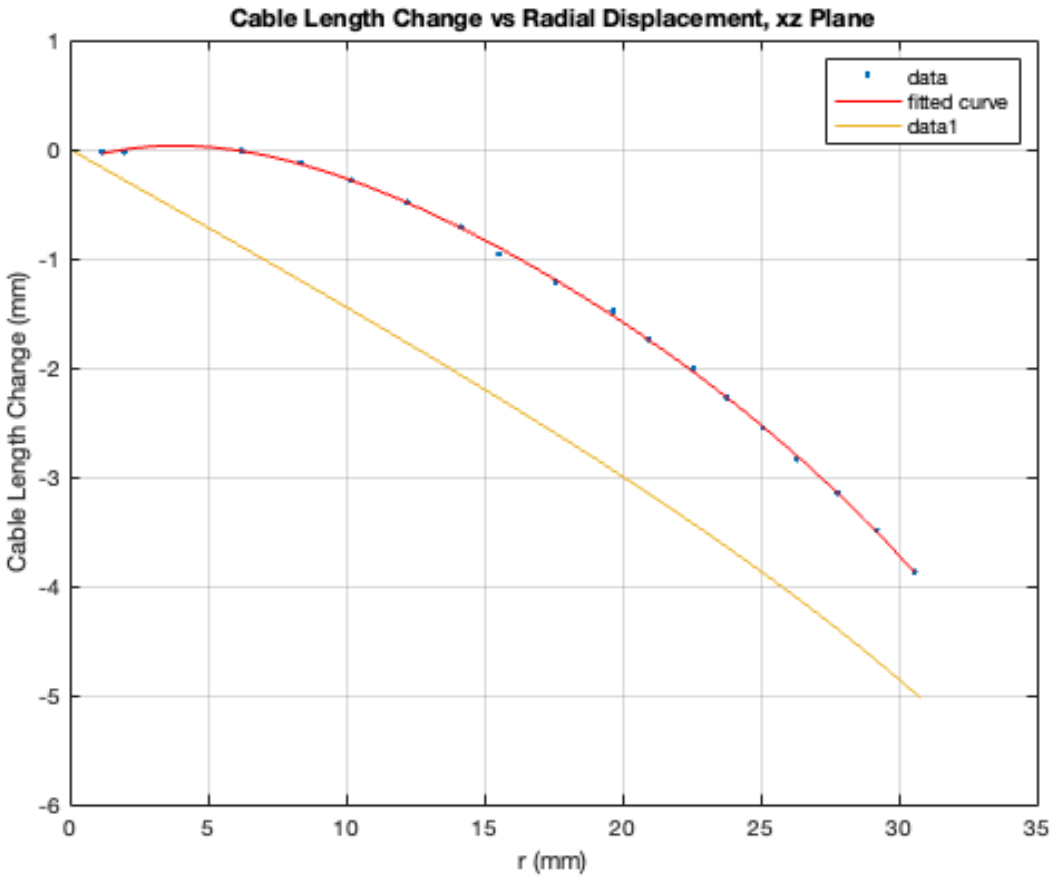
```
    dl(1:57,i) = dl_all_iterations_Q1(57*(i-1)+1:i*57)';
end

for i = 1:10
    dl(1:57,10+i) = dl_all_iterations_Q2(57*(i-1)+1:i*57)';
end

for i = 1:10
    dl(1:57,20+i) = dl_all_iterations_Q3(57*(i-1)+1:i*57)';
end

for i = 1:10
    dl(1:57,30+i) = dl_all_iterations_Q4(57*(i-1)+1:i*57)';
end

for i = 1:res_theta
    for k = 1:iterations
        points_record(:,:,k,i) = points_record_2D(:,(i-1)*res_curve
+1:i*res_curve);
        dlplane(:,k,i) = dl2D(:,(i-1)*(res_curve+1)+2:i*(res_curve+1))';
        x((k-1)*res_curve+1:k*res_curve,i) = points_record(1,:,k,i);
        y((k-1)*res_curve+1:k*res_curve,i) = points_record(2,:,k,i);
        z((k-1)*res_curve+1:k*res_curve,i) = points_record(3,:,k,i);
        r((k-1)*res_curve+1:k*res_curve,i) =
 sqrt(points_record(1,:,k,i).^2+points_record(2,:,k,i).^2);
        u1((k-1)*res_curve+1:k*res_curve,i) = points_record(4,:,k,i);
    end
end

[xfit, gofx] = fit(points_record(1,:,1,1)',dlplane(:,1,1),'poly4')
figure(2)
plot(xfit,points_record(1,:,1,1),dlplane(:,1,1),'.')
grid on;
xlabel('r (mm)')
ylabel('Cable Length Change (mm)')


[xfit, gofx] = fit(r(18*2+1:18*3,33),dlplane(:,3,33),'poly4')

figure(1)
plot(xfit,r(18*2+1:18*3,33),dlplane(:,3,33),'.')
grid on;
xlabel('r (mm)')
ylabel('Cable Length Change (mm)')


%add the zero points to r for fitting. They already exist in the dl data
r0 = zeros(1,res_theta);
%r = [r0; r(1:18,:); r0; r(19:18*2,:); r0; r(18*2+1:18*3,:)];

%These values give a turn angle (theta) and a bend amount (Rc)
res = 500;
minR = log10(2.5*L/(pi));
maxR = log10(10000);
```

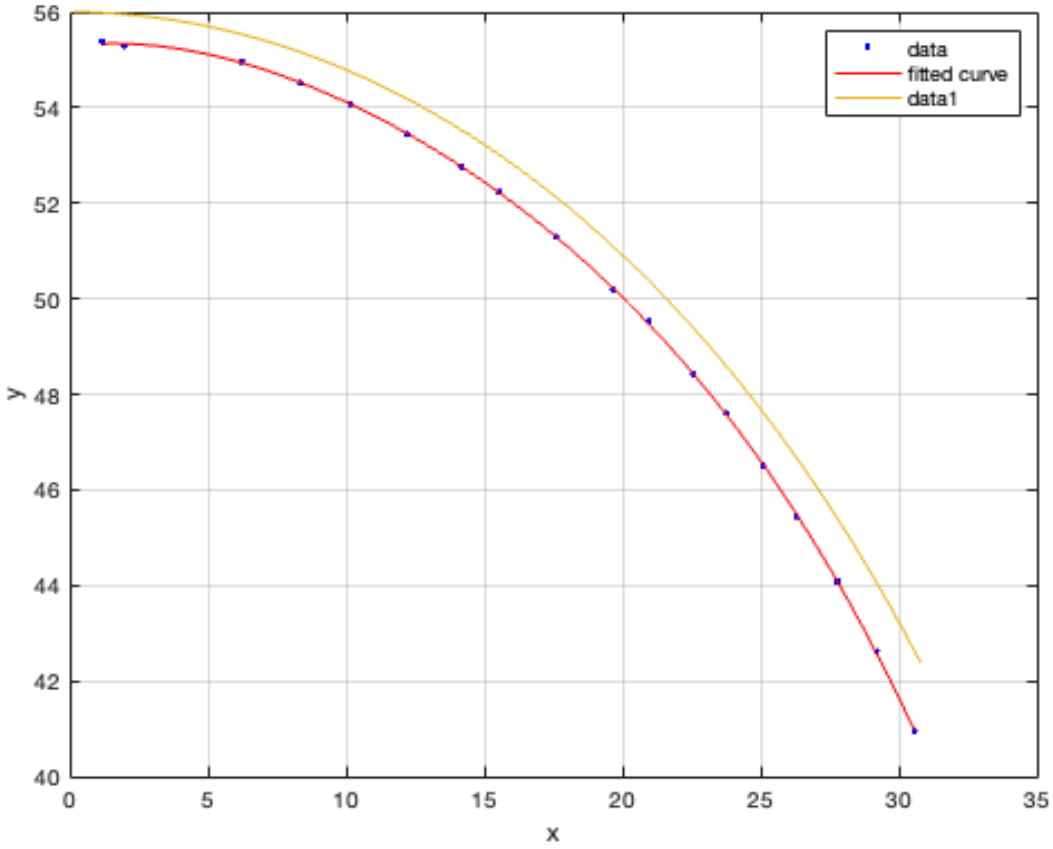
```
Rc = [logspace(minR,maxR,res)];
phi = L./Rc;

rmodel = Rc.*(1-cos(L./Rc));
zmodel = Rc.*sin(L./Rc);
dlmodel = (phi.*(Rc-d)-L);

%other interesting spot is theta(11) = pi/2

figure(1)
hold on;
plot(rmodel,dlmodel)
title('Cable Length Change vs Radial Displacement, theta = 5.3')

figure(2)
hold on;
plot(rmodel,dlmodel)
title('Cable Length Change vs Radial Displacement, xz Plane')

[zfit, gofz] = fit(points_record(1,:,1,1)',points_record(3,:,1,1)','poly4')

figure(3)
plot(zfit,points_record(1,:,1,1)',points_record(3,:,1,1)')
hold on; grid on;
plot(rmodel,zmodel)

[xfit, gofx] = fit(r(18*2+1:18*3,33),z(18*2+1:18*3,33),'poly4')

figure(4)
plot(zfit,r(18*2+1:18*3,33),z(18*2+1:18*3,33))
hold on; grid on;
plot(rmodel,zmodel)

figure(5)
plot(rmodel,zmodel)
grid on;
xlabel('x (mm)')
ylabel('z (mm)')
title('Model Prediction, x vs z In Plane')
axis([0 35 0 60])

figure(6)
plot(rmodel,dlmodel)
grid on;
xlabel('x (mm)')
ylabel('dl (mm)')
title('Model Prediction, x vs Cable Length Change')


xfit =

     Linear model Poly4:
     xfit(x) = p1*x^4 + p2*x^3 + p3*x^2 + p4*x + p5
     Coefficients (with 95% confidence bounds):
```

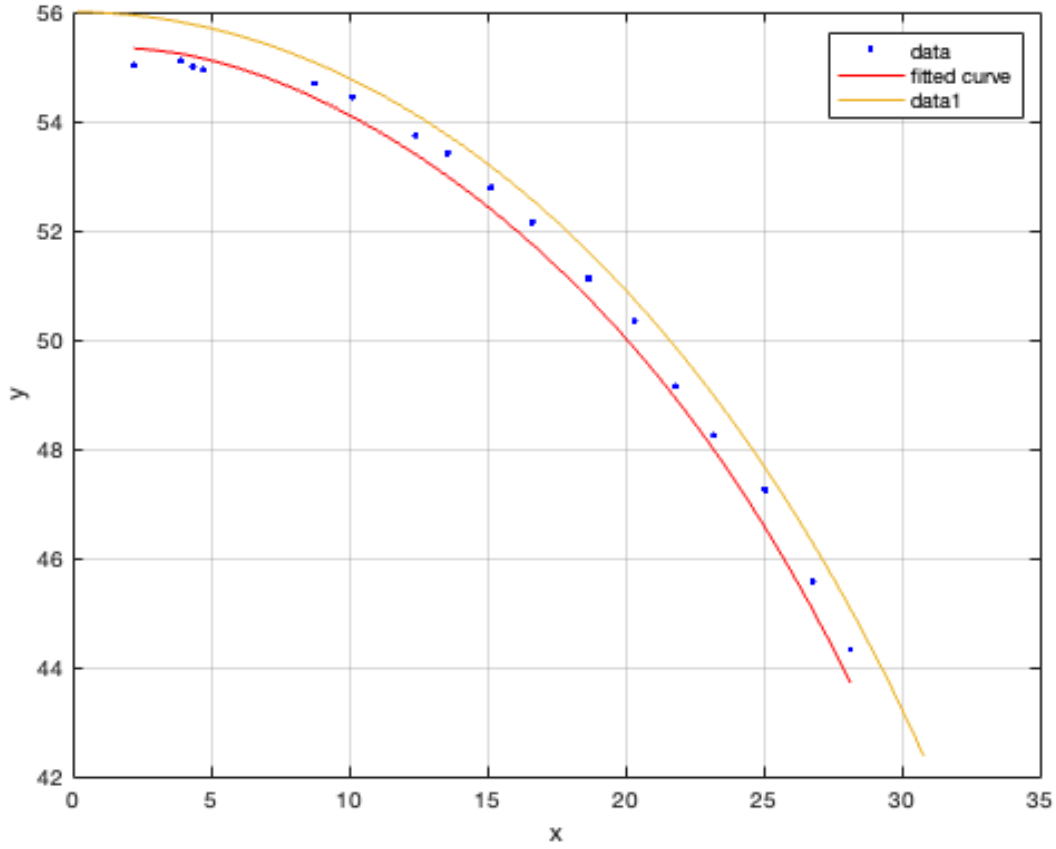
```
       p1 =  -5.108e-06  (-8.497e-06, -1.719e-06)
       p2 =   0.0003652  (0.0001467, 0.0005836)
       p3 =    -0.01324  (-0.01788, -0.008599)
       p4 =     0.08665  (0.05096, 0.1223)
       p5 =     -0.1247  (-0.1989, -0.05045)

gofx =

  struct with fields:

           sse: 0.009493980400905
       rsquare: 0.999661765458963
           dfe: 13
    adjrsquare: 0.999557693292490
          rmse: 0.027024177780000


xfit =

     Linear model Poly4:
     xfit(x) = p1*x^4 + p2*x^3 + p3*x^2 + p4*x + p5
     Coefficients (with 95% confidence bounds):
       p1 =  -2.152e-05  (-2.881e-05, -1.422e-05)
       p2 =    0.001373  (0.0009203, 0.001825)
       p3 =    -0.03207  (-0.04159, -0.02254)
       p4 =      0.2107  (0.1334, 0.2881)
       p5 =     -0.4882  (-0.6752, -0.3013)

gofx =

  struct with fields:

           sse: 0.015851359117274
       rsquare: 0.998899464343118
           dfe: 13
    adjrsquare: 0.998560837987154
          rmse: 0.034918982183239


zfit =

     Linear model Poly4:
     zfit(x) = p1*x^4 + p2*x^3 + p3*x^2 + p4*x + p5
     Coefficients (with 95% confidence bounds):
       p1 =  -1.451e-05  (-1.891e-05, -1.01e-05)
       p2 =   0.0006397  (0.0003556, 0.0009238)
       p3 =    -0.02358  (-0.02962, -0.01755)
       p4 =     0.06902  (0.0226, 0.1154)
       p5 =       55.29  (55.19, 55.39)

gofz =

  struct with fields:
```

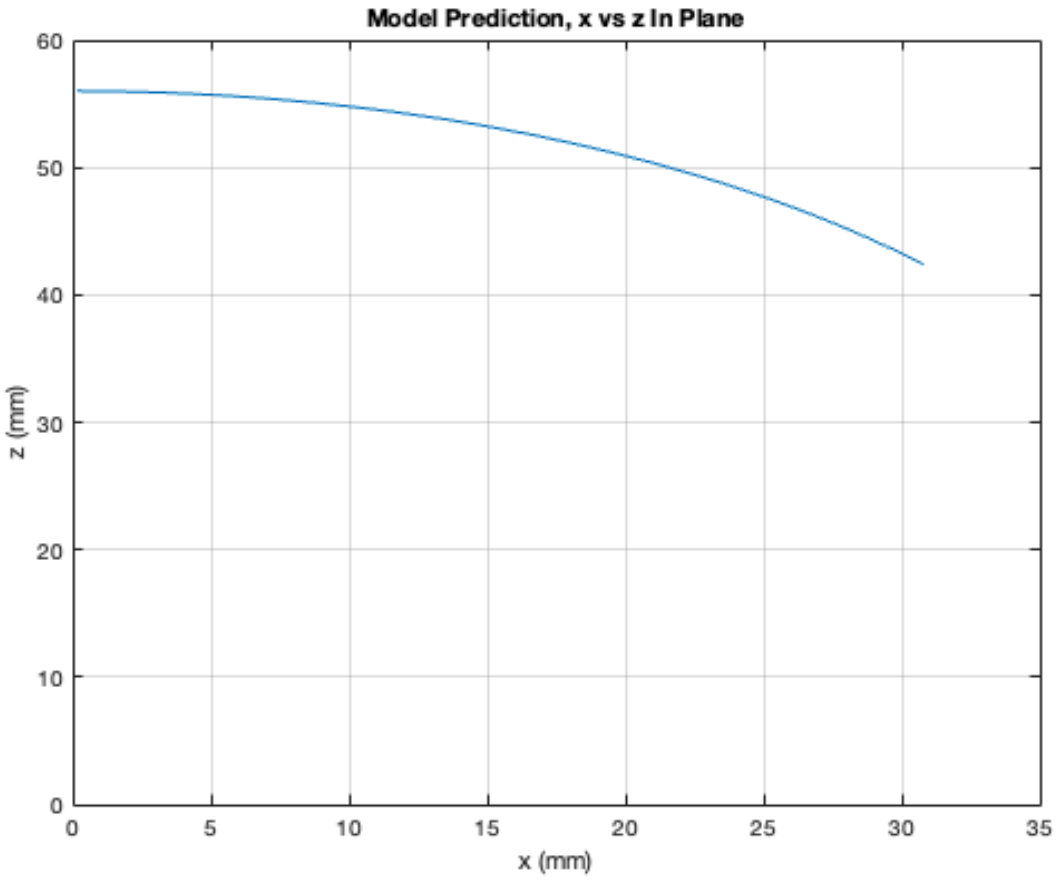
```
           sse: 0.016057658494405
       rsquare: 0.999955062004405
           dfe: 13
    adjrsquare: 0.999941234928837
          rmse: 0.035145476231937


xfit =

     Linear model Poly4:
     xfit(x) = p1*x^4 + p2*x^3 + p3*x^2 + p4*x + p5
     Coefficients (with 95% confidence bounds):
       p1 =  -3.847e-06  (-2.623e-05, 1.854e-05)
       p2 =   0.0002071  (-0.001181, 0.001595)
       p3 =    -0.02195  (-0.05118, 0.007271)
       p4 =      0.1731  (-0.06423, 0.4105)
       p5 =        54.7  (54.12, 55.27)

gofx =

  struct with fields:

           sse: 0.149251691457352
       rsquare: 0.999296777177539
           dfe: 13
    adjrsquare: 0.999080400924475
          rmse: 0.107148958664437
```

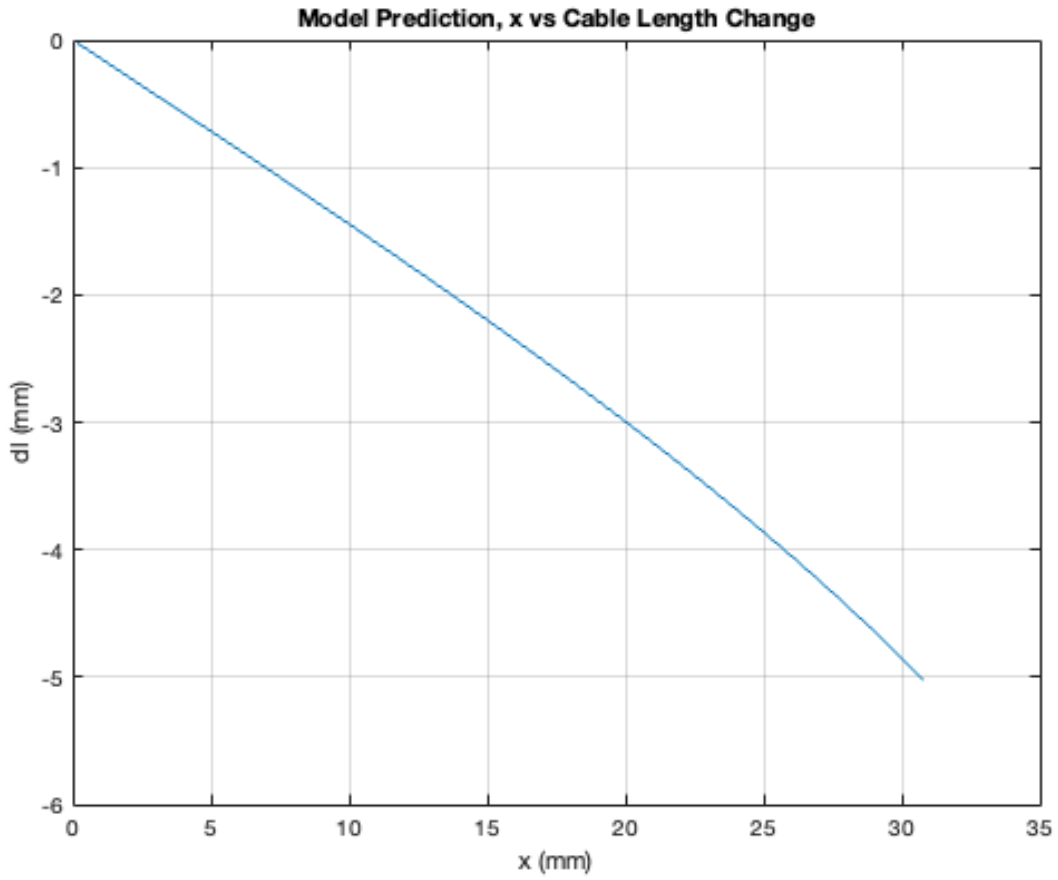

Cable Length Change vs Radial Displacement, theta = 5.3
data
fitted curve
data1
Cable Length Change (mm)
r (mm)
0
-1
-2
-3
-4
-5
-6
0
5
10
15
20
25
30
35


Cable Length Change vs Radial Displacement, xz Plane
data
fitted curve
data1
Cable Length Change (mm)
r (mm)
1
0
-1
-2
-3
-4
-5
-6
0
5
10
15
20
25
30
35


data
fitted curve
data1
56
54
52
50
48
46
44
42
40
y
0
5
10
15
20
25
30
35
x


data
fitted curve
data1
56
54
52
50
48
46
44
42
y
0
5
10
15
20
25
30
35
x


Model Prediction, x vs z In Plane
z (mm)
x (mm)
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35



Published with MATLAB® R2023a