Blog Entry © Monday, August 25, 2025, by James Pate Williams, Jr. and the Microsoft Copilot, Air Pressure in the Gap Between a Read/Write Head and a Magnetic Disk Platter

The air pressure is modeled by a nonlinear second order differential equation with four input parameters: h0, theta, k, and n. The parameter k is dependent upon the rotational speed of the disk. The function h(x) is the gap and assumed to be a straight line of a given slope and intercept. Theta is the slope of the linear function. The parameter, n, is the number of points to be plotted This equation is from Chapter 14 page 275 of ***Numerical Computation 2 Methods, Software, and Analysis*** by C.W. Hueberhuber. The numerical solution routine was translated from the C code found in ***A Numerical Library in C for Scientists and Engineers*** by H.T. Lau, Ph.D. The Dr. Lau function is nonlinfemlagskew.

$$p'' = \frac{p'^2}{p} + \frac{3h'h^2p'}{p} + \frac{k(p'h + ph')}{ph^3} = f(x, p, p')$$

$$\frac{\partial f}{\partial p} = -\frac{p'^2}{p^2} - \frac{3h'h^2p'}{p^2} - \frac{kp'h}{p^2h^3}$$

$$\frac{\partial f}{\partial p'} = \frac{2p'}{p} + \frac{3h'h^2}{p} + \frac{kh}{ph^3}$$

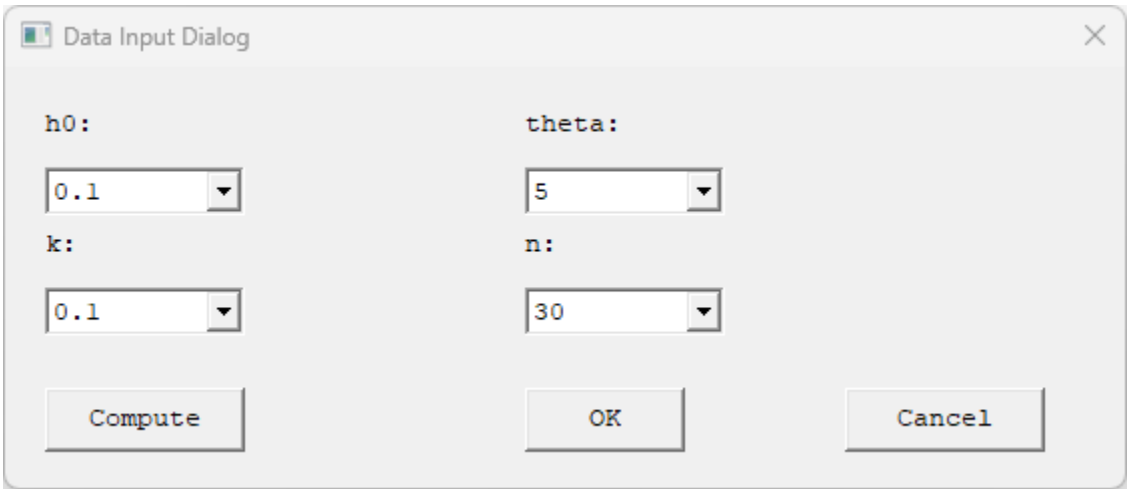
$$h(x) = a(x - x_0) + b$$

$$a = \frac{h_1 - h_0}{x_1 - x_0} = \tan\theta$$

$$h_1 = h_0 + (x_1 - x_0)\tan\theta$$

$$x_0 = 0, x_1 = 1$$

$$p(0) = p(1) = p_0$$


Data Input Dialog
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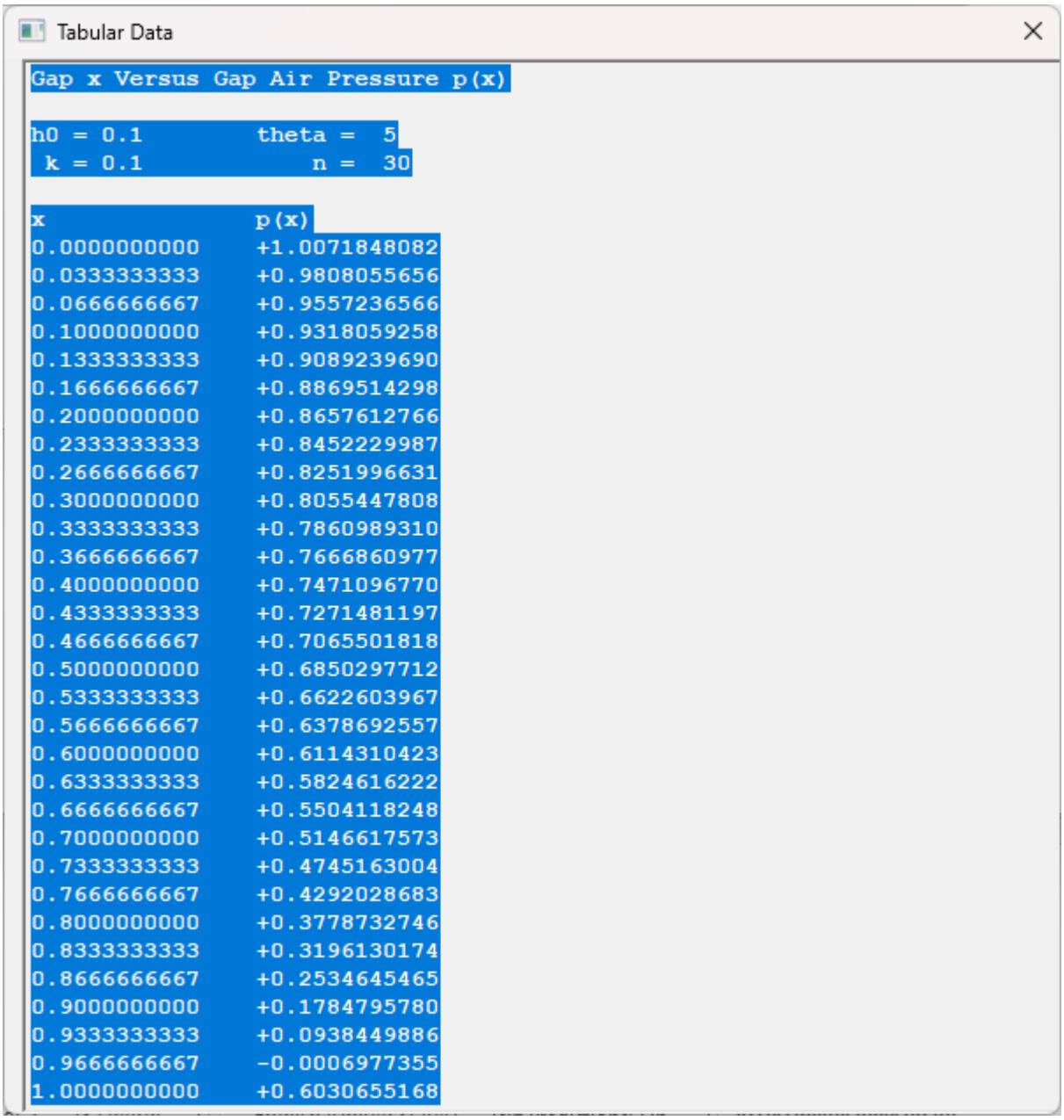
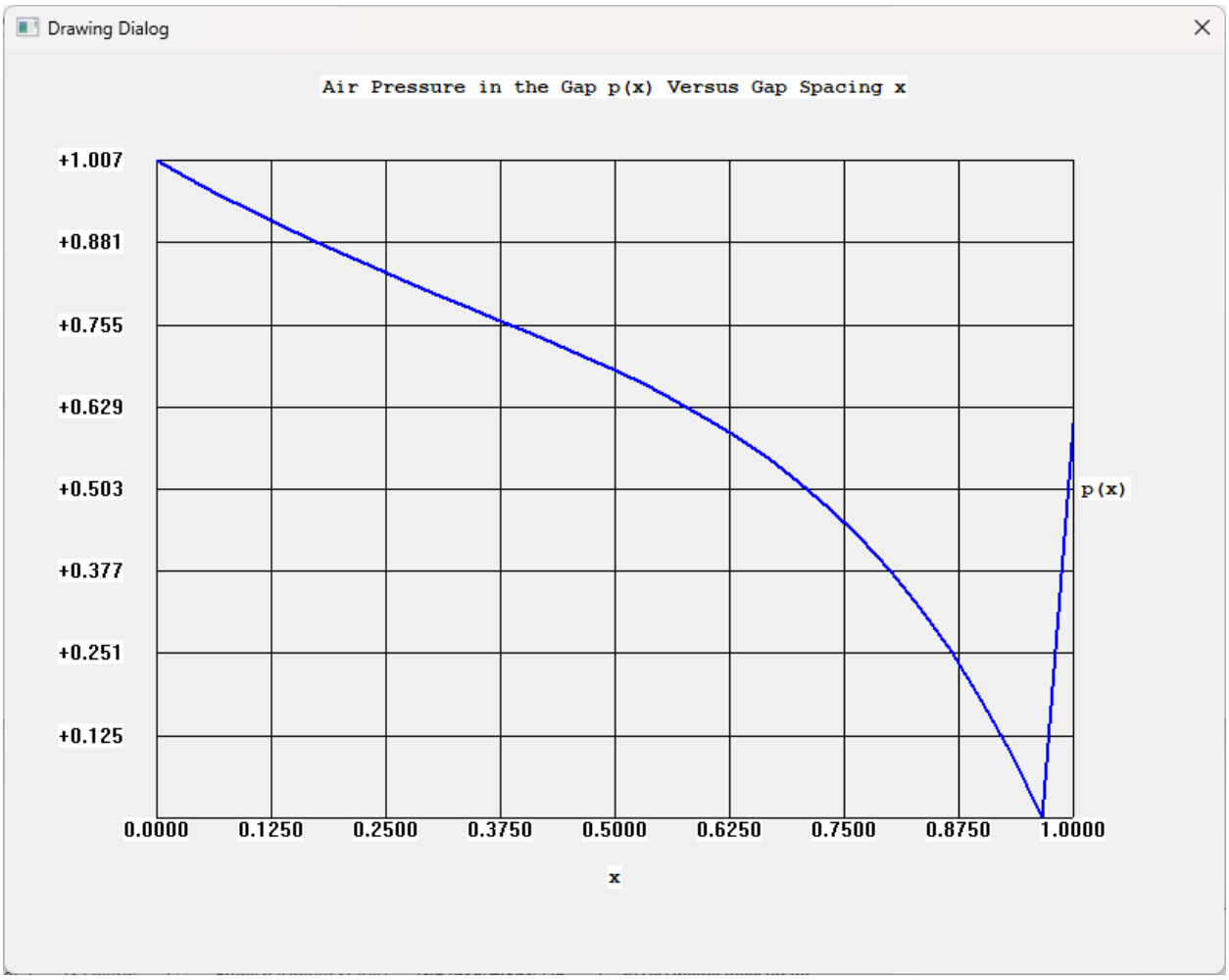
theta:
0.1
5
k:
n:
0.1
30
Compute
OK
Cancel

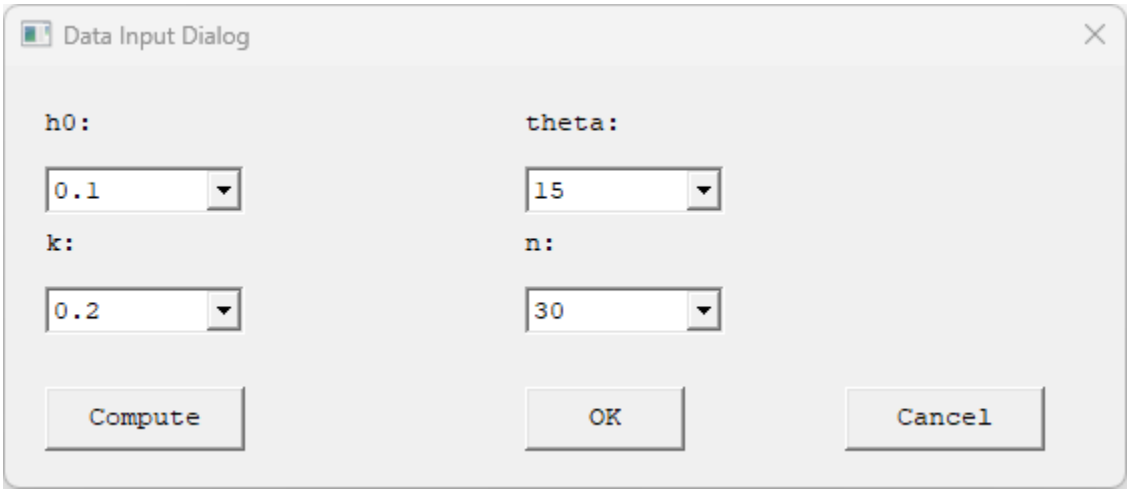

Tabular Data

Gap x Versus Gap Air Pressure p(x)

h0 = 0.1 theta = 5
k = 0.1 n = 30

x	p(x)
0.0000000000	+1.0071848082
0.0333333333	+0.9808055656
0.0666666667	+0.9557236566
0.1000000000	+0.9318059258
0.1333333333	+0.9089239690
0.1666666667	+0.8869514298
0.2000000000	+0.8657612766
0.2333333333	+0.8452229987
0.2666666667	+0.8251996631
0.3000000000	+0.8055447808
0.3333333333	+0.7860989310
0.3666666667	+0.7666860977
0.4000000000	+0.7471096770
0.4333333333	+0.7271481197
0.4666666667	+0.7065501818
0.5000000000	+0.6850297712
0.5333333333	+0.6622603967
0.5666666667	+0.6378692557
0.6000000000	+0.6114310423
0.6333333333	+0.5824616222
0.6666666667	+0.5504118248
0.7000000000	+0.5146617573
0.7333333333	+0.4745163004
0.7666666667	+0.4292028683
0.8000000000	+0.3778732746
0.8333333333	+0.3196130174
0.8666666667	+0.2534645465
0.9000000000	+0.1784795780
0.9333333333	+0.0938449886
0.9666666667	-0.0006977355
1.0000000000	+0.6030655168


Drawing Dialog
Air Pressure in the Gap p(x) Versus Gap Spacing x
+1.007
+0.881
+0.755
+0.629
+0.503
+0.377
+0.251
+0.125
p(x)
0.0000
0.1250
0.2500
0.3750
0.5000
0.6250
0.7500
0.8750
1.0000
x

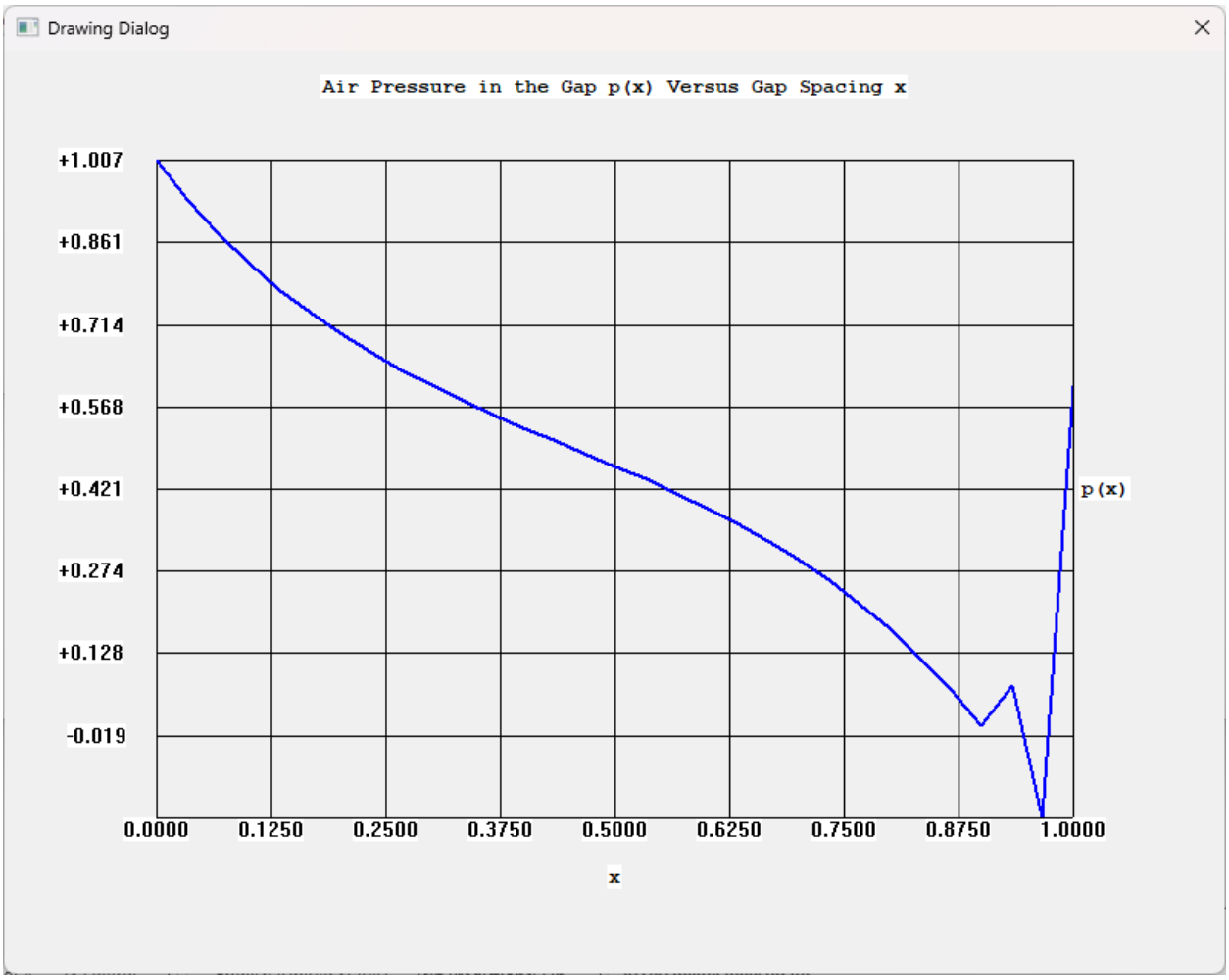

Data Input Dialog
h0:
0.1
theta:
15
k:
0.2
n:
30
Compute
OK
Cancel

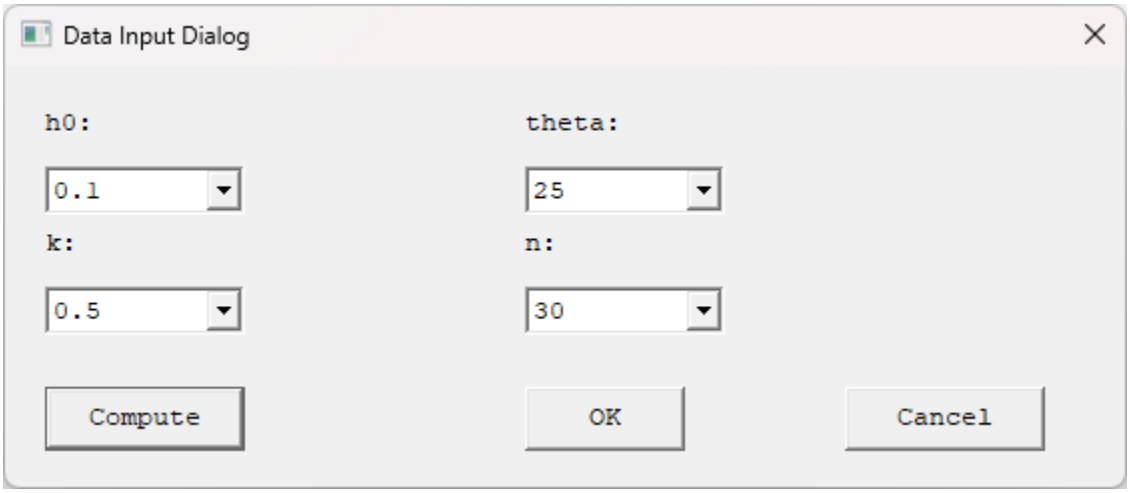
Tabular Data

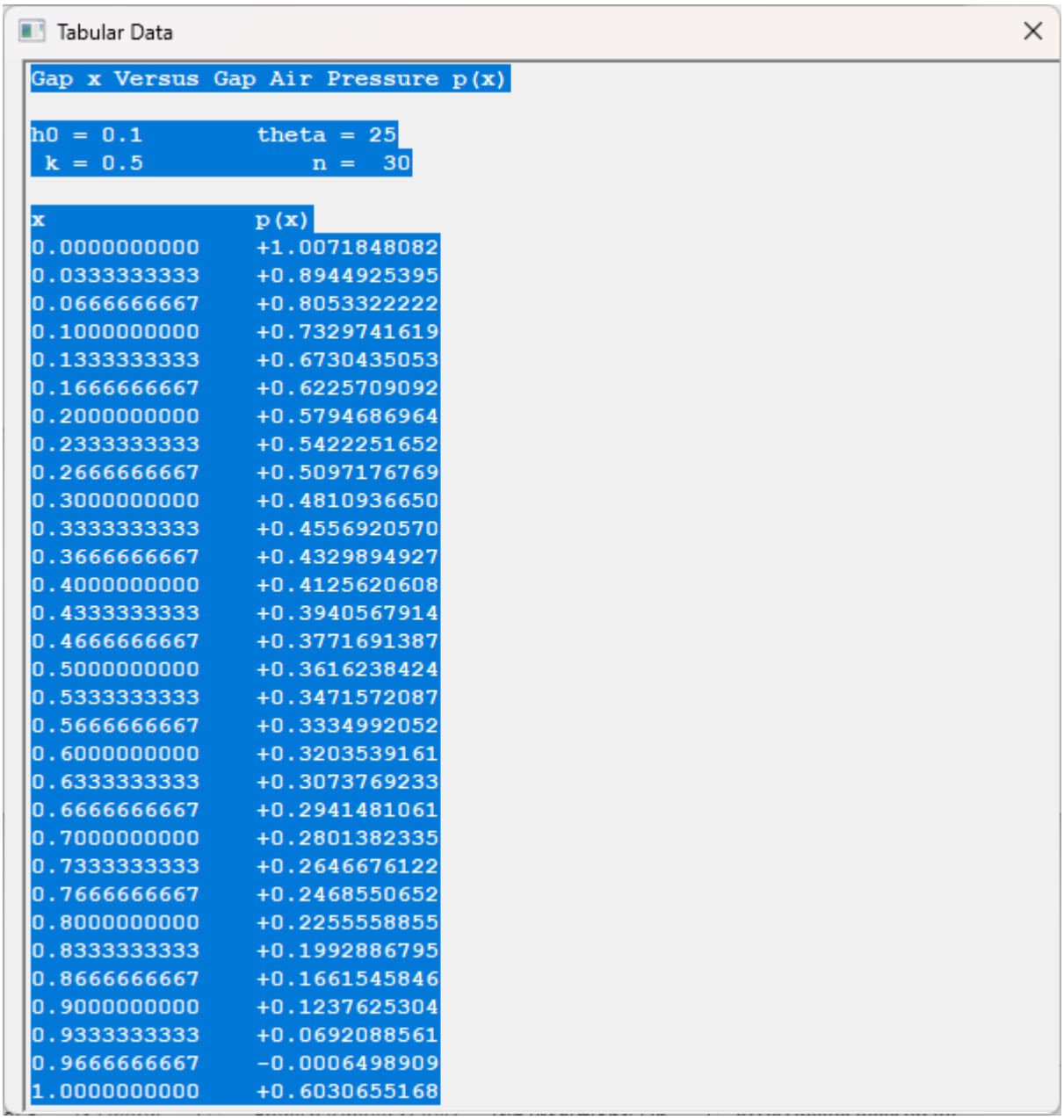
Gap x Versus Gap Air Pressure p(x)

h0 = 0.1 theta = 15
k = 0.2 n = 30

x	p(x)
0.0000000000	+1.0071848082
0.0333333333	+0.9368056963
0.0666666667	+0.8761796981
0.1000000000	+0.8233524133
0.1333333333	+0.7768458880
0.1666666667	+0.7355145596
0.2000000000	+0.6984486621
0.2333333333	+0.6649074290
0.2666666667	+0.6342715410
0.3000000000	+0.6060083159
0.3333333333	+0.5796455185
0.3666666667	+0.5547511207
0.4000000000	+0.5309172509
0.4333333333	+0.5077471641
0.4666666667	+0.4848444600
0.5000000000	+0.4618040619
0.5333333333	+0.4382046850
0.5666666667	+0.4136027062
0.6000000000	+0.3875275314
0.6333333333	+0.3594787607
0.6666666667	+0.3289257254
0.7000000000	+0.2953103783
0.7333333333	+0.2580552073
0.7666666667	+0.2165791396
0.8000000000	+0.1703272414
0.8333333333	+0.1188274720
0.8666666667	+0.0618137559
0.9000000000	-0.0003892758
0.9333333333	+0.0712631840
0.9666666667	-0.1652996480
1.0000000000	+0.6030655168


Drawing Dialog
Air Pressure in the Gap p(x) Versus Gap Spacing x
+1.007
+0.861
+0.714
+0.568
+0.421
+0.274
+0.128
-0.019
p(x)
0.0000
0.1250
0.2500
0.3750
0.5000
0.6250
0.7500
0.8750
1.0000
x


Data Input Dialog
h0:
0.1
theta:
25
k:
0.5
n:
30
Compute
OK
Cancel

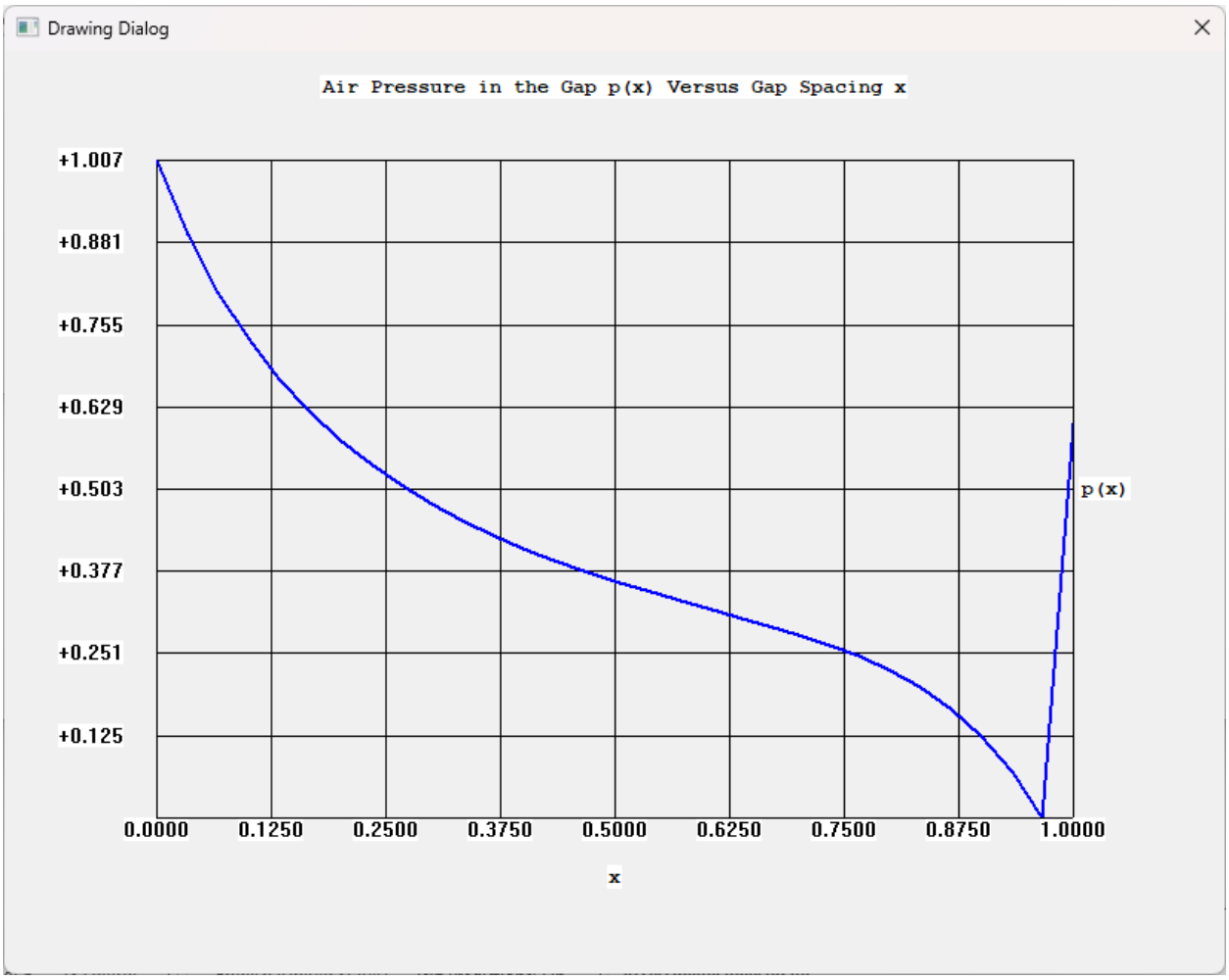


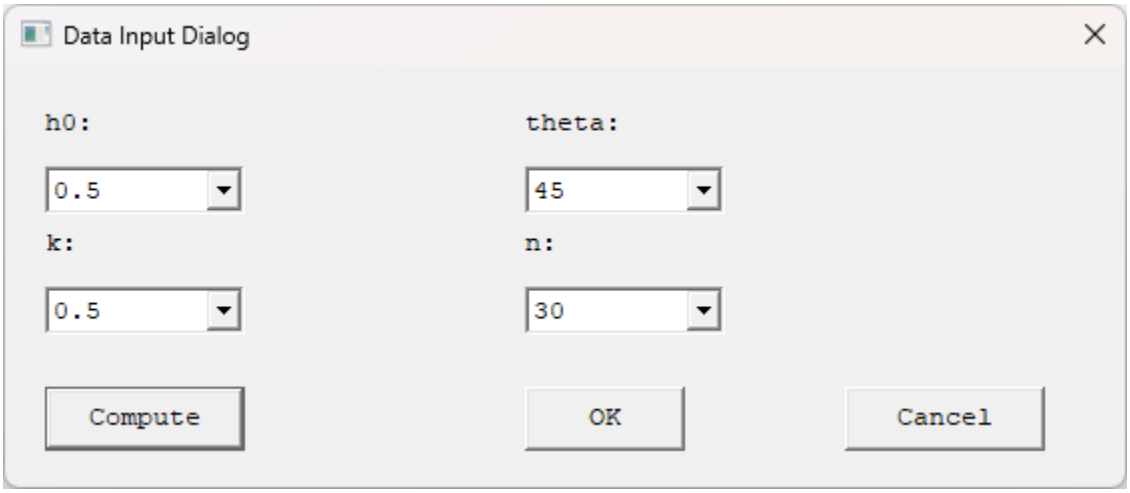
Tabular Data

Gap x Versus Gap Air Pressure p(x)

h0 = 0.1 theta = 25
k = 0.5 n = 30

x	p(x)
0.0000000000	+1.0071848082
0.0333333333	+0.8944925395
0.0666666667	+0.8053322222
0.1000000000	+0.7329741619
0.1333333333	+0.6730435053
0.1666666667	+0.6225709092
0.2000000000	+0.5794686964
0.2333333333	+0.5422251652
0.2666666667	+0.5097176769
0.3000000000	+0.4810936650
0.3333333333	+0.4556920570
0.3666666667	+0.4329894927
0.4000000000	+0.4125620608
0.4333333333	+0.3940567914
0.4666666667	+0.3771691387
0.5000000000	+0.3616238424
0.5333333333	+0.3471572087
0.5666666667	+0.3334992052
0.6000000000	+0.3203539161
0.6333333333	+0.3073769233
0.6666666667	+0.2941481061
0.7000000000	+0.2801382335
0.7333333333	+0.2646676122
0.7666666667	+0.2468550652
0.8000000000	+0.2255558855
0.8333333333	+0.1992886795
0.8666666667	+0.1661545846
0.9000000000	+0.1237625304
0.9333333333	+0.0692088561
0.9666666667	-0.0006498909
1.0000000000	+0.6030655168


Drawing Dialog
Air Pressure in the Gap p(x) Versus Gap Spacing x
+1.007
+0.881
+0.755
+0.629
+0.503
+0.377
+0.251
+0.125
p(x)
0.0000
0.1250
0.2500
0.3750
0.5000
0.6250
0.7500
0.8750
1.0000
x


Data Input Dialog
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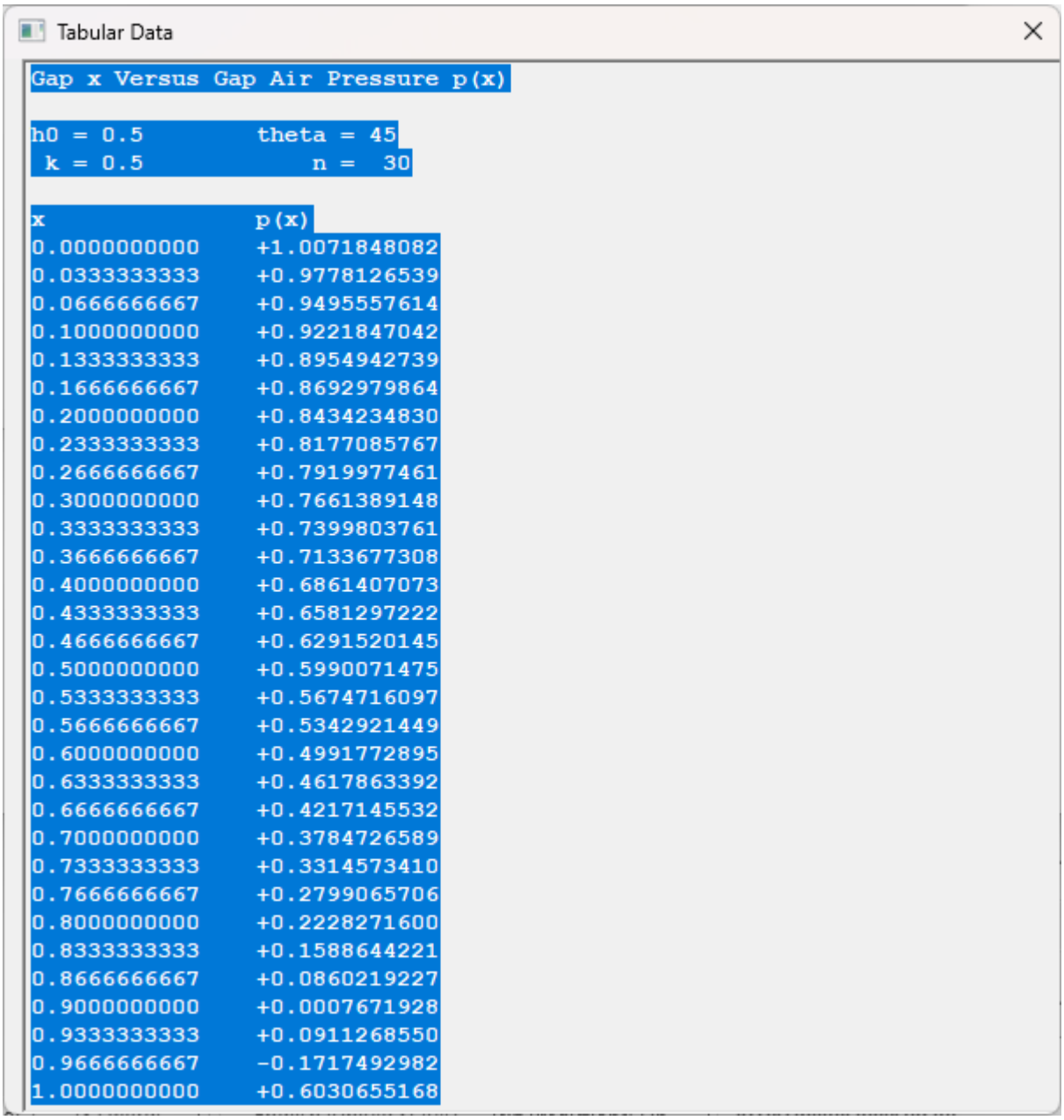
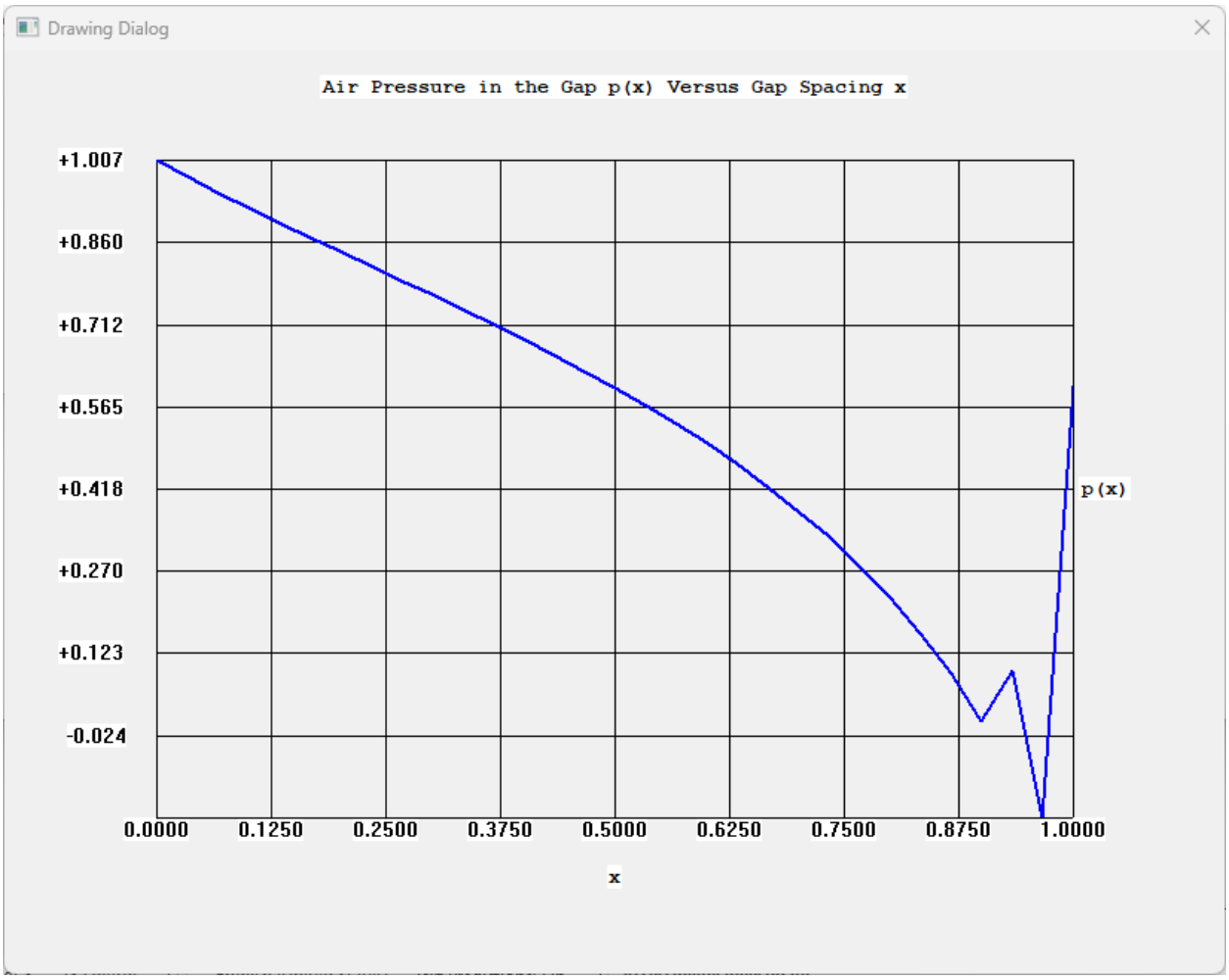
0.5
theta:
45
k:
0.5
n:
30
Compute
OK
Cancel


Tabular Data

Gap x Versus Gap Air Pressure p(x)

h0 = 0.5 theta = 45
k = 0.5 n = 30

x	p(x)
0.0000000000	+1.0071848082
0.0333333333	+0.9778126539
0.0666666667	+0.9495557614
0.1000000000	+0.9221847042
0.1333333333	+0.8954942739
0.1666666667	+0.8692979864
0.2000000000	+0.8434234830
0.2333333333	+0.8177085767
0.2666666667	+0.7919977461
0.3000000000	+0.7661389148
0.3333333333	+0.7399803761
0.3666666667	+0.7133677308
0.4000000000	+0.6861407073
0.4333333333	+0.6581297222
0.4666666667	+0.6291520145
0.5000000000	+0.5990071475
0.5333333333	+0.5674716097
0.5666666667	+0.5342921449
0.6000000000	+0.4991772895
0.6333333333	+0.4617863392
0.6666666667	+0.4217145532
0.7000000000	+0.3784726589
0.7333333333	+0.3314573410
0.7666666667	+0.2799065706
0.8000000000	+0.2228271600
0.8333333333	+0.1588644221
0.8666666667	+0.0860219227
0.9000000000	+0.0007671928
0.9333333333	+0.0911268550
0.9666666667	-0.1717492982
1.0000000000	+0.6030655168


Drawing Dialog
Air Pressure in the Gap p(x) Versus Gap Spacing x
+1.007
+0.860
+0.712
+0.565
+0.418
+0.270
+0.123
-0.024
p(x)
0.0000
0.1250
0.2500
0.3750
0.5000
0.6250
0.7500
0.8750
1.0000
x