Numerical Methods:

Nonlinear Equations, Numerical Calculus, & Differential Equations

...just the figures for those who got the B&W text...

by D. James Benton

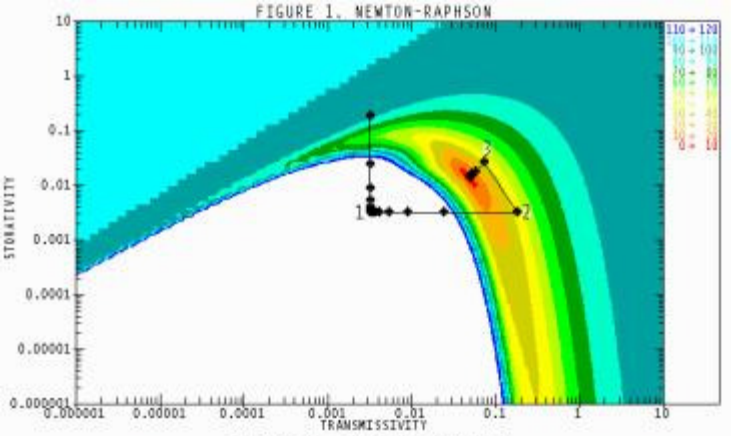


FIGURE 1. NEWTON-RAPHSON
STORATIVITY
TRANSMISSIVITY
1
2
3

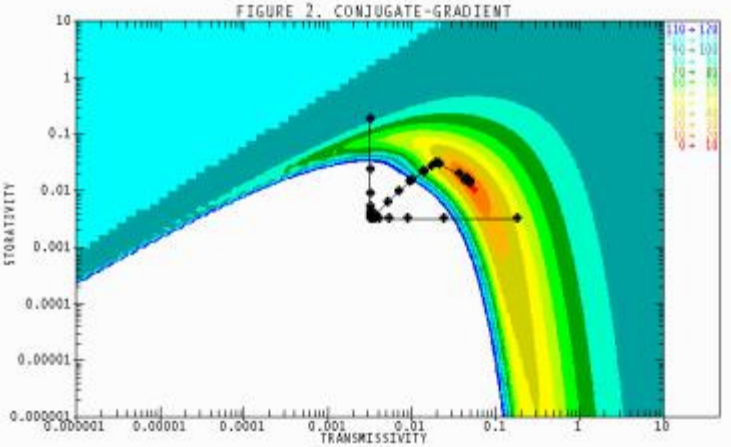


FIGURE 2. CONJUGATE-GRADIENT
STORATIVITY
TRANSMISSIVITY

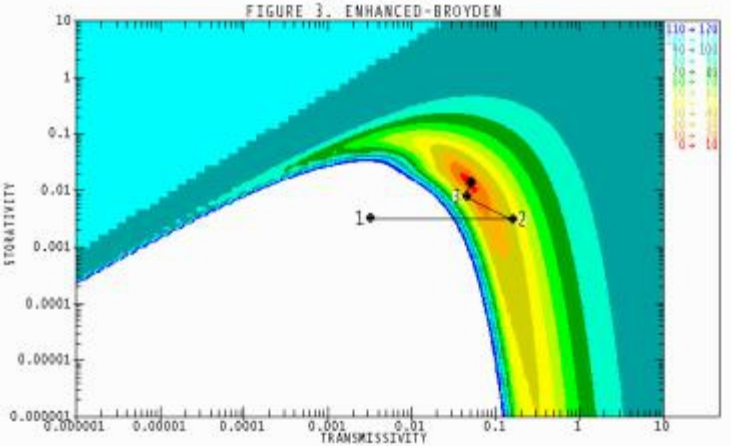
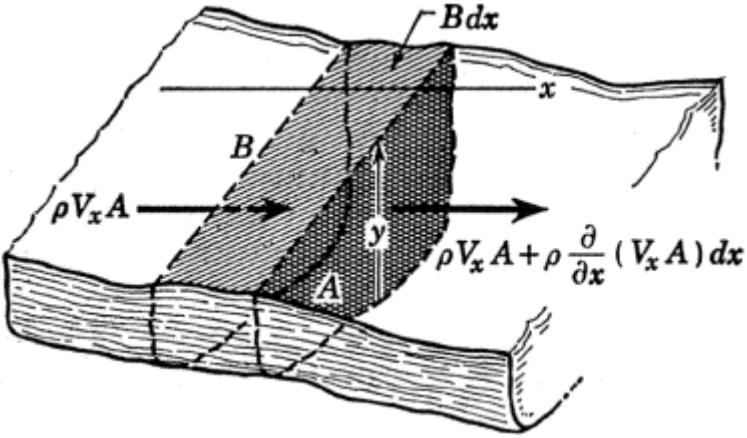
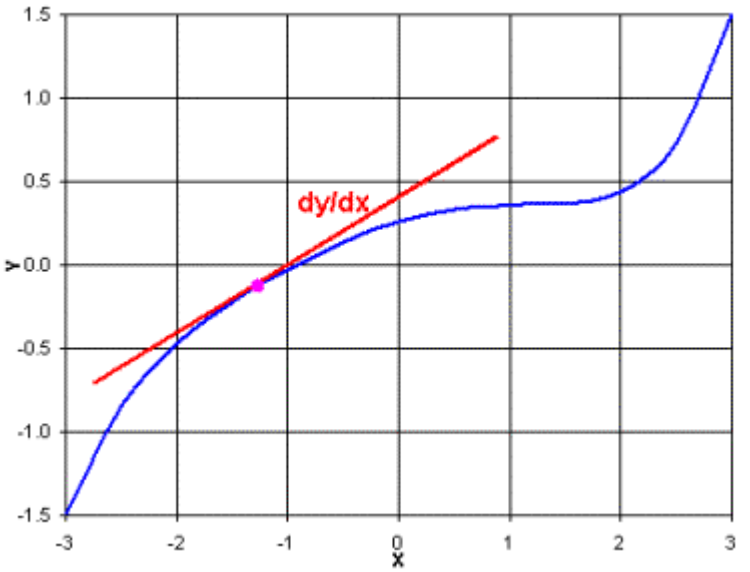
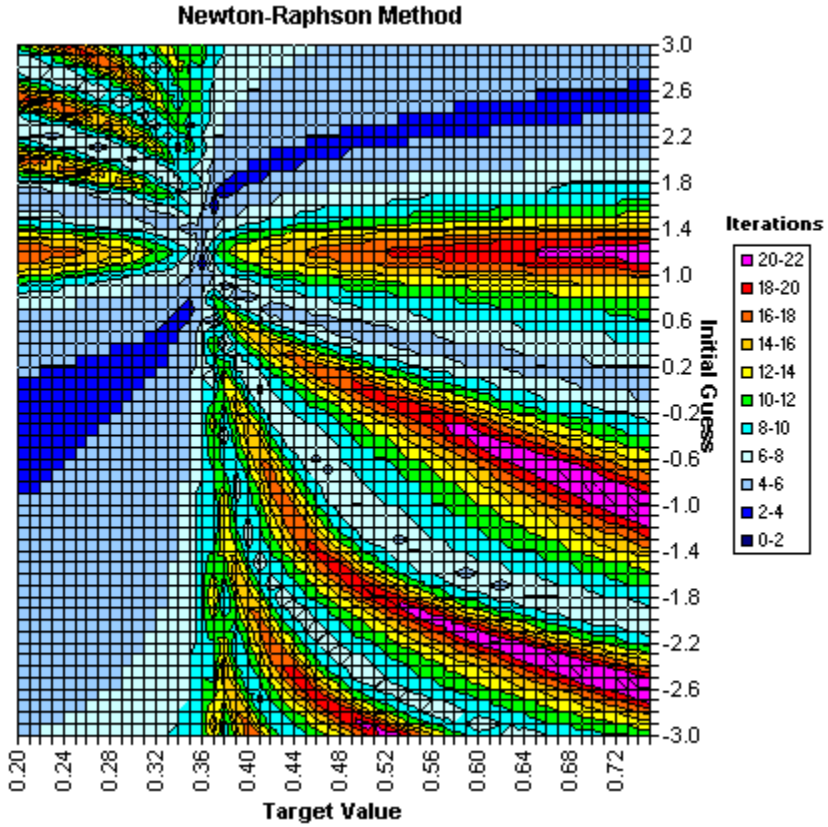
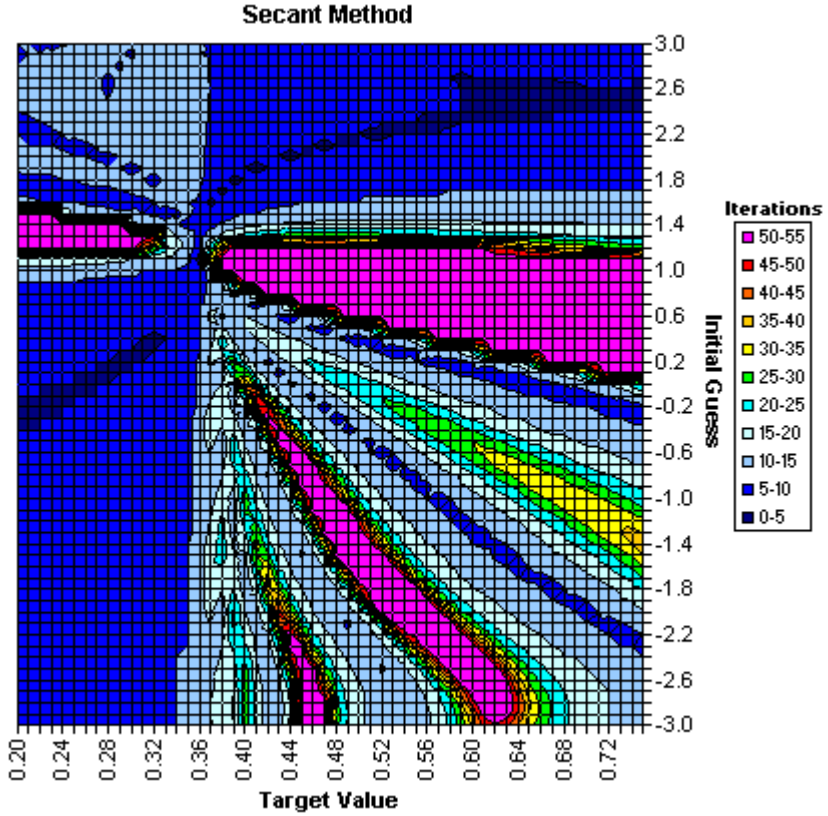


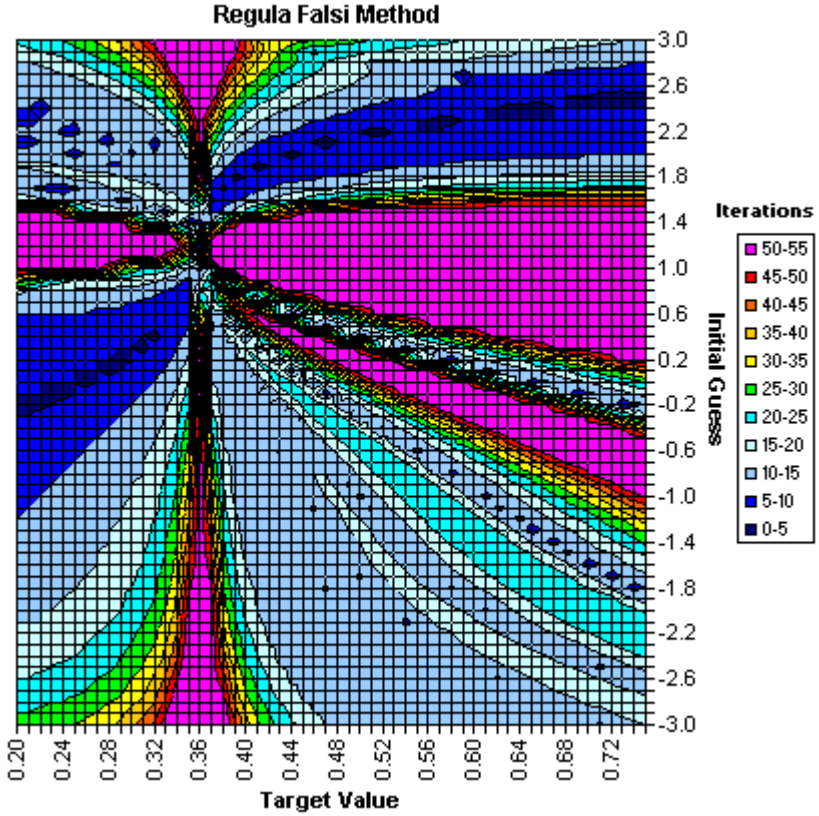
FIGURE 3. ENHANCED-BROYDEN
STORATIVITY
TRANSMISSIVITY
1
2
3

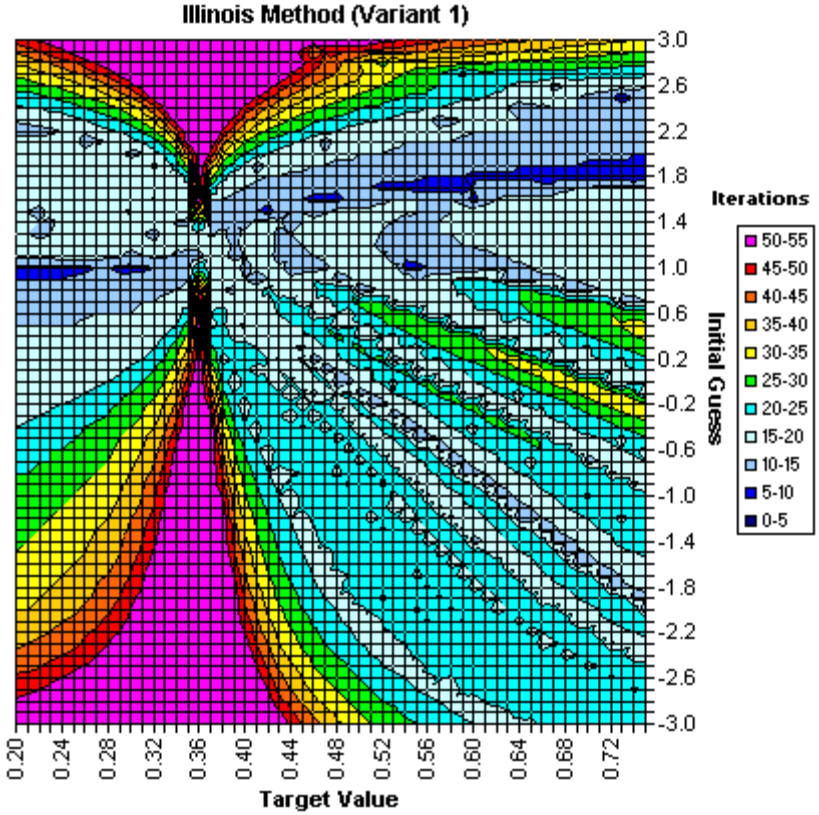

Bdx
x
B
ρV_x A
y
A
ρV_x A + ρ ∂/∂x (V_x A) dx

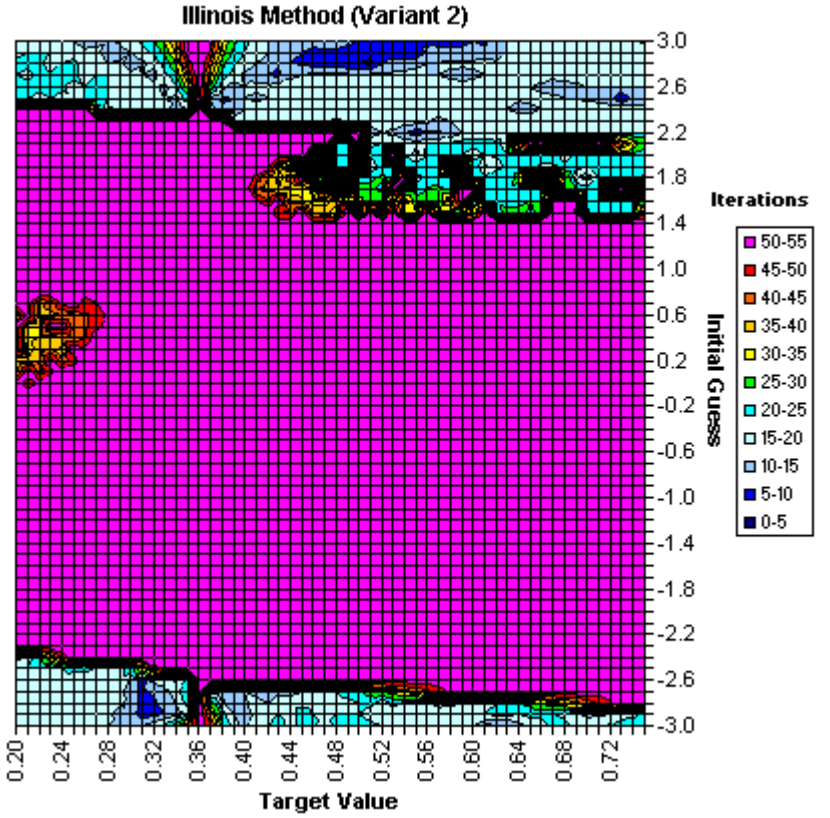

1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
y
-3
-2
-1
0
1
2
3
x
dy/dx

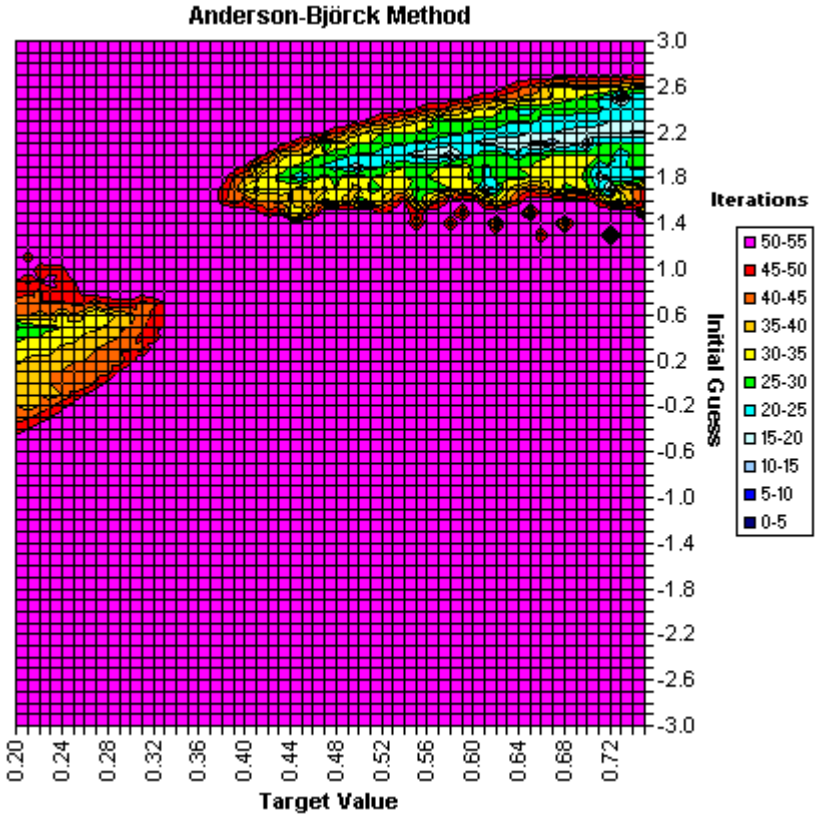

Newton-Raphson Method
Iterations
20-22
18-20
16-18
14-16
12-14
10-12
8-10
6-8
4-6
2-4
0-2
Initial Guess
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-2.2
-2.6
-3.0
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
0.52
0.56
0.60
0.64
0.68
0.72
Target Value

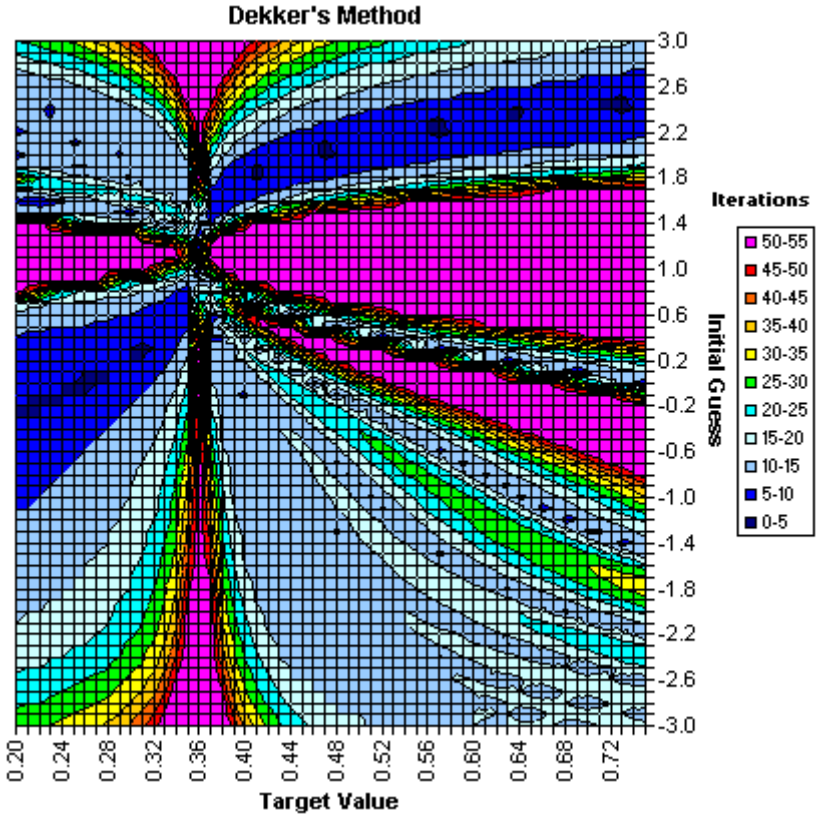

Secant Method
Iterations
50-55
45-50
40-45
35-40
30-35
25-30
20-25
15-20
10-15
5-10
0-5
Initial Guess
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-2.2
-2.6
-3.0
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
0.52
0.56
0.60
0.64
0.68
0.72
Target Value


Regula Falsi Method
Iterations
50-55
45-50
40-45
35-40
30-35
25-30
20-25
15-20
10-15
5-10
0-5
Initial Guess
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-2.2
-2.6
-3.0
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
0.52
0.56
0.60
0.64
0.68
0.72
Target Value


Illinois Method (Variant 1)
Iterations
50-55
45-50
40-45
35-40
30-35
25-30
20-25
15-20
10-15
5-10
0-5
Initial Guess
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-2.2
-2.6
-3.0
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
0.52
0.56
0.60
0.64
0.68
0.72
Target Value

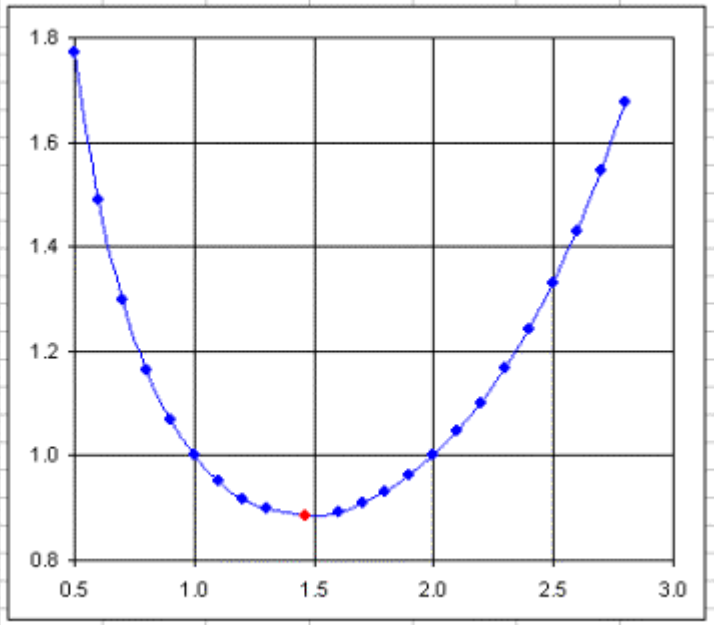

Illinois Method (Variant 2)
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-2.2
-2.6
-3.0
Initial Guess
Iterations
50-55
45-50
40-45
35-40
30-35
25-30
20-25
15-20
10-15
5-10
0-5
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
0.52
0.56
0.60
0.64
0.68
0.72
Target Value

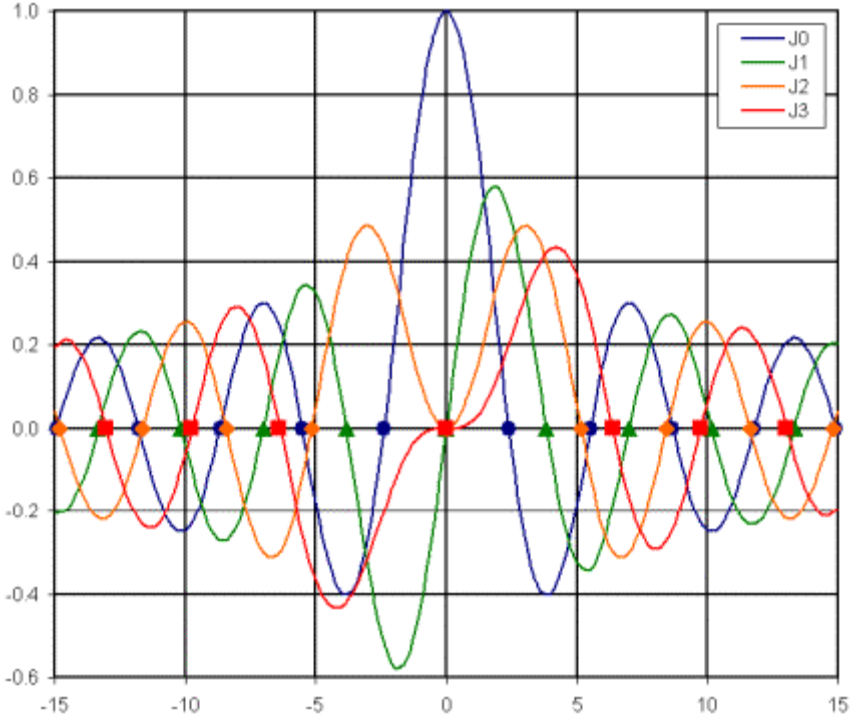

Anderson-Björck Method
Iterations
50-55
45-50
40-45
35-40
30-35
25-30
20-25
15-20
10-15
5-10
0-5
Initial Guess
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-2.2
-2.6
-3.0
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
0.52
0.56
0.60
0.64
0.68
0.72
Target Value

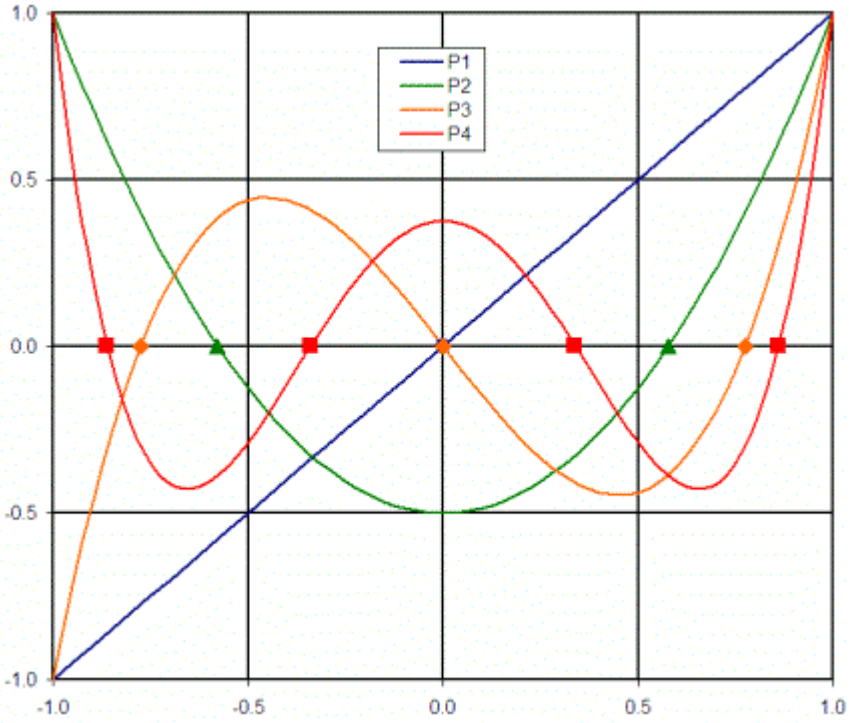


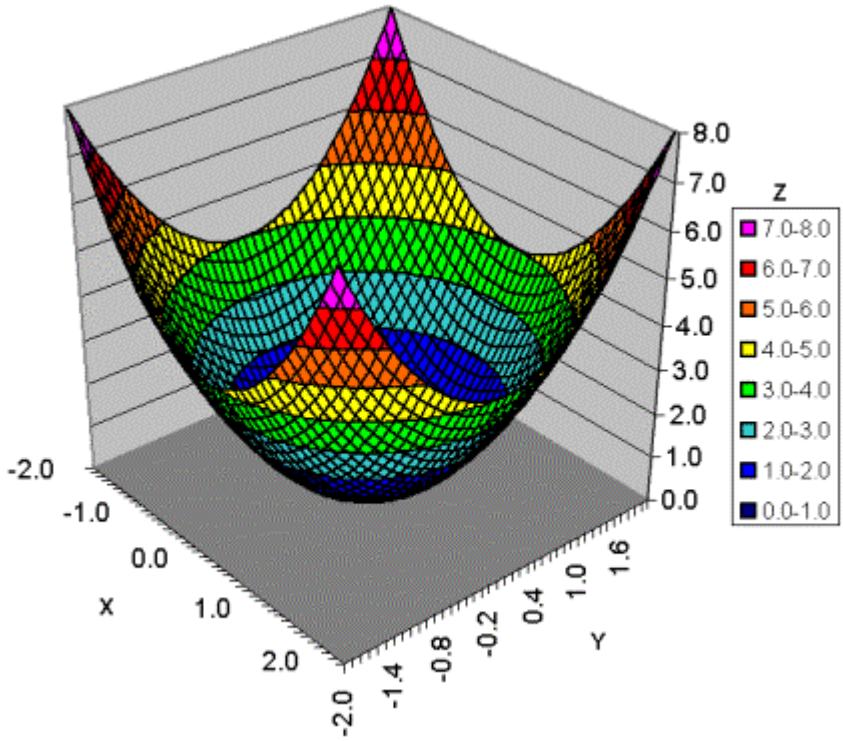
Bisection Search

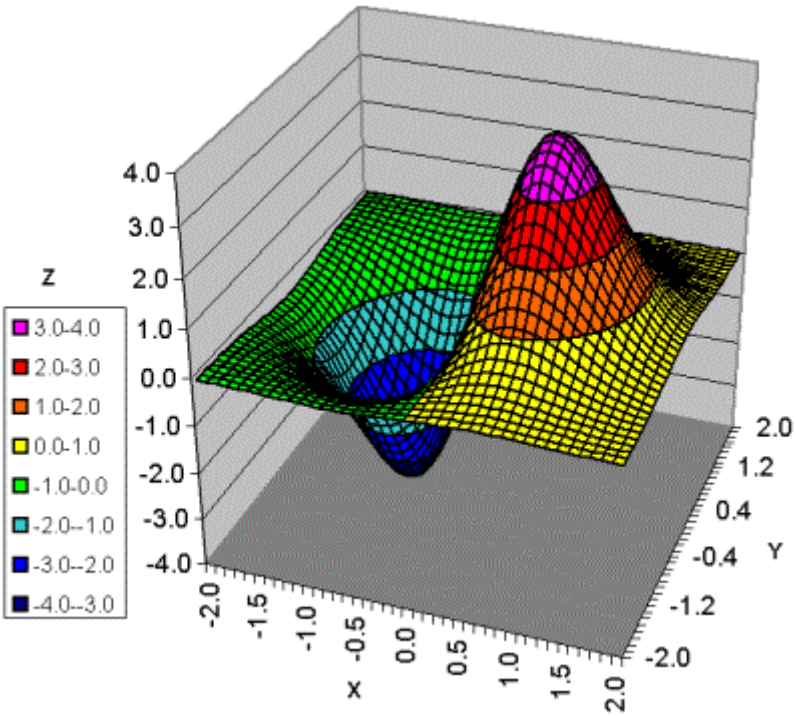
x	y
0.5	1.77
0.6	1.49
0.7	1.30
0.8	1.16
0.9	1.07
1.0	1.00
1.1	0.95
1.2	0.92
1.3	0.90
1.4616	0.8856
1.6	0.89
1.7	0.91
1.8	0.93
1.9	0.96
2.0	1.00
2.1	1.05
2.2	1.10
2.3	1.17
2.4	1.24
2.5	1.33
2.6	1.43
2.7	1.54
2.8	1.68

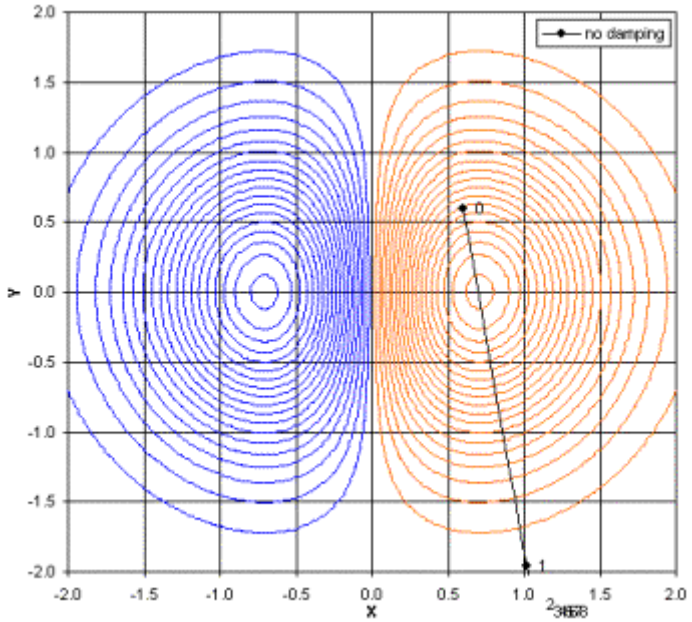


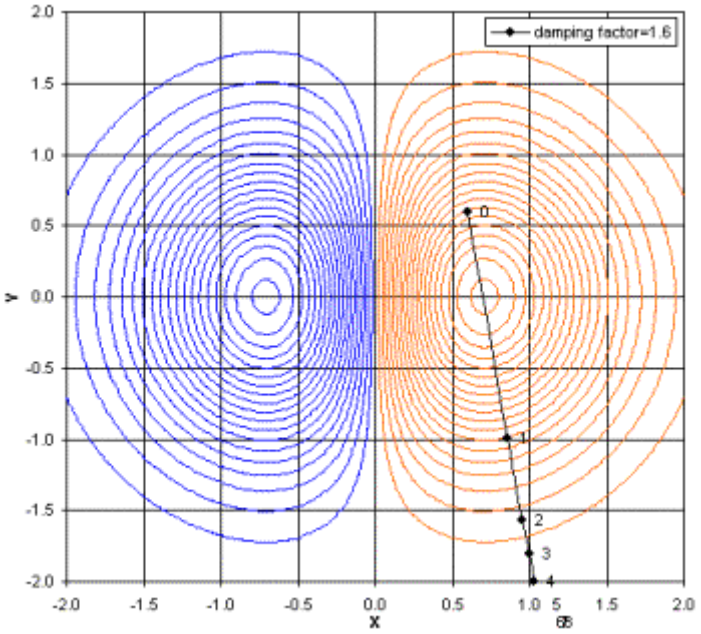

J0
J1
J2
J3
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-15
-10
-5
0
5
10
15

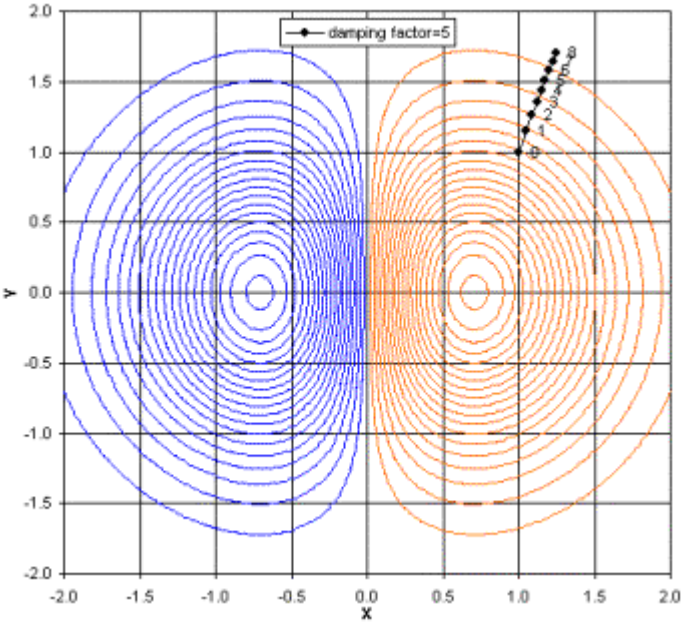

P1
P2
P3
P4
1.0
0.5
0.0
-0.5
-1.0
-1.0
-0.5
0.0
0.5
1.0

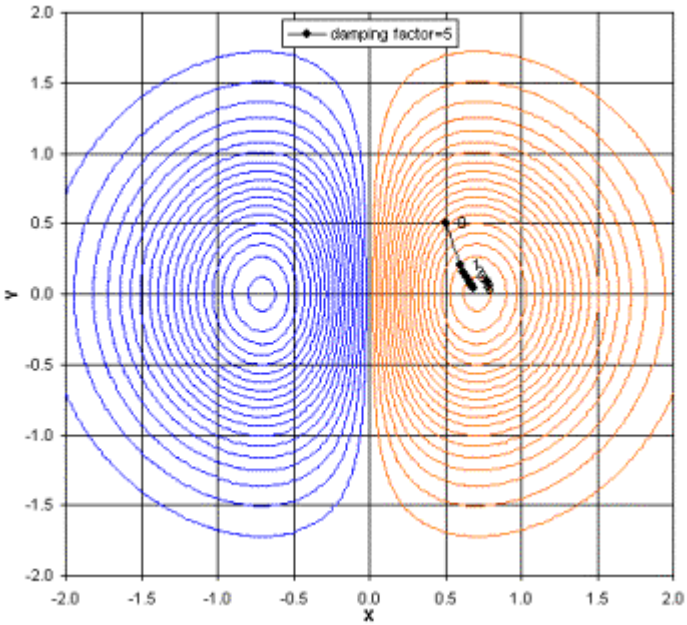

8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Z
7.0-8.0
6.0-7.0
5.0-6.0
4.0-5.0
3.0-4.0
2.0-3.0
1.0-2.0
0.0-1.0
-2.0
-1.0
0.0
1.0
2.0
X
-2.0
-1.4
-0.8
-0.2
0.4
1.0
1.6
Y

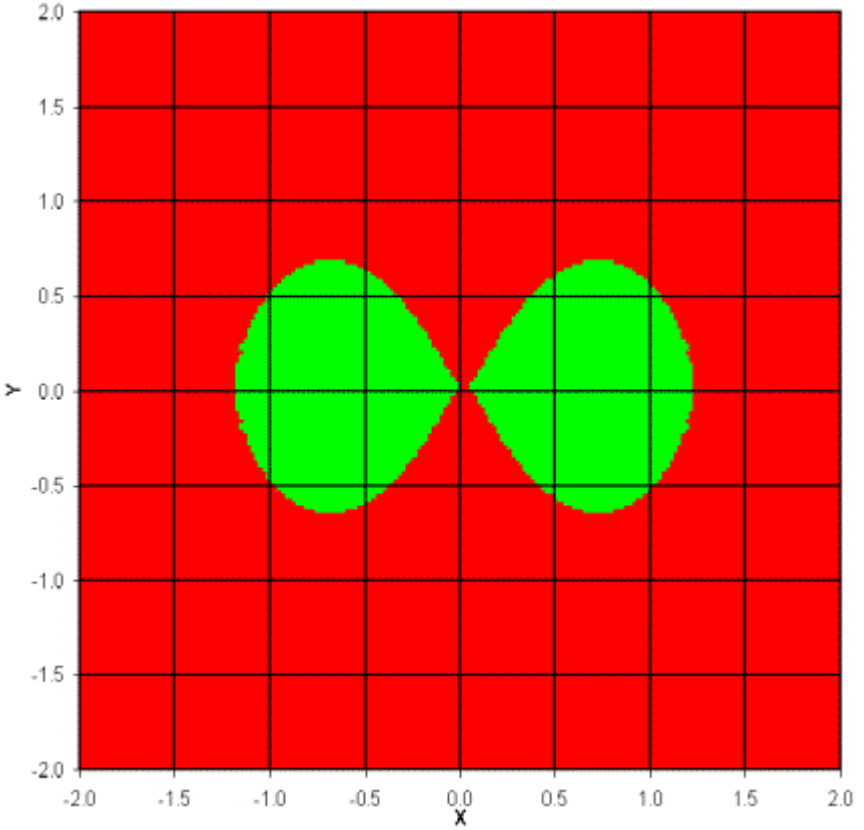

Z
3.0-4.0
2.0-3.0
1.0-2.0
0.0-1.0
-1.0-0.0
-2.0--1.0
-3.0--2.0
-4.0--3.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
X
2.0
1.2
0.4
-0.4
-1.2
-2.0
Y

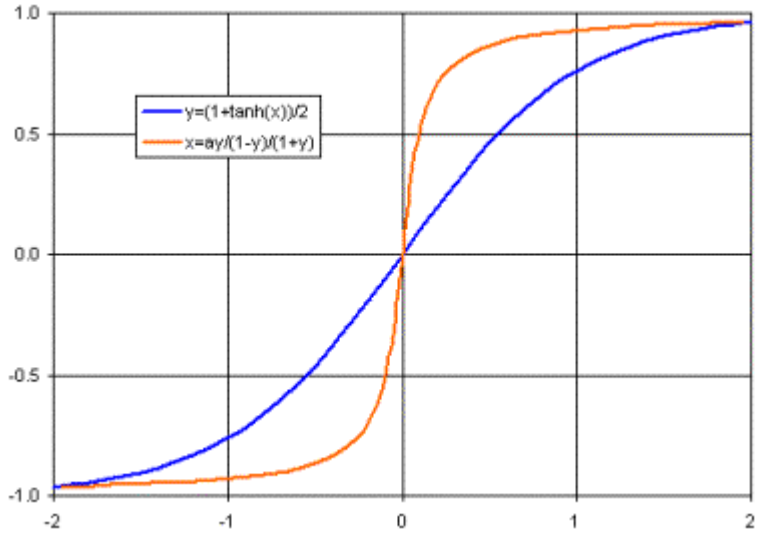

no damping
0
1
2
3
4
x
y

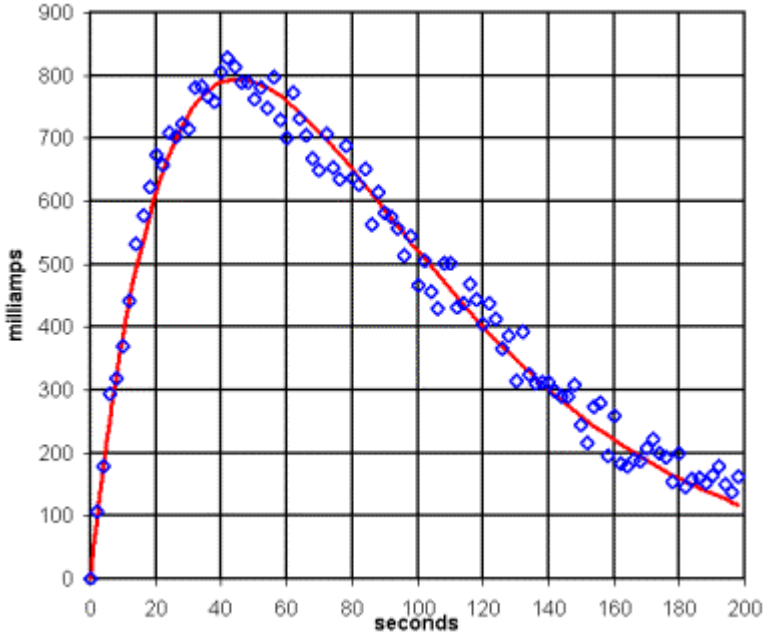

damping factor=1.6
0
1
2
3
4
x
y

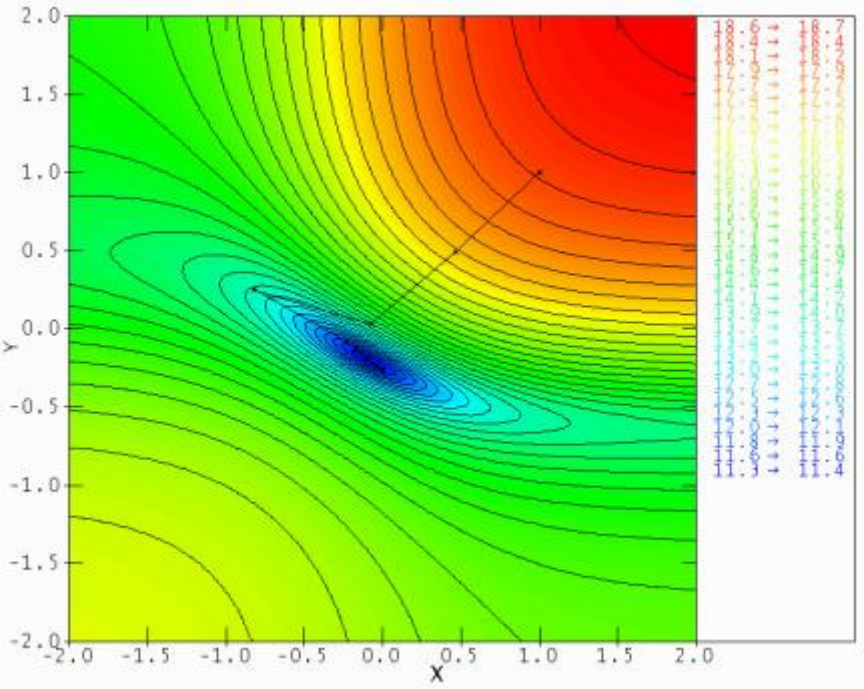

damping factor=5
0
1
2
3
4
5
6
7
8
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
x

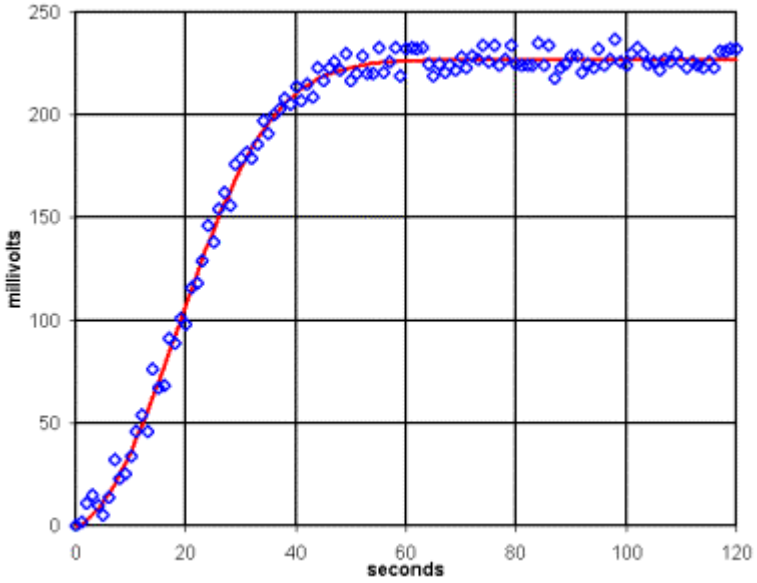

damping factor=5
0
1
2
3
4
5
6
7
8
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
x

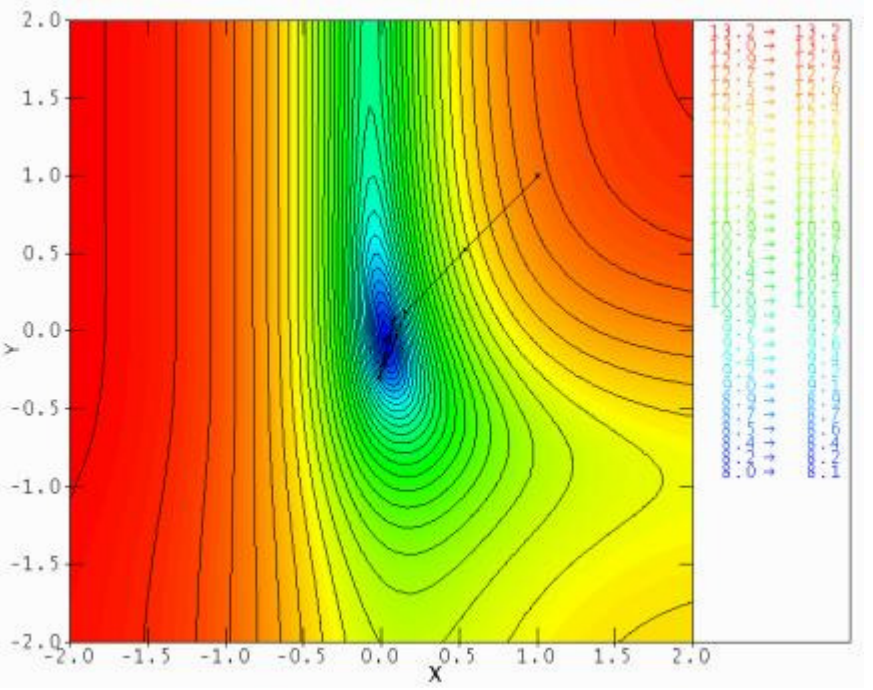

2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
X

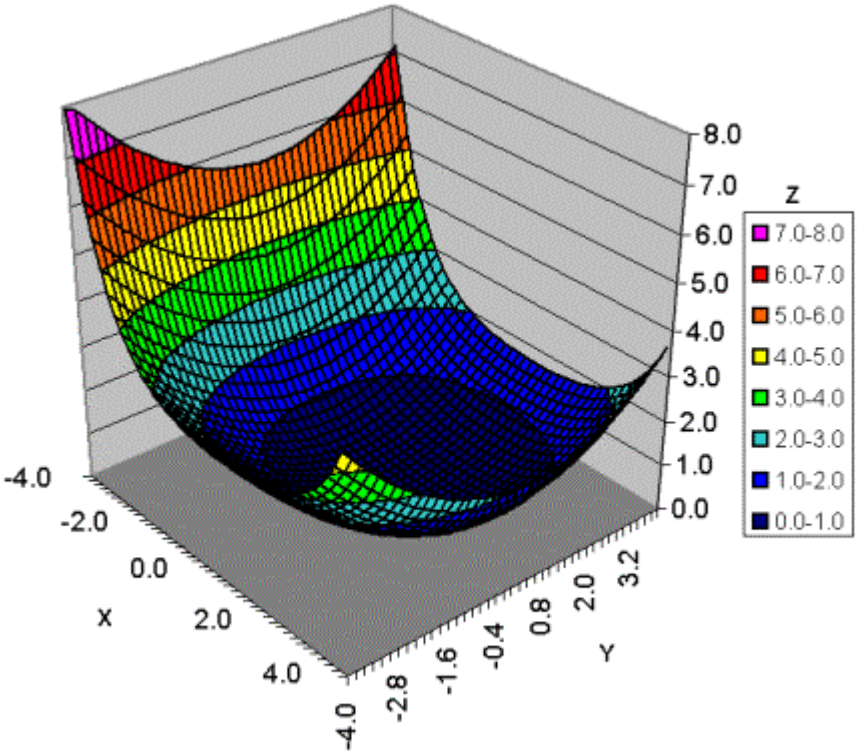

y=(1+tanh(x))/2
x=ay/(1-y)/(1+y)
1.0
0.5
0.0
-0.5
-1.0
-2
-1
0
1
2

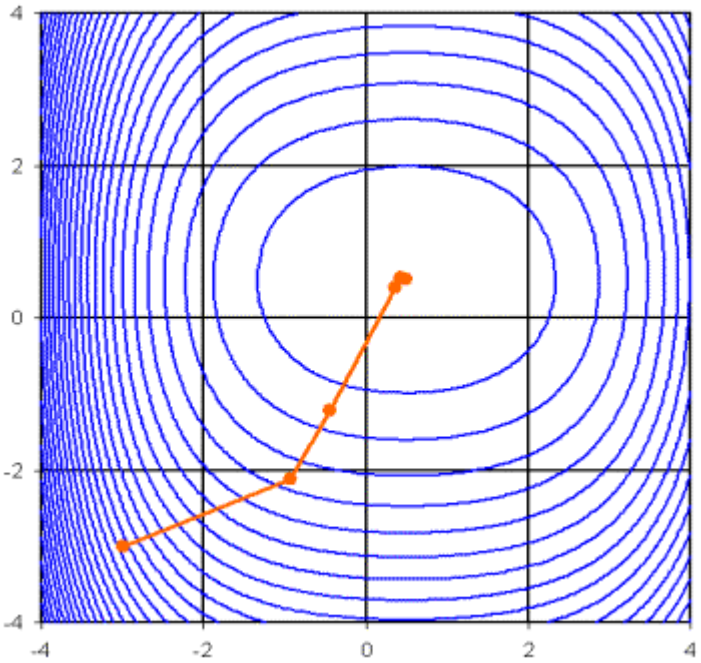

milliamps
seconds
900
800
700
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
160
180
200

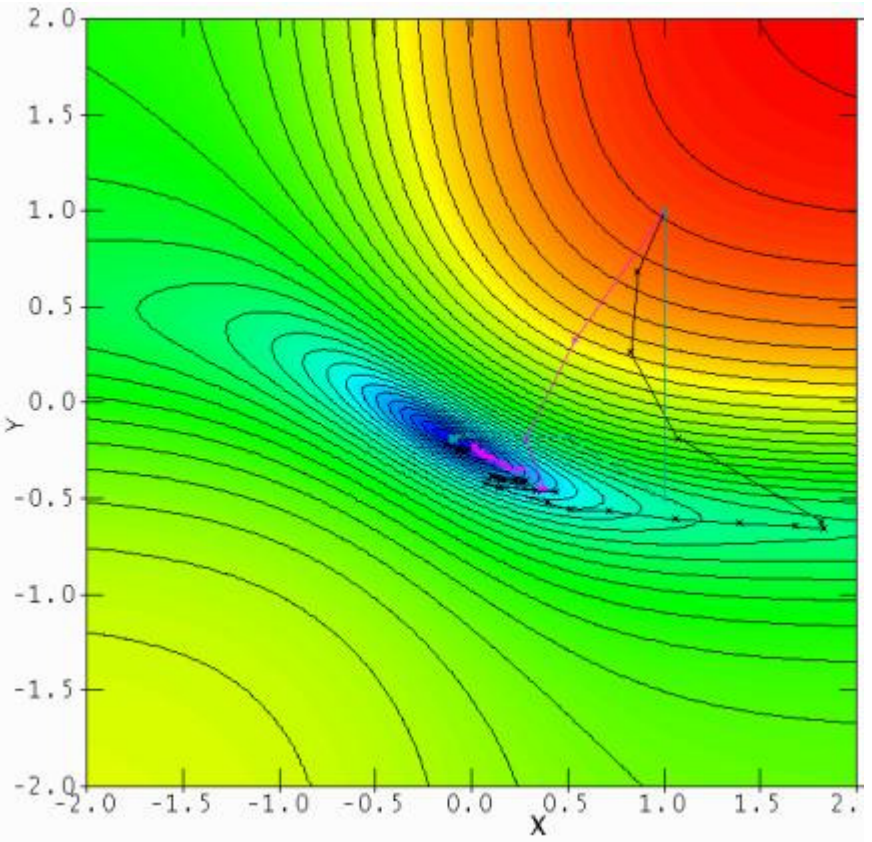

2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Y
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0
X

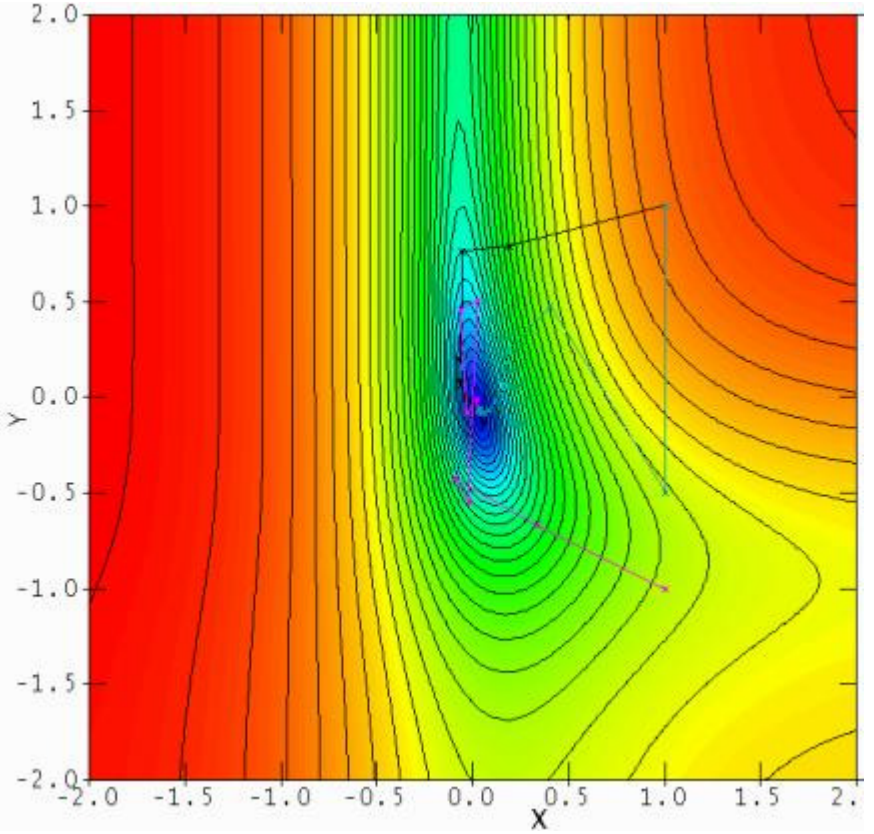

250
200
150
100
50
0
millivolts
0 20 40 60 80 100 120
seconds

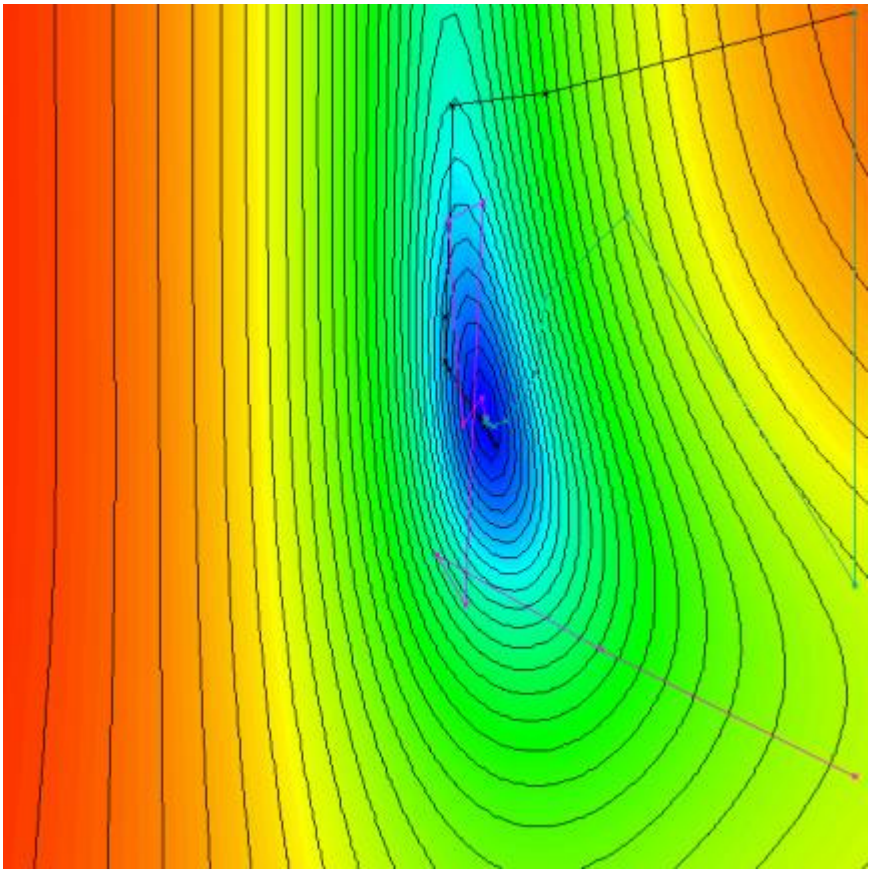

2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
x

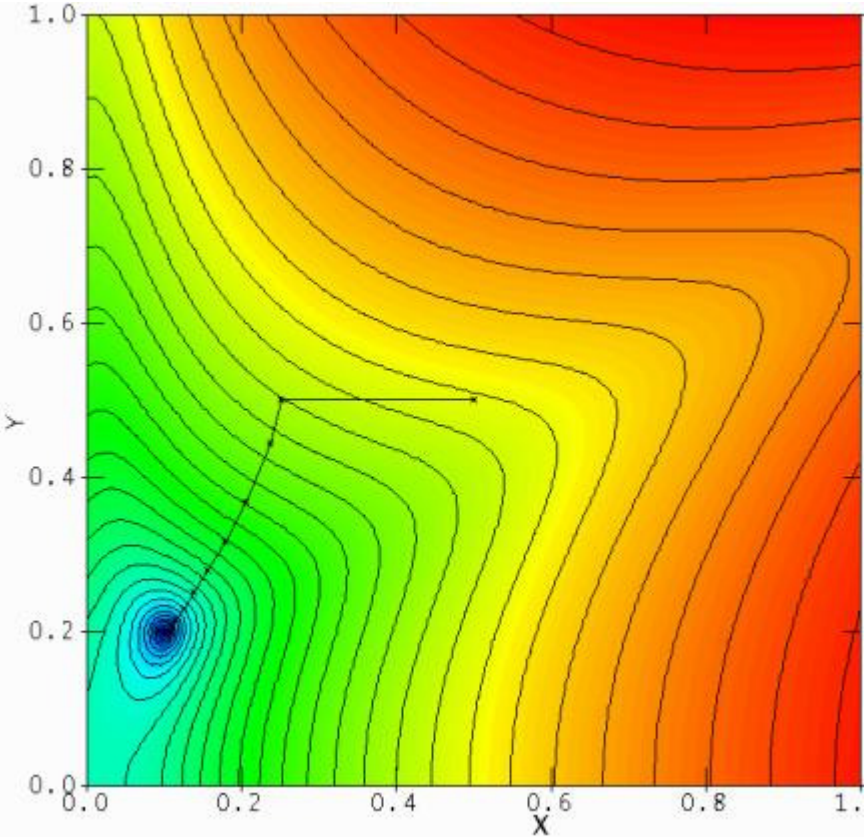

8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Z
7.0-8.0
6.0-7.0
5.0-6.0
4.0-5.0
3.0-4.0
2.0-3.0
1.0-2.0
0.0-1.0
-4.0
-2.0
0.0
2.0
4.0
X
-4.0
-2.8
-1.6
-0.4
0.8
2.0
3.2
Y

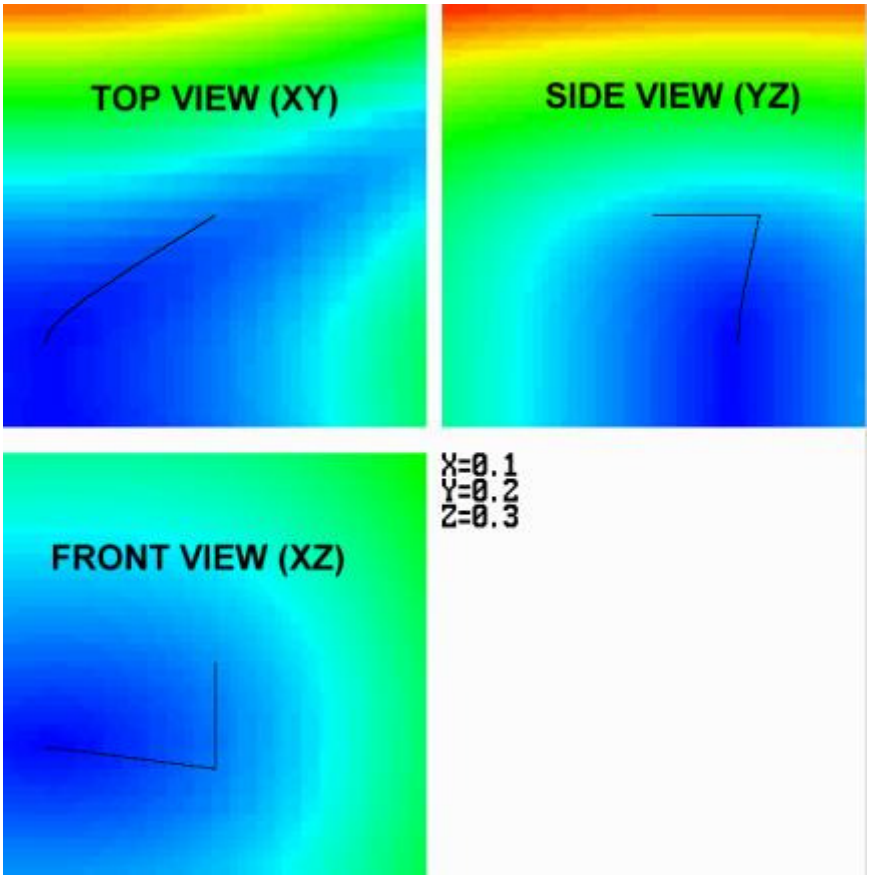

4
2
0
-2
-4
-4
-2
0
2
4

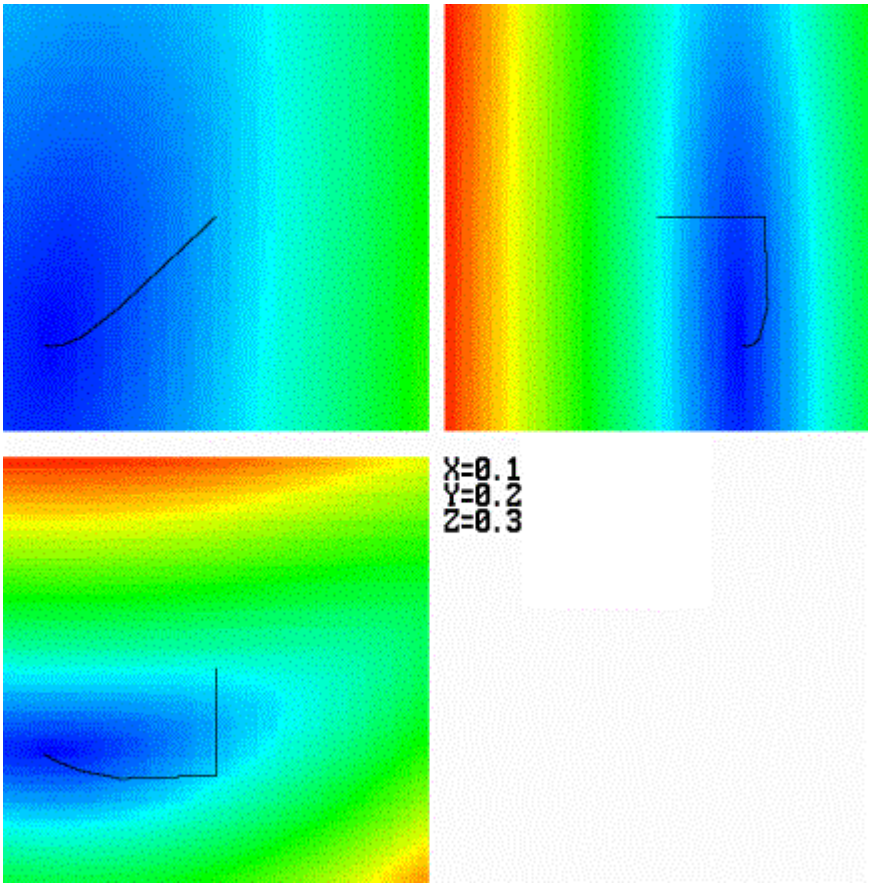

2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.
X

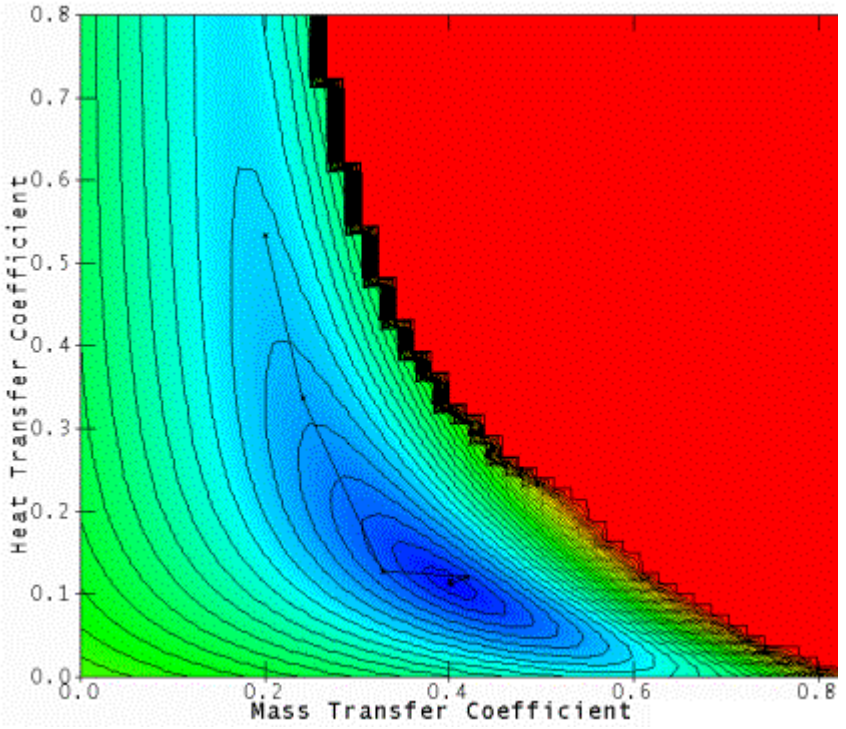

2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.
X

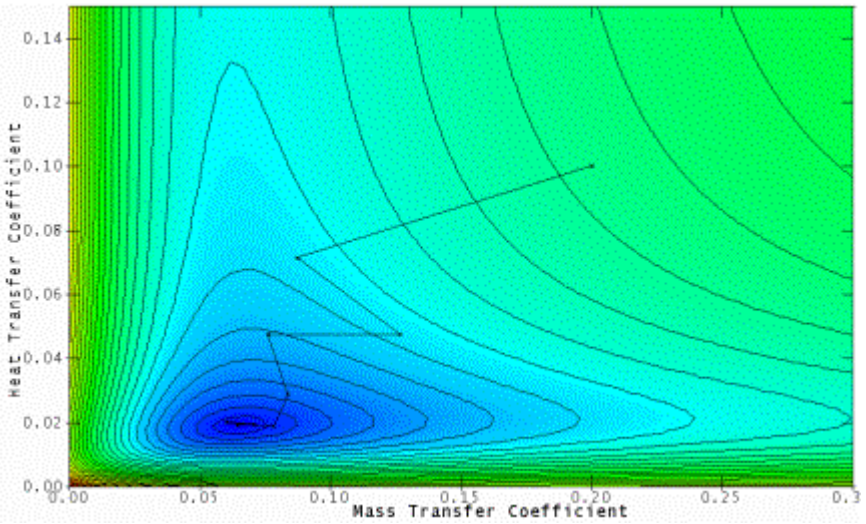


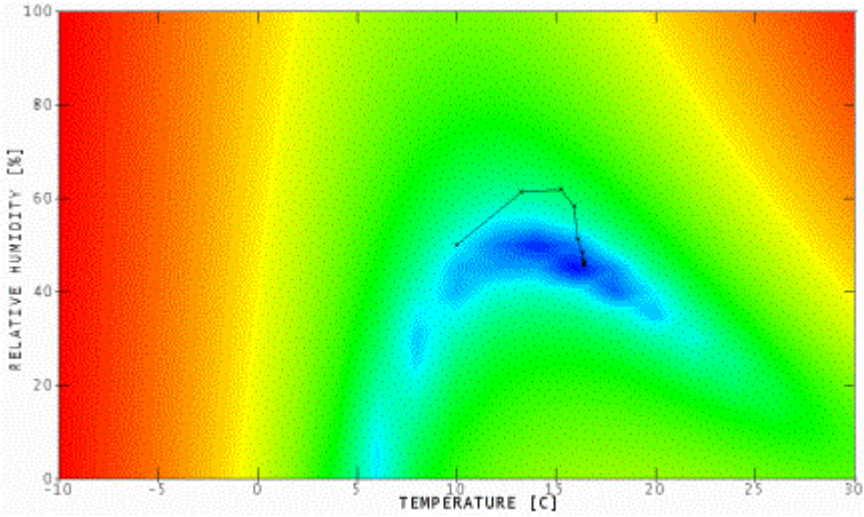

1.0
0.8
0.6
0.4
0.2
0.0
Y
0.0
0.2
0.4
0.6
0.8
1.
X

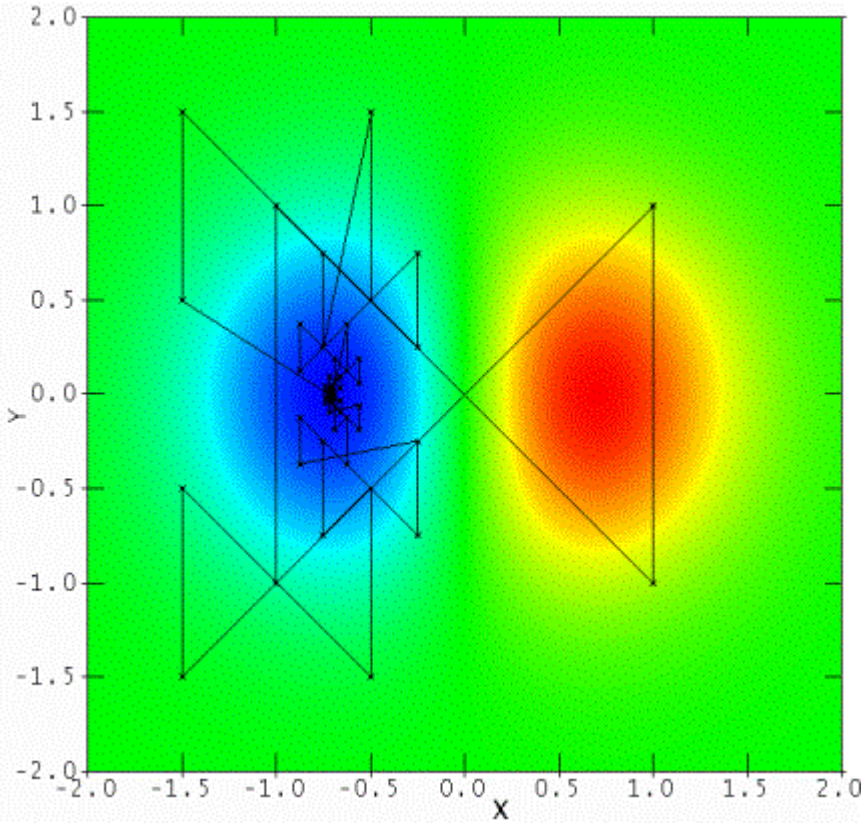

TOP VIEW (XY)
SIDE VIEW (YZ)
FRONT VIEW (XZ)
X=0.1
Y=0.2
Z=0.3

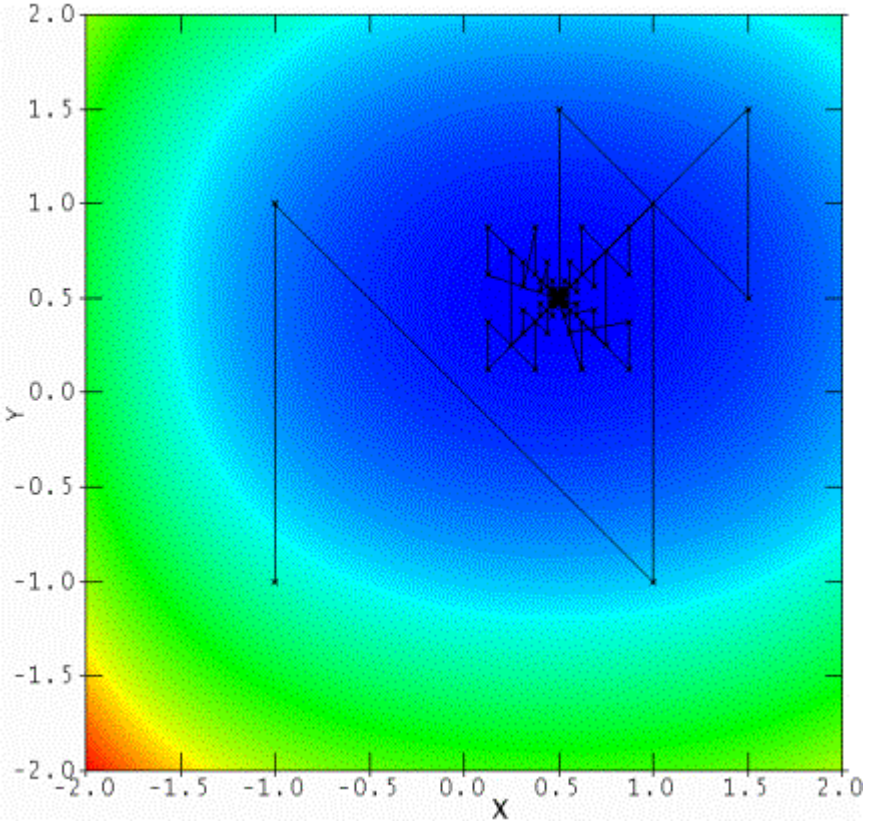

X=0.1
Y=0.2
Z=0.3

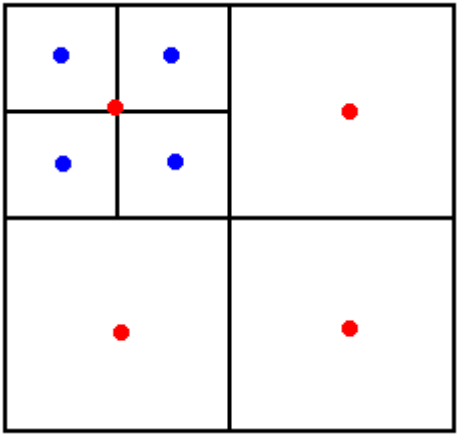

Heat Transfer Coefficient
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.0
0.2
0.4
0.6
0.8
Mass Transfer Coefficient

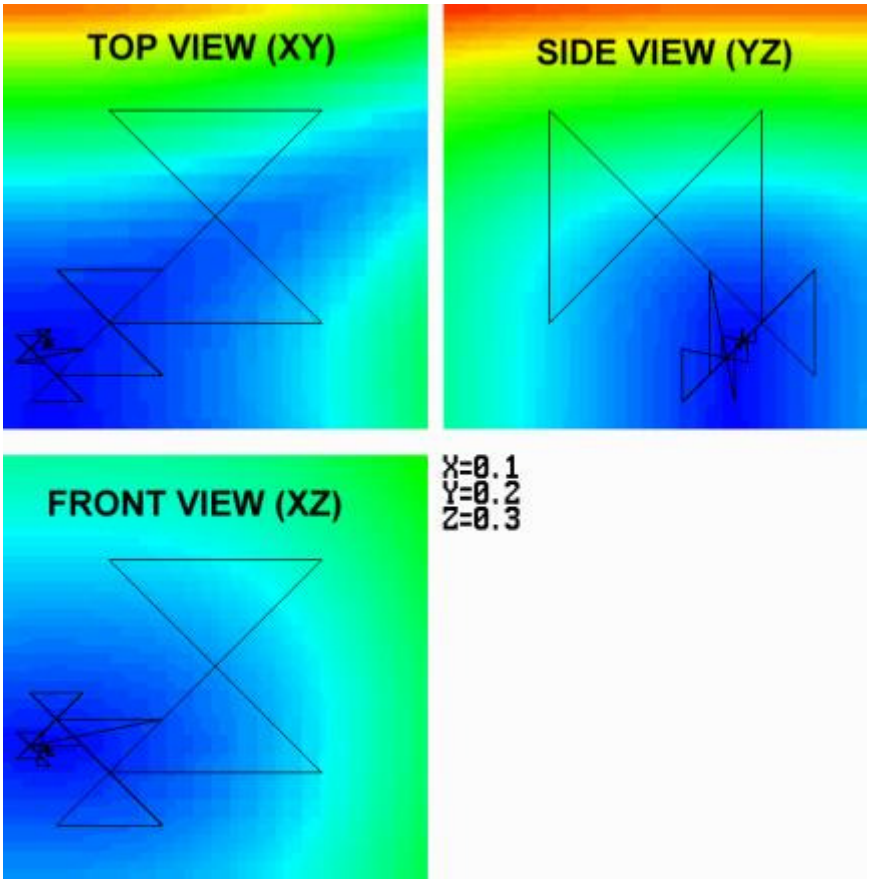

Heat Transfer Coefficient
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.00
0.05
0.10
0.15
0.20
0.25
0.3
Mass Transfer Coefficient

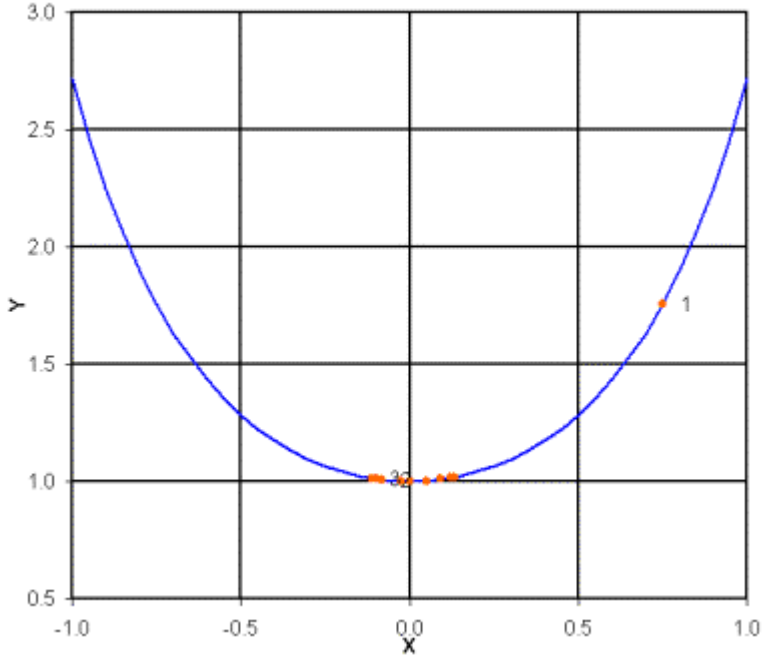

RELATIVE HUMIDITY [%]
100
80
60
40
20
0
-10
-5
0
5
10
15
20
25
30
TEMPERATURE [C]

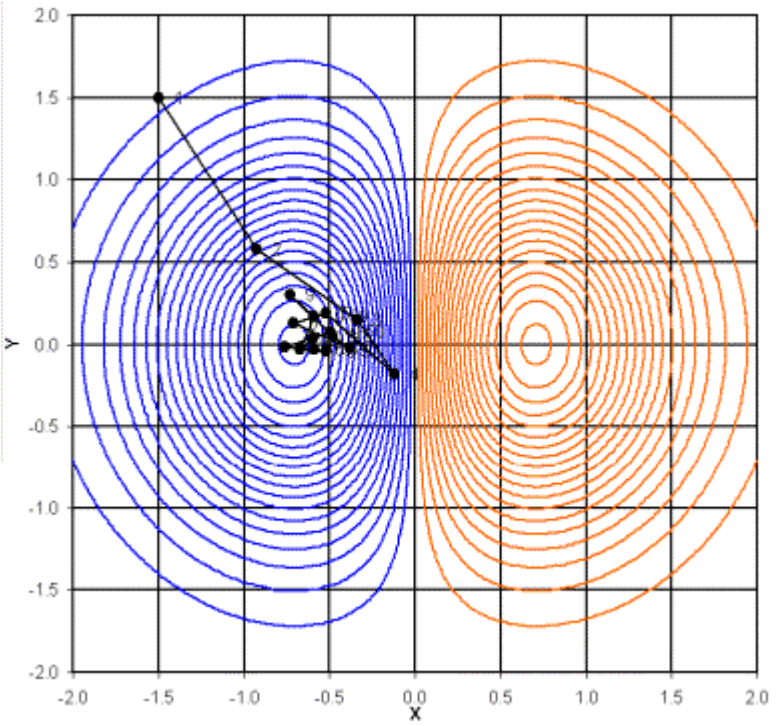

2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
X

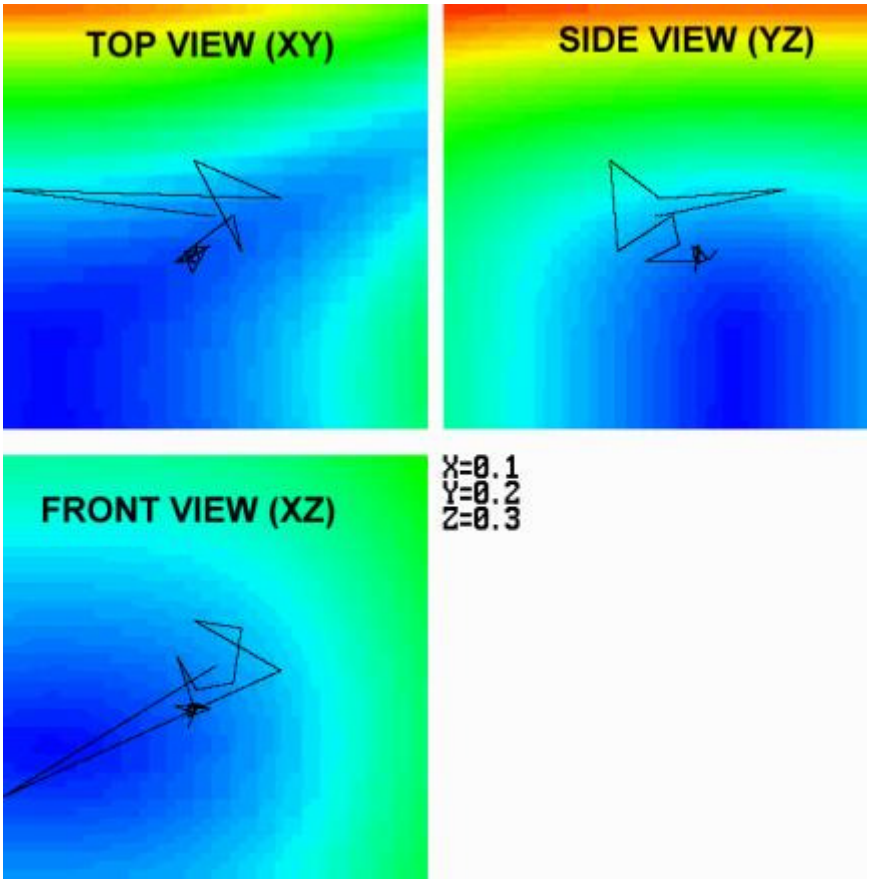

2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
X

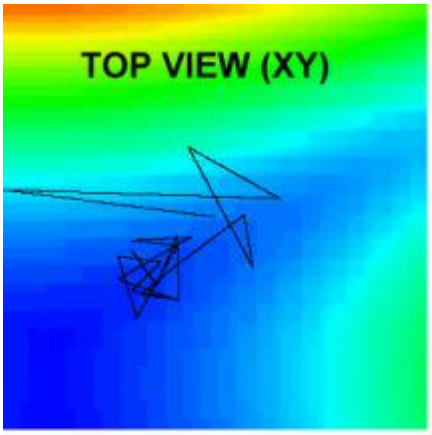


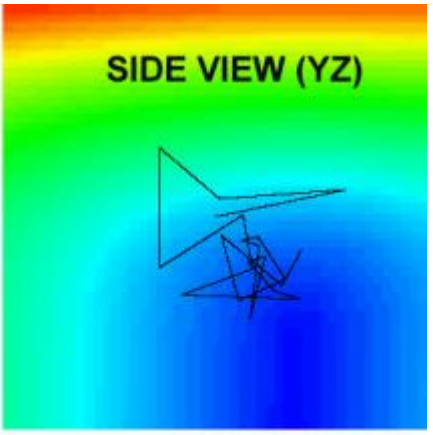

TOP VIEW (XY)
SIDE VIEW (YZ)
FRONT VIEW (XZ)
X=0.1
Y=0.2
Z=0.3

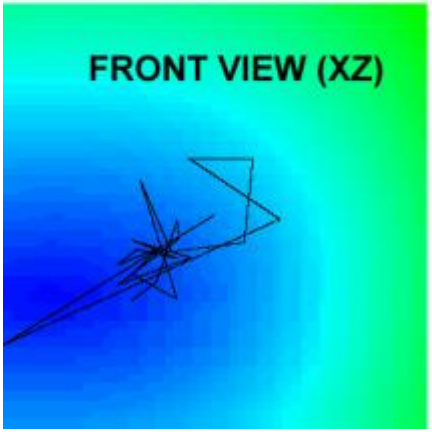

3.0
2.5
2.0
1.5
1.0
0.5
Y
-1.0
-0.5
0.0
0.5
1.0
X
1
32


2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Y
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
X

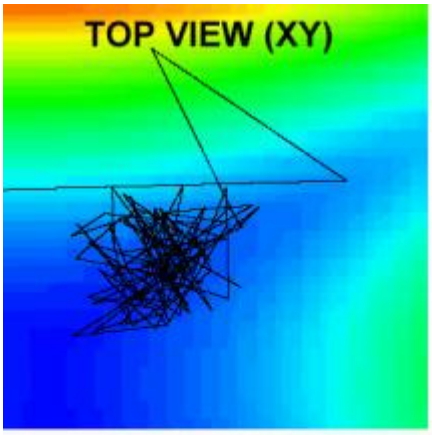

TOP VIEW (XY)
SIDE VIEW (YZ)
FRONT VIEW (XZ)
X=0.1
Y=0.2
Z=0.3

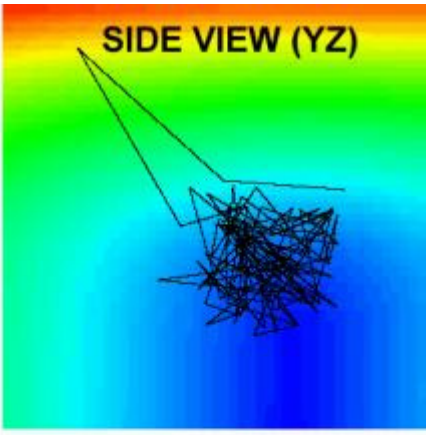


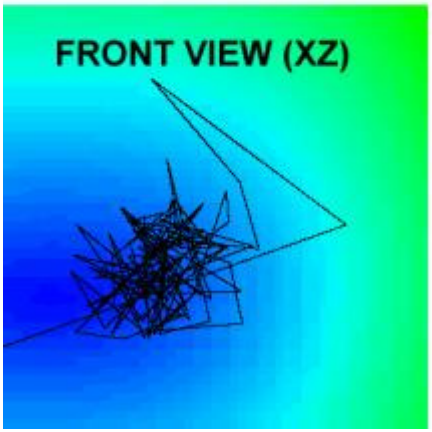




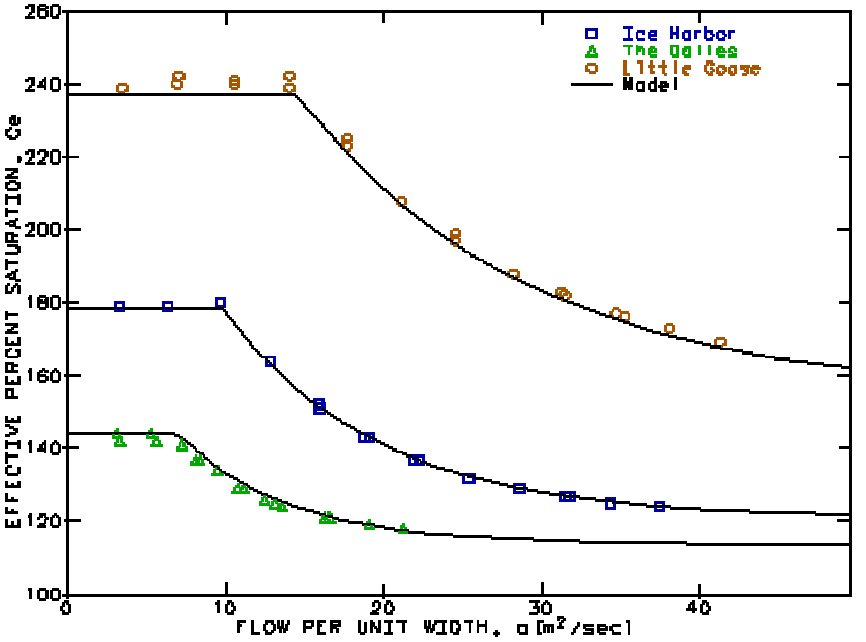
X=0.1
Y=0.2
Z=0.3

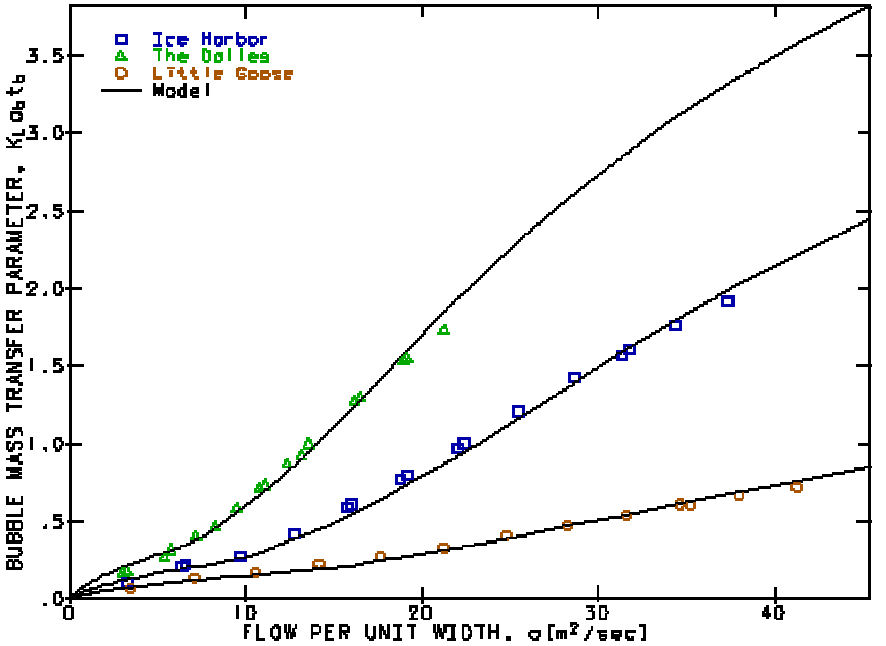


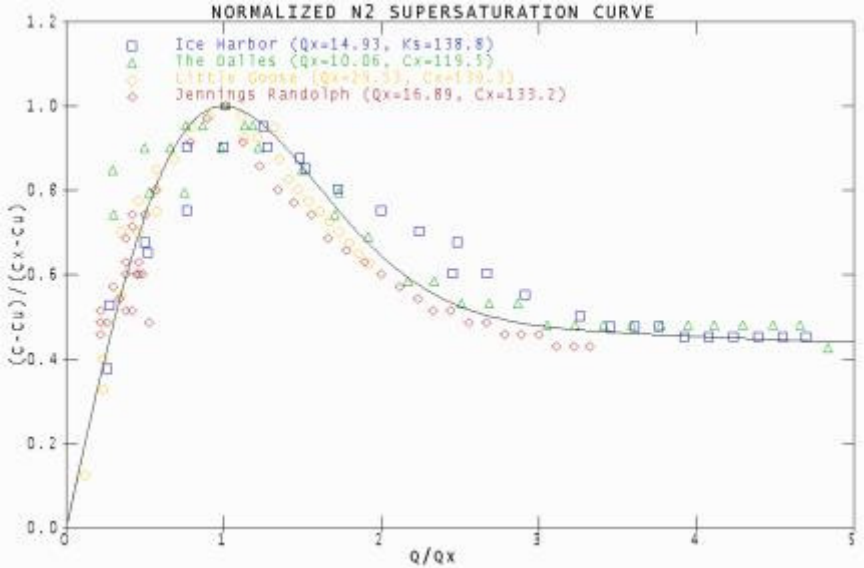


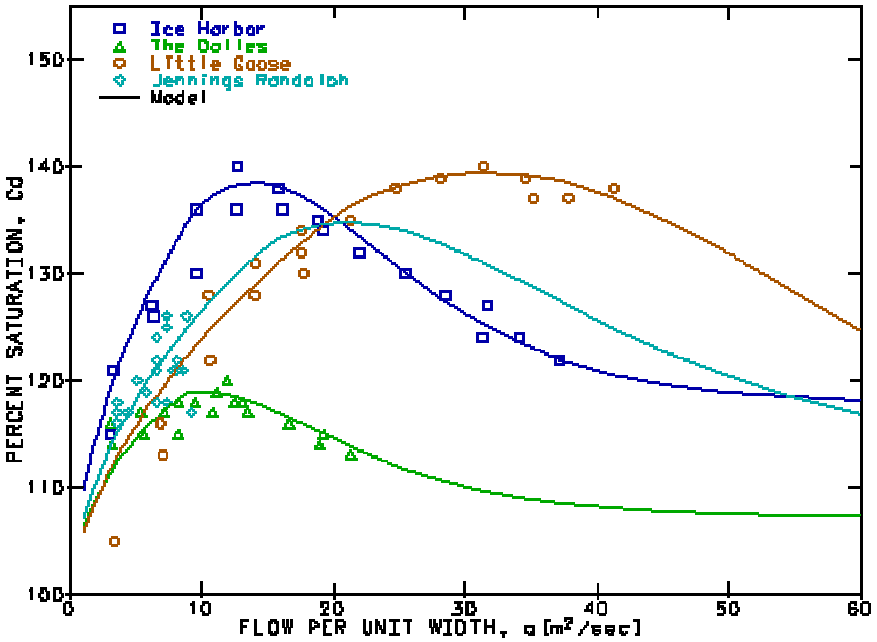


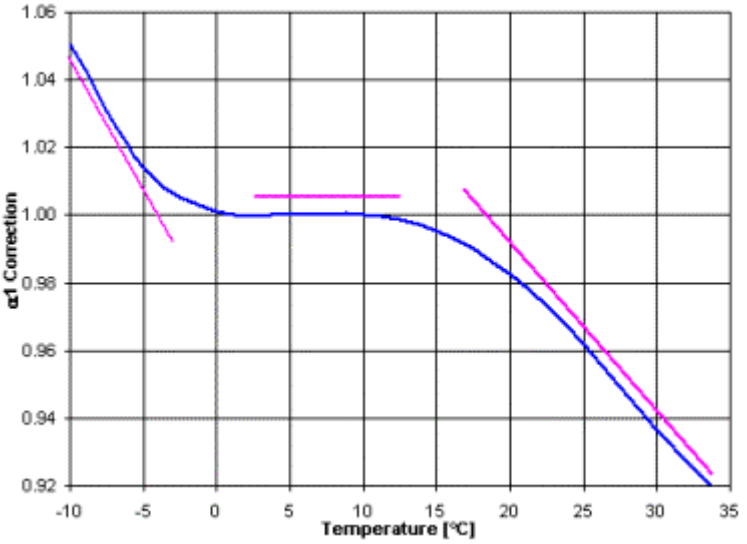
X=0.1
Y=0.2
Z=0.3

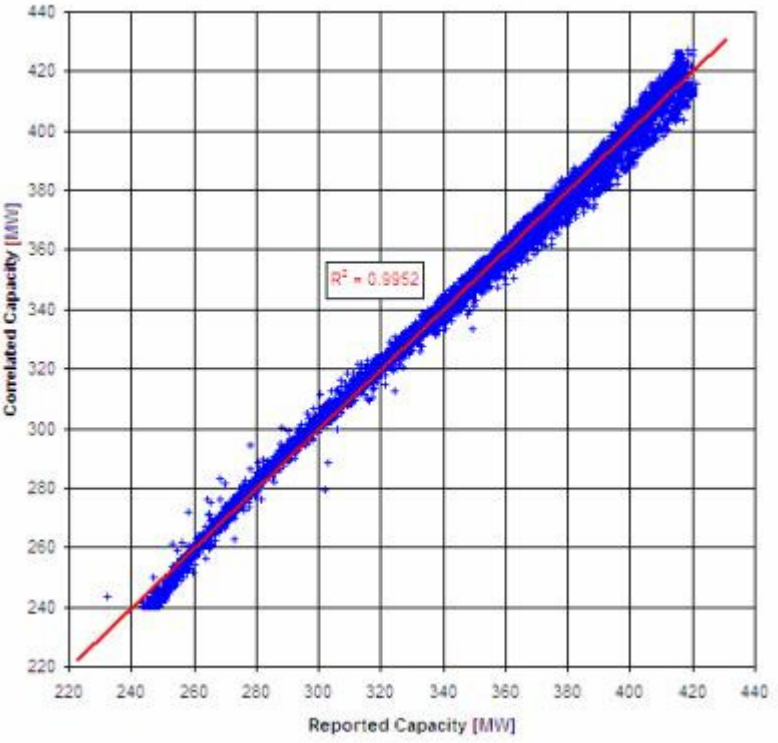

Ice Harbor
The Dalles
Little Goose
Model
EFFECTIVE PERCENT SATURATION, Ce
260
240
220
200
180
160
140
120
100
0
10
20
30
40
FLOW PER UNIT WIDTH, q [m²/sec]

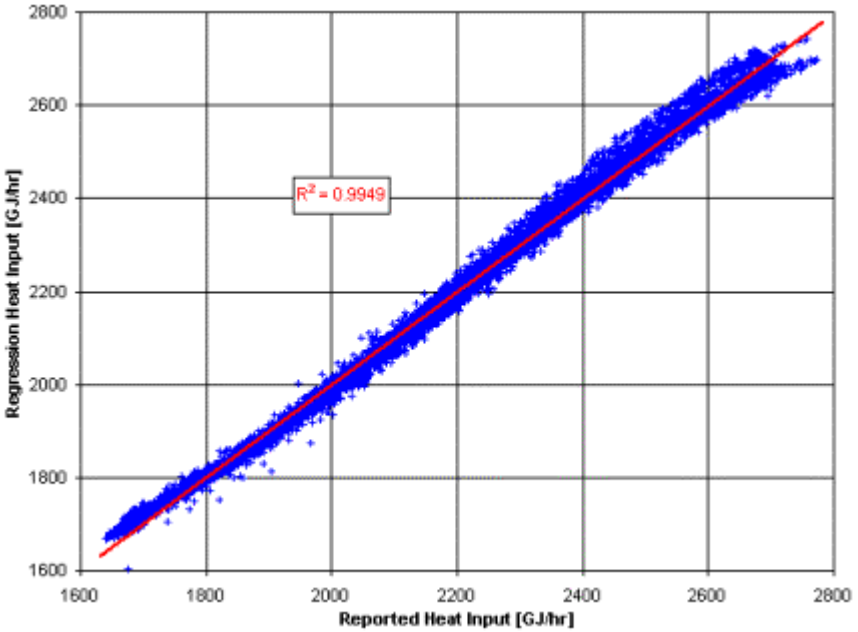

Ice Harbor
The Dalles
Little Goose
Model
BUBBLE MASS TRANSFER PARAMETER, KLaBtb
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
0
10
20
30
40
FLOW PER UNIT WIDTH, q [m²/sec]

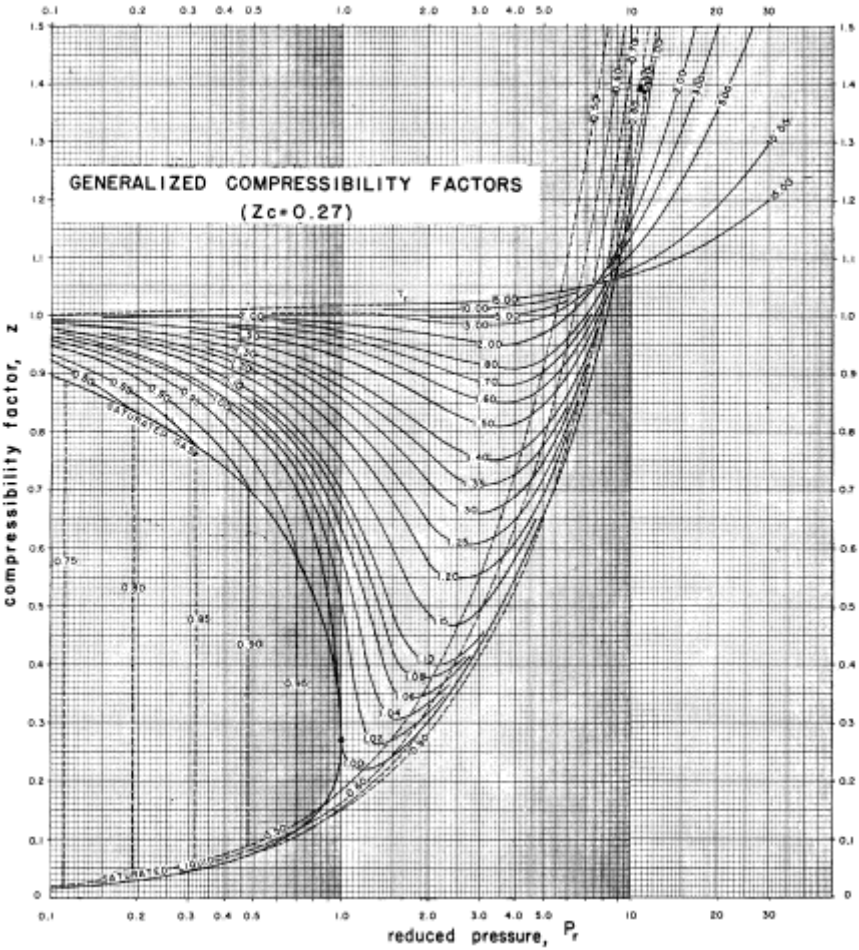

NORMALIZED N2 SUPERSATURATION CURVE
Ice Harbor (Qx=14.93, Ks=138.8)
The Dalles (Qx=10.06, Cx=119.5)
Little Goose (Qx=13.51, Cx=130.3)
Jennings Randolph (Qx=16.89, Cx=133.2)
(c-cu)/(cx-cu)
Q/Qx
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
1
2
3
4
5

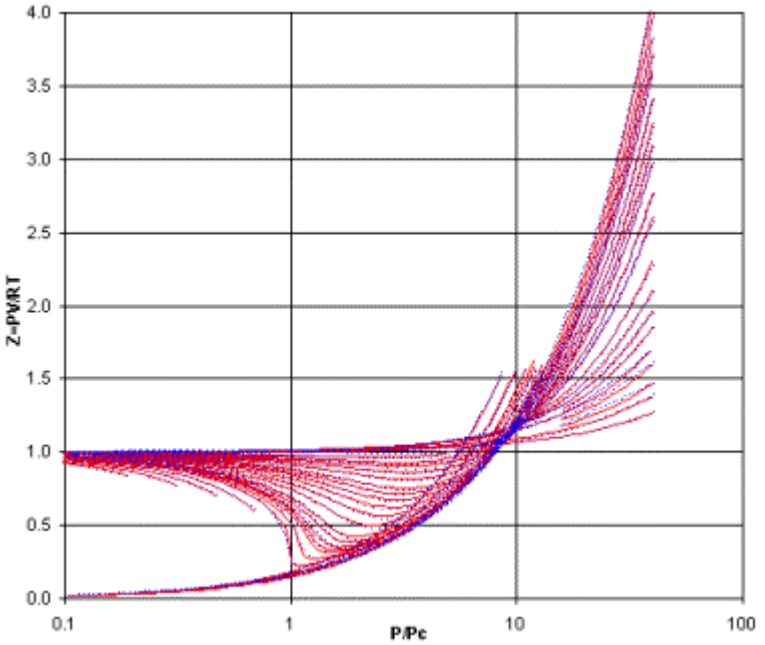

Ice Harbor
The Dalles
Little Goose
Jennings Randolph
Model
PERCENT SATURATION, Cd
FLOW PER UNIT WIDTH, q [m²/sec]
100
110
120
130
140
150
0
10
20
30
40
50
60

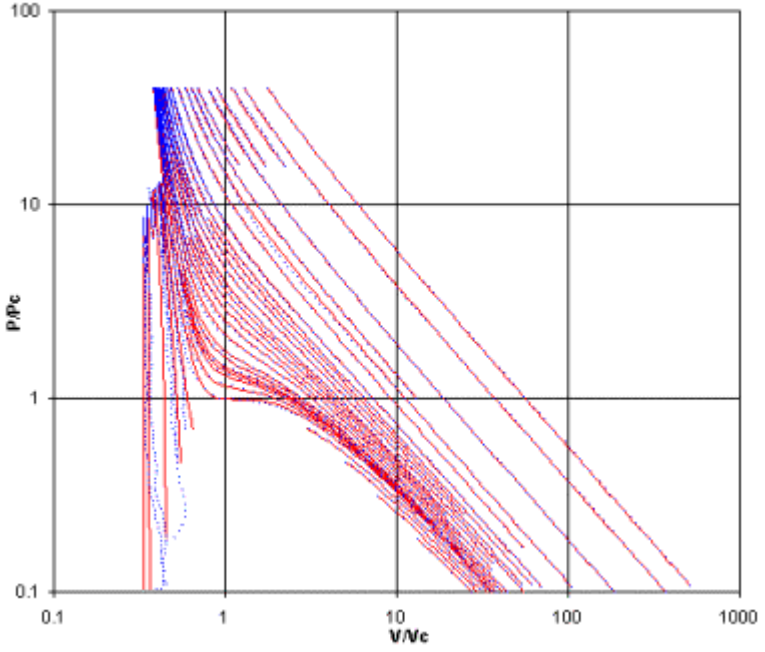

1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
α1 Correction
-10
-5
0
5
10
15
20
25
30
35
Temperature [°C]

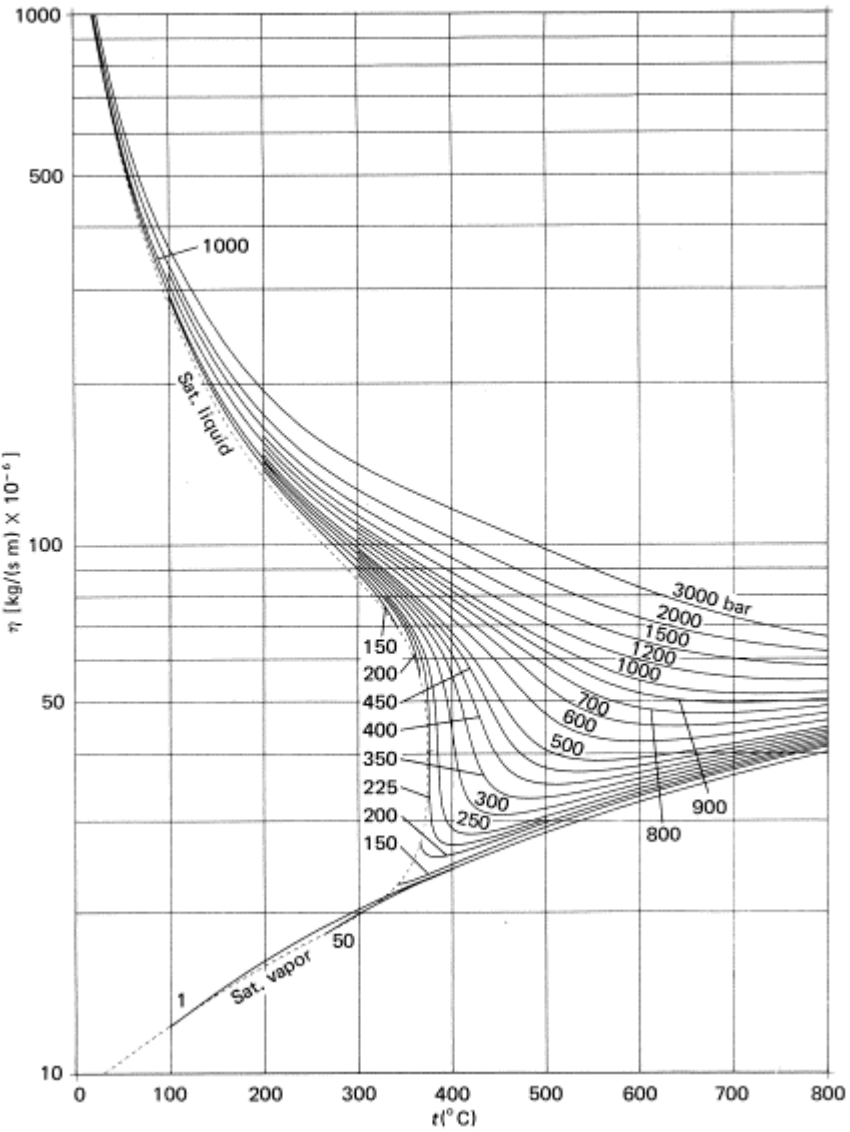

440
420
400
380
360
340
320
300
280
260
240
220
Correlated Capacity [MW]
R² = 0.9952
220
240
260
280
300
320
340
360
380
400
420
440
Reported Capacity [MW]

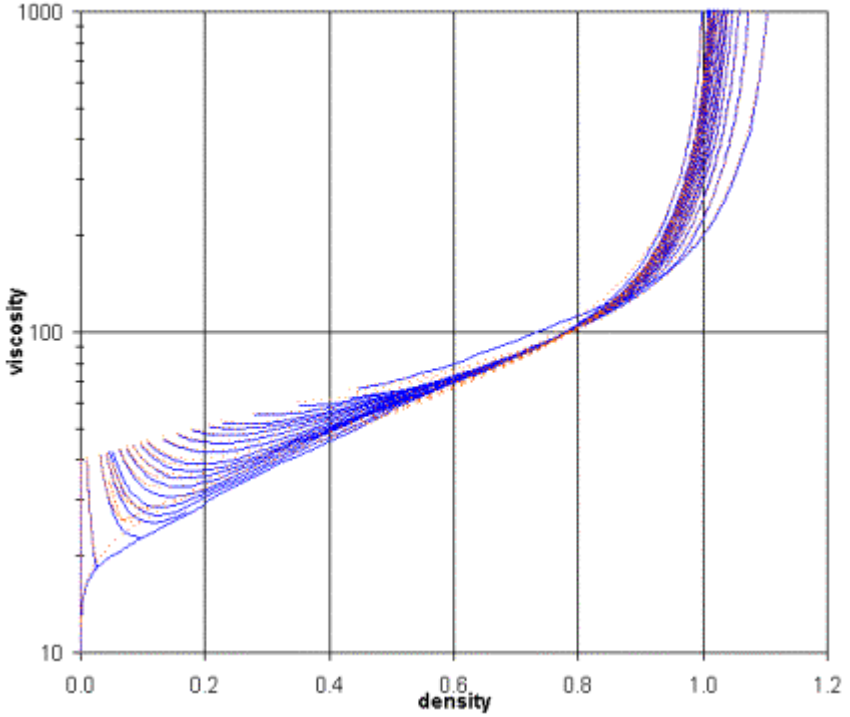

2800
2600
2400
2200
2000
1800
1600
Regression Heat Input [GJ/hr]
R² = 0.9949
1600
1800
2000
2200
2400
2600
2800
Reported Heat Input [GJ/hr]

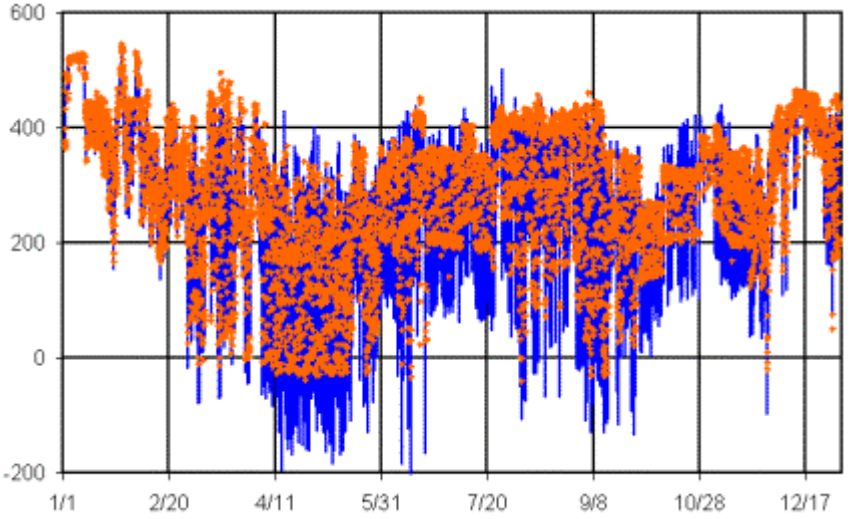

GENERALIZED COMPRESSIBILITY FACTORS
(Zc=0.27)
compressibility factor, z
reduced pressure, P_r
SATURATED
T_r

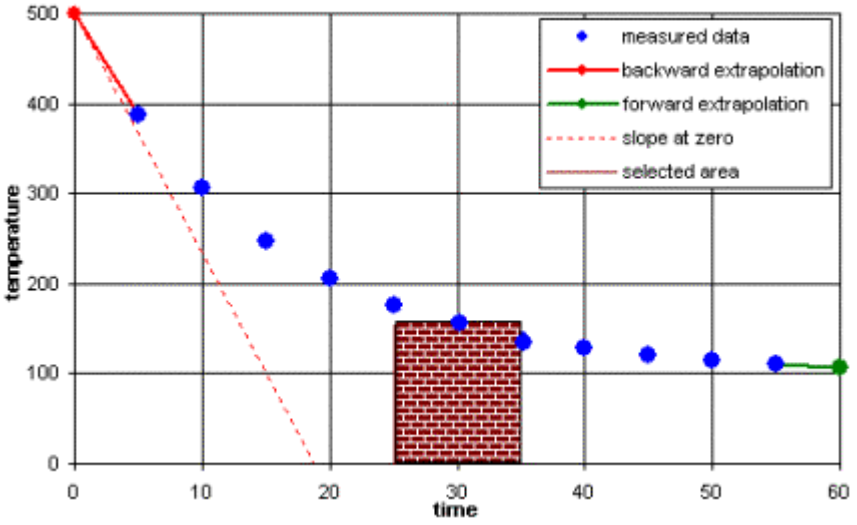

4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Z=PV/RT
0.1
1
10
100
P/Pc

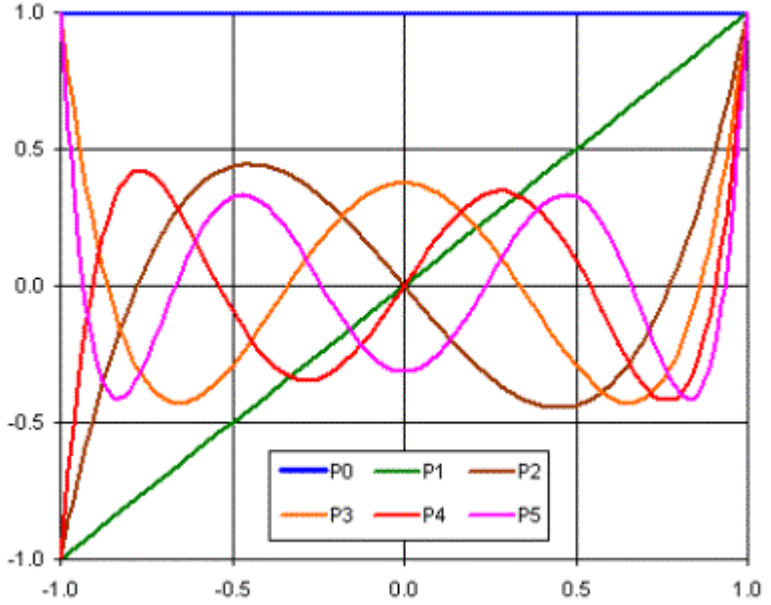

100
10
1
0.1
P/Pc
0.1
1
10
100
1000
V/Vc

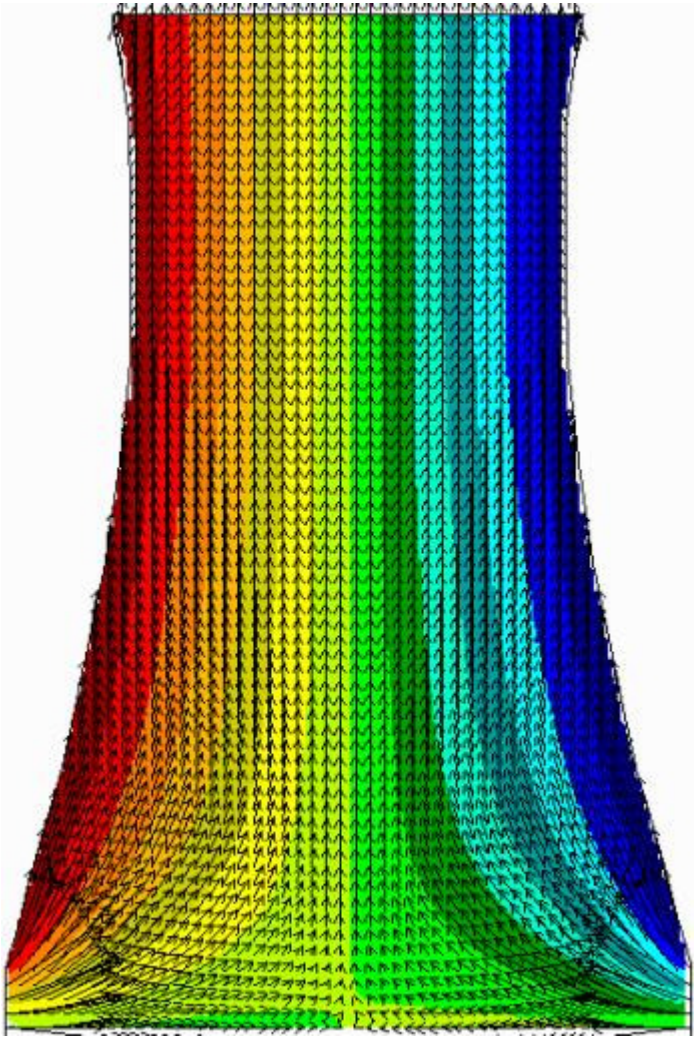

1000
500
100
50
10
0
100
200
300
400
500
600
700
800
η [kg/(s m) X 10⁻⁶]
t(°C)
1000
Sat. liquid
3000 bar
2000
1500
1200
1000
700
600
500
900
800
150
200
450
400
350
225
300
250
200
150
50
1
Sat. vapor


1000
100
10
viscosity
0.0
0.2
0.4
0.6
0.8
1.0
1.2
density


600
400
200
0
-200
1/1
2/20
4/11
5/31
7/20
9/8
10/28
12/17

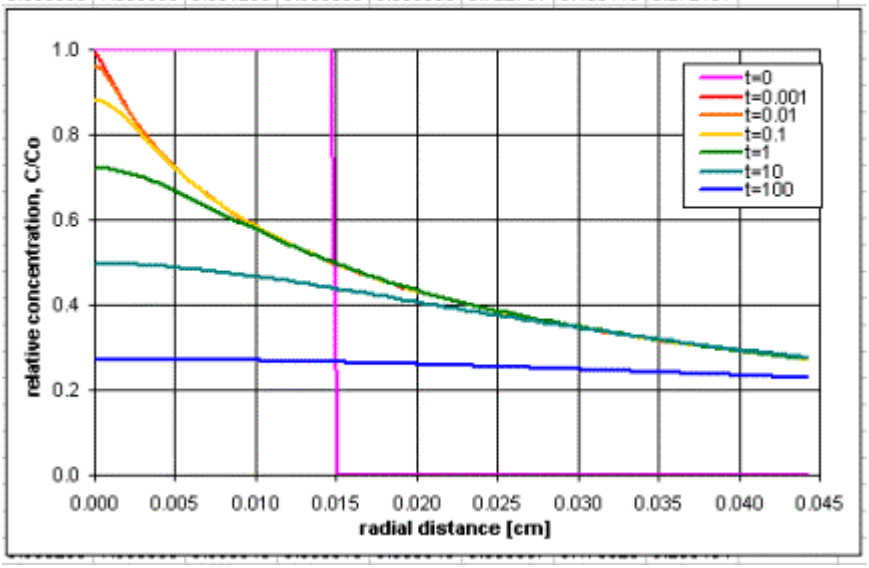

measured data
backward extrapolation
forward extrapolation
slope at zero
selected area
temperature
time
500
400
300
200
100
0
0
10
20
30
40
50
60

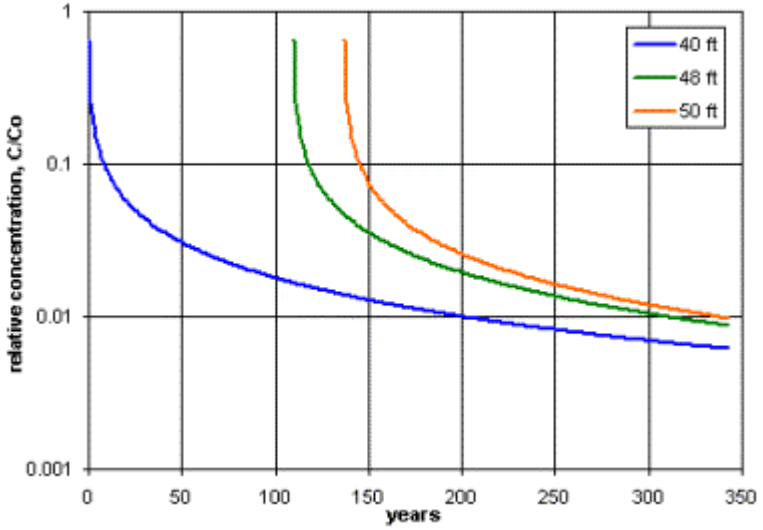

P0
P1
P2
P3
P4
P5
1.0
0.5
0.0
-0.5
-1.0
-1.0
-0.5
0.0
0.5
1.0

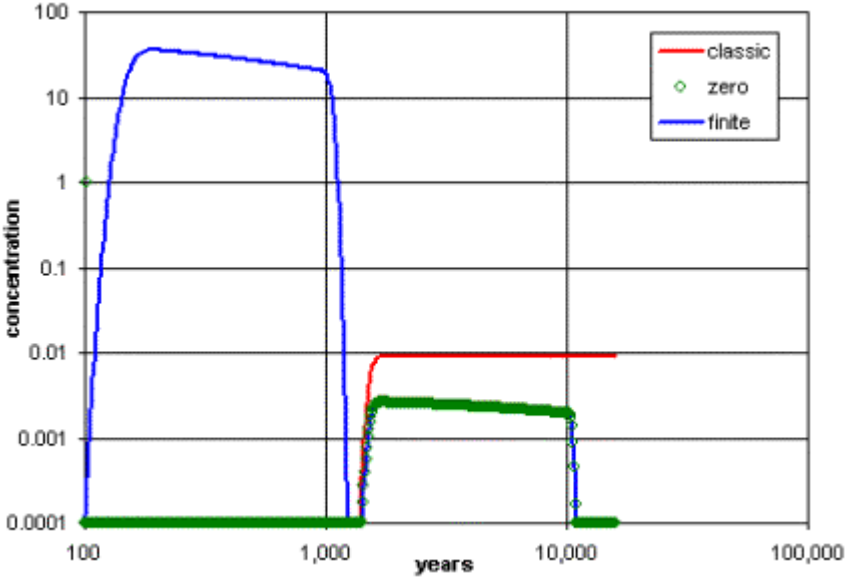


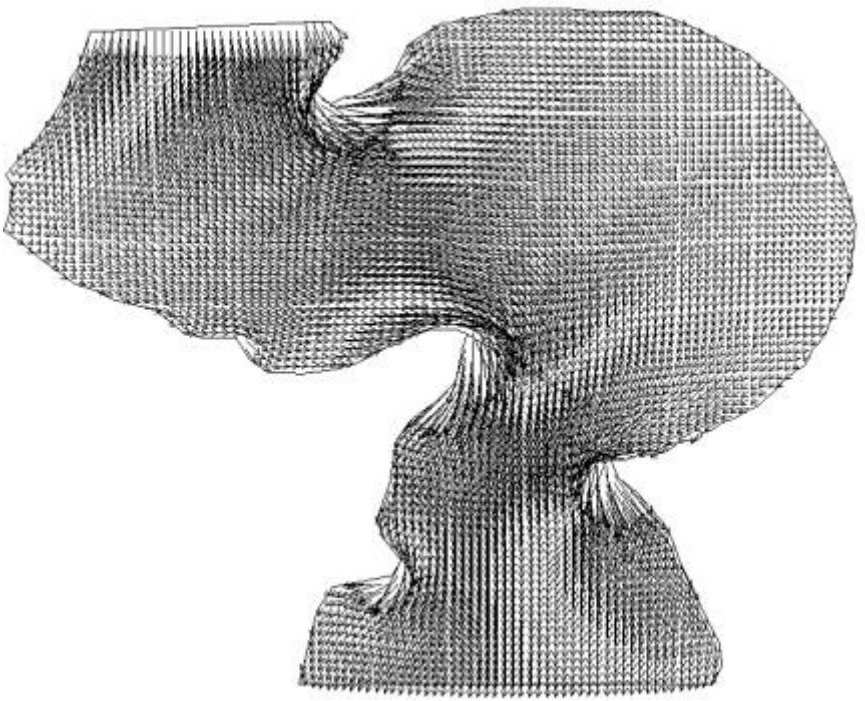
diffusion through a granulated media

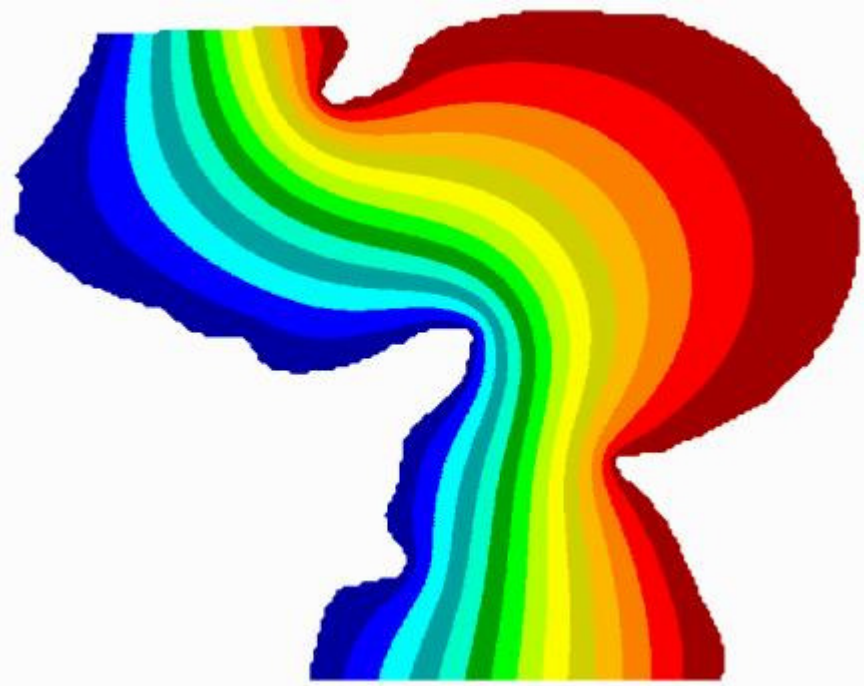
radius	relative concentration, C/Co, at various times						
cm	t=0	t=0.001	t=0.01	t=0.1	t=1	t=10	t=100
0.000000	1.000000	0.991233	0.963563	0.883600	0.722751	0.496415	0.272451

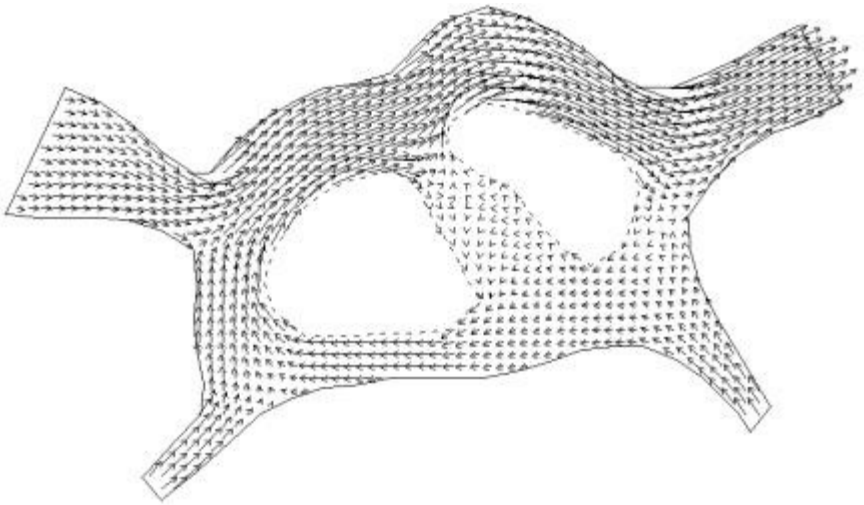


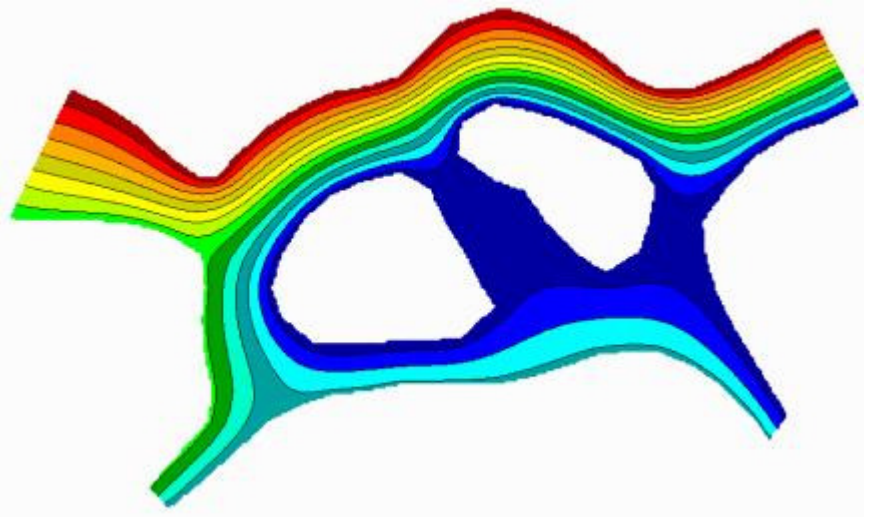


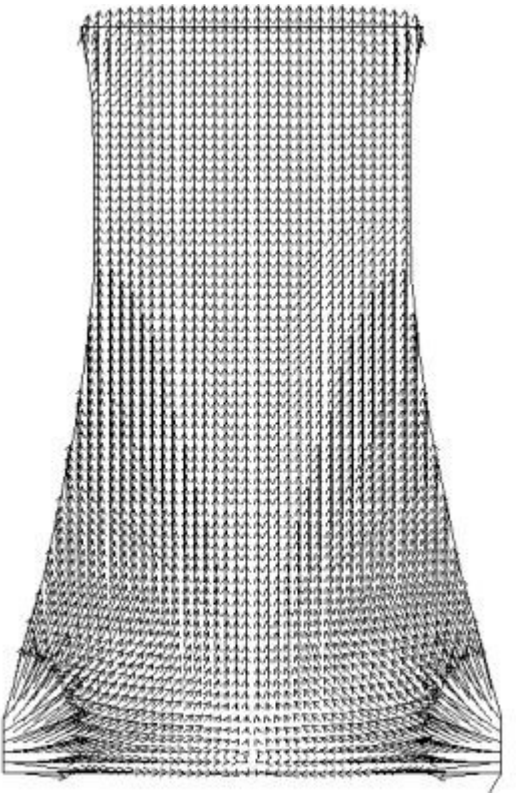

100
10
1
0.1
0.01
0.001
0.0001
concentration
100
1,000
10,000
100,000
years
classic
zero
finite

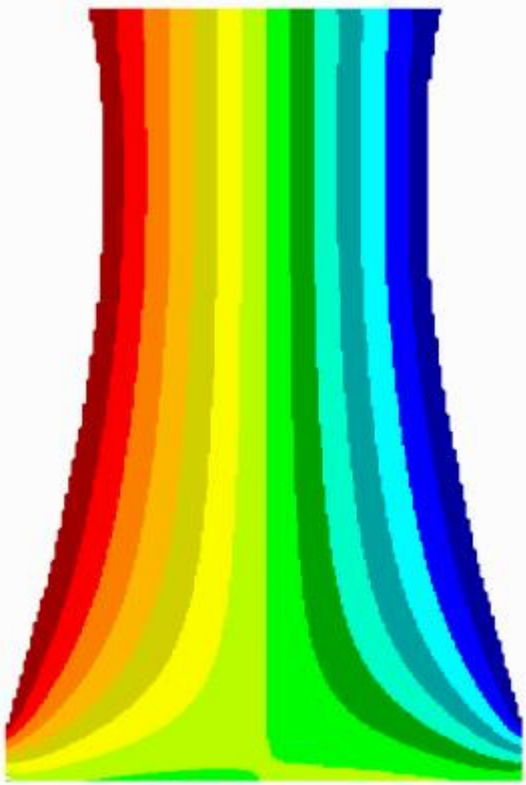


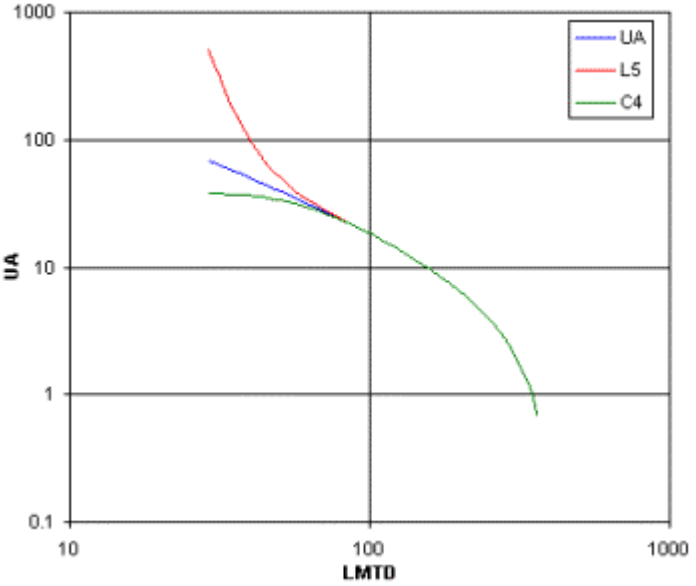


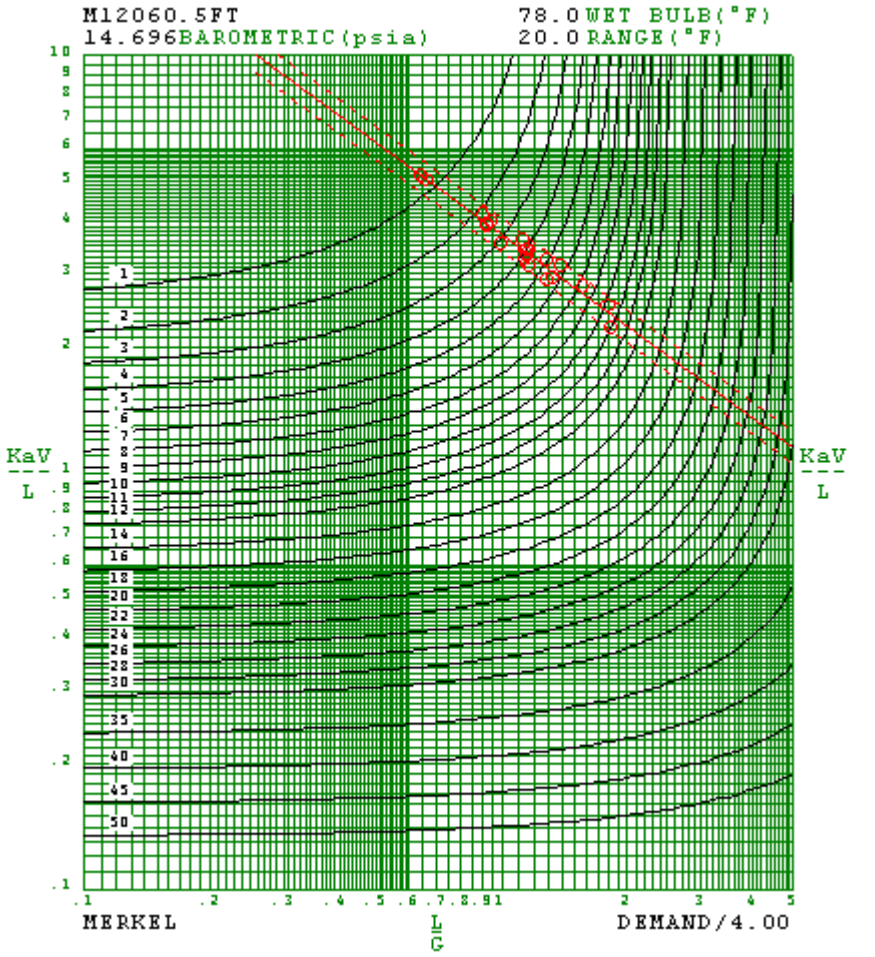


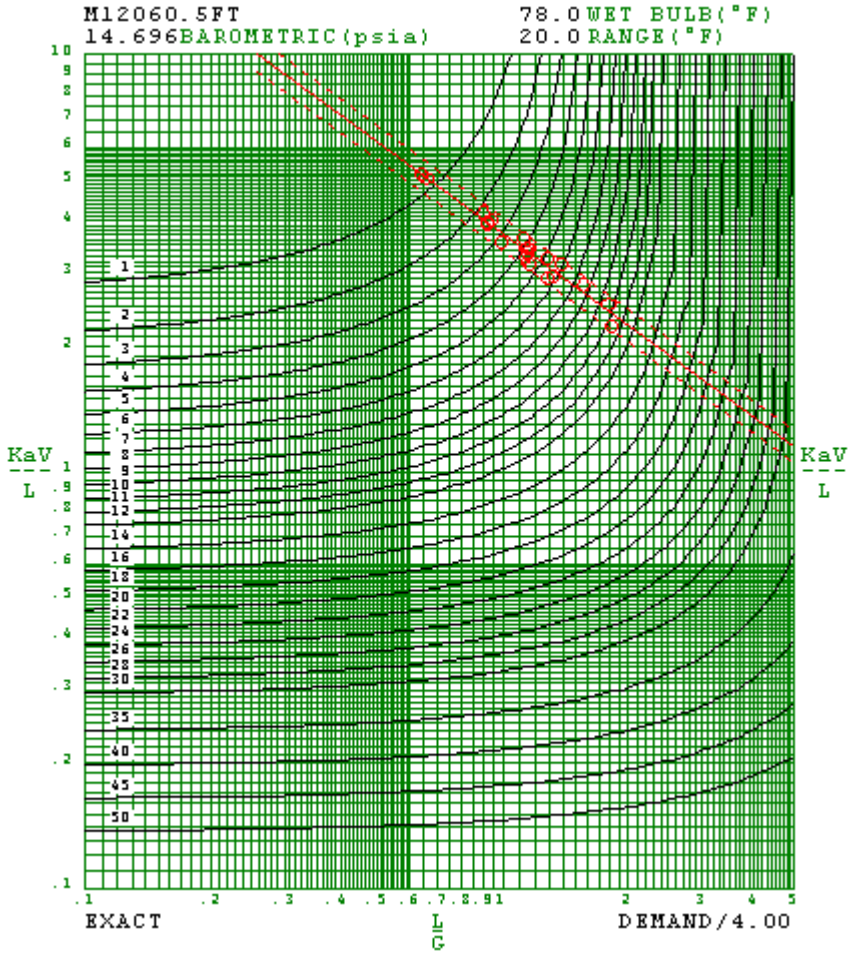


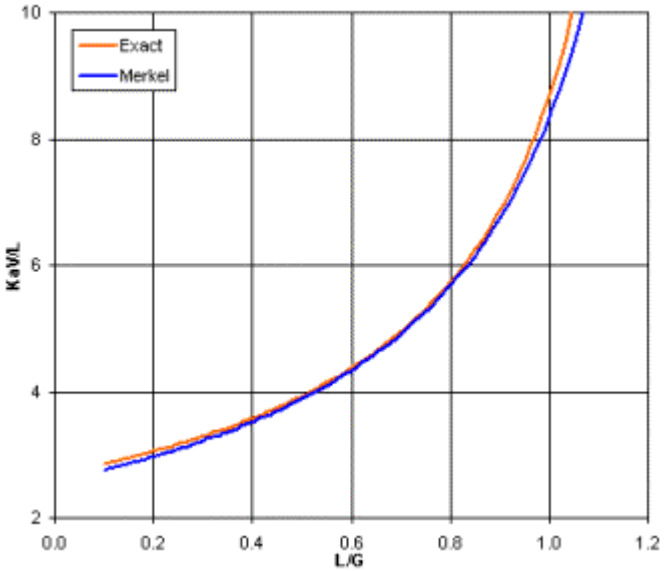


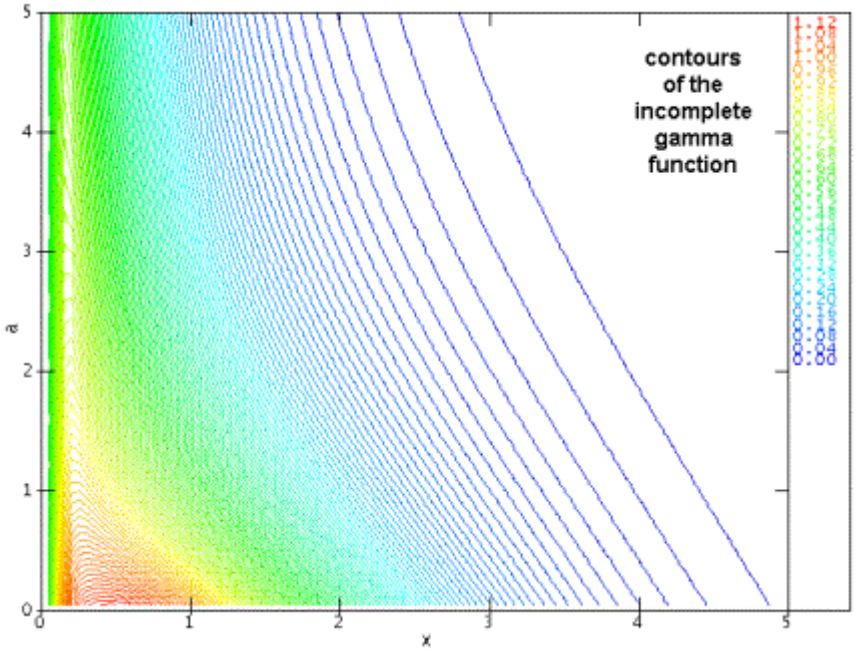


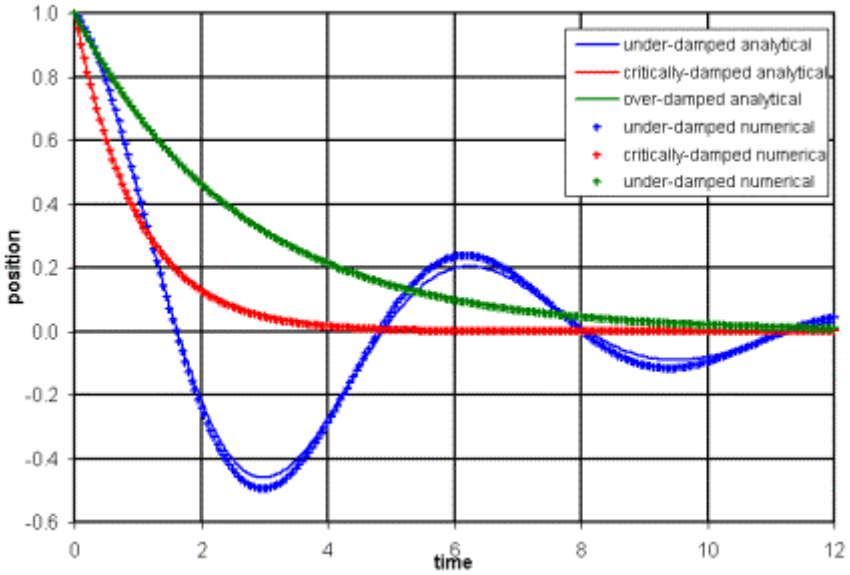

1000
100
10
1
0.1
UA
10
100
1000
LMTD
UA
L5
C4

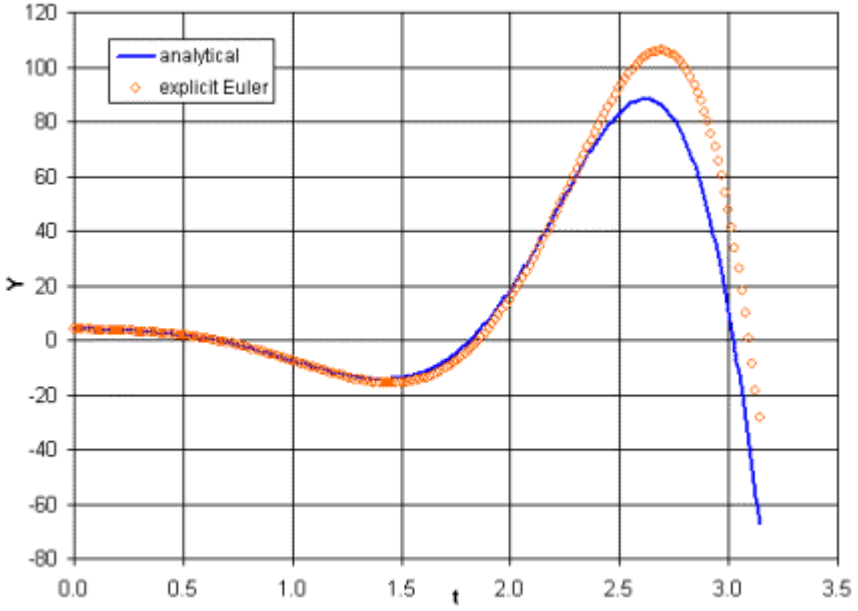

M12060.5FT
78.0 WET BULB(°F)
14.696 BAROMETRIC(psia)
20.0 RANGE(°F)
KaV/L
KaV/L
MERKEL
L/G
DEMAND/4.00

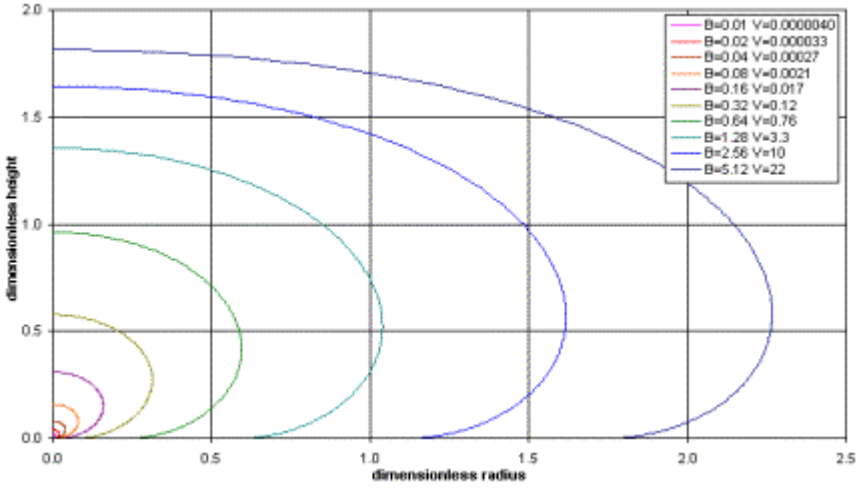

M12060.5FT
14.696BAROMETRIC(psia)
78.0WET BULB(°F)
20.0RANGE(°F)
KaV / L
KaV / L
EXACT
L / G
DEMAND/4.00

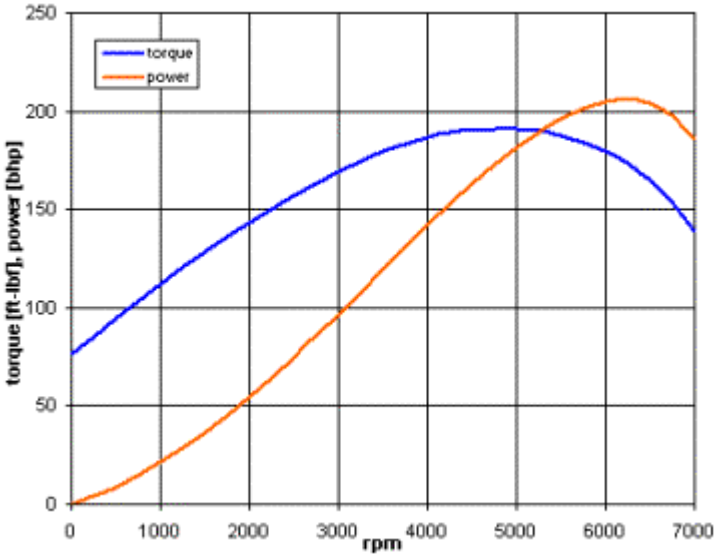

Exact
Merkel
KaV/L
L/G
10
8
6
4
2
0.0
0.2
0.4
0.6
0.8
1.0
1.2

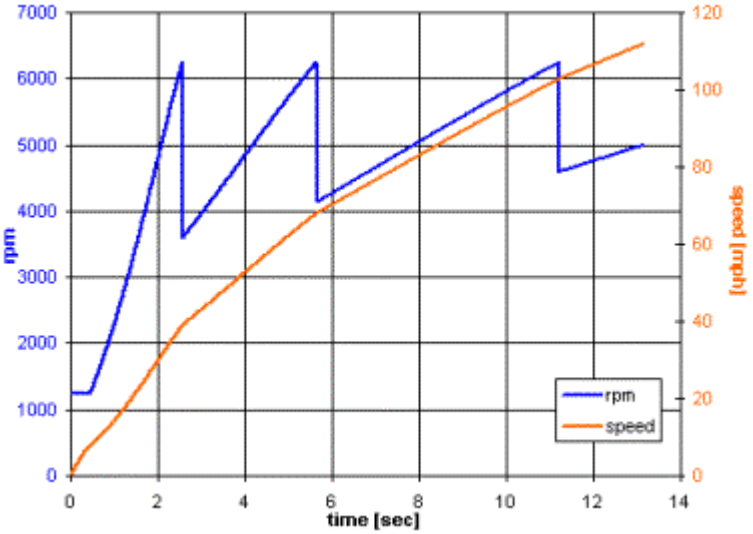

contours
of the
incomplete
gamma
function
a
x
5
4
3
2
1
0
0
1
2
3
4
5

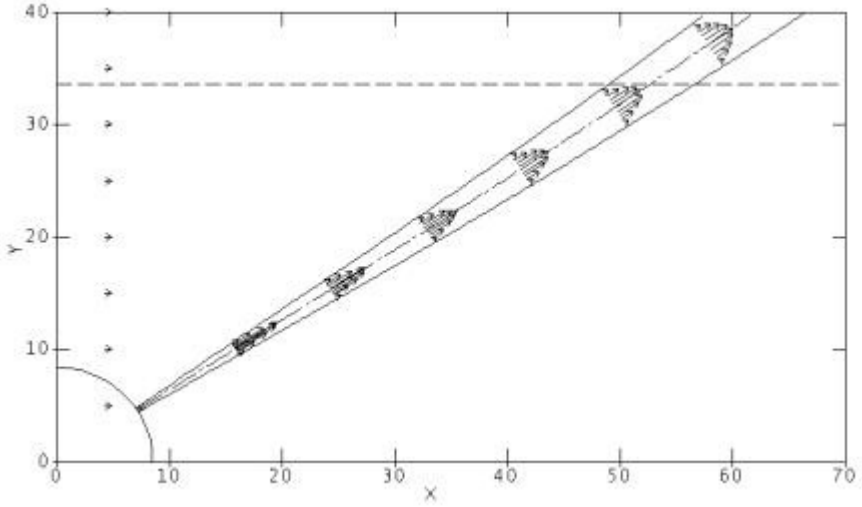

under-damped analytical
critically-damped analytical
over-damped analytical
under-damped numerical
critically-damped numerica
under-damped numerical
position
time
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
2
4
6
8
10
12

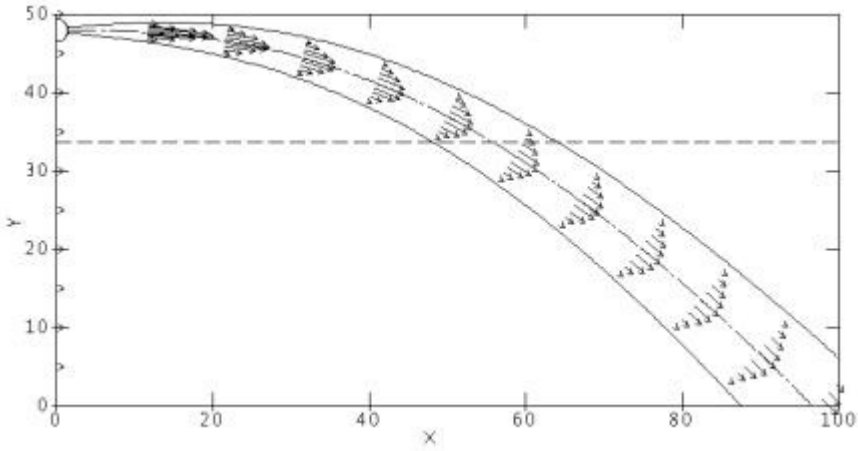

analytical
explicit Euler
Y
t
120
100
80
60
40
20
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

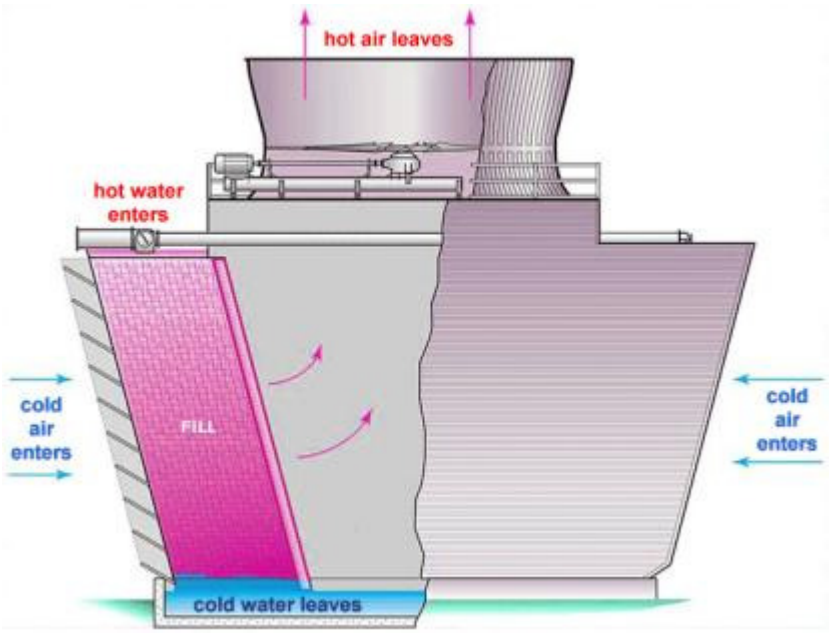

B=0.01 V=0.0000040
B=0.02 V=0.000033
B=0.04 V=0.00027
B=0.08 V=0.0021
B=0.16 V=0.017
B=0.32 V=0.12
B=0.64 V=0.76
B=1.28 V=3.3
B=2.56 V=10
B=5.12 V=22
dimensionless height
dimensionless radius
0.0
0.5
1.0
1.5
2.0
2.5

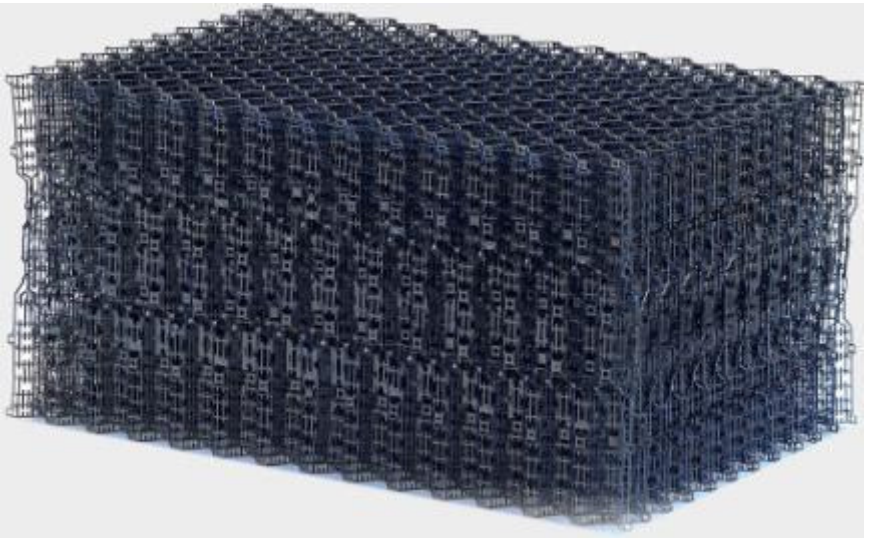

torque
power
torque [ft-lbf], power [bhp]
rpm
0
50
100
150
200
250
0
1000
2000
3000
4000
5000
6000
7000


7000
6000
5000
4000
3000
2000
1000
0
rpm
120
100
80
60
40
20
0
speed [mph]
0
2
4
6
8
10
12
14
time [sec]
rpm
speed

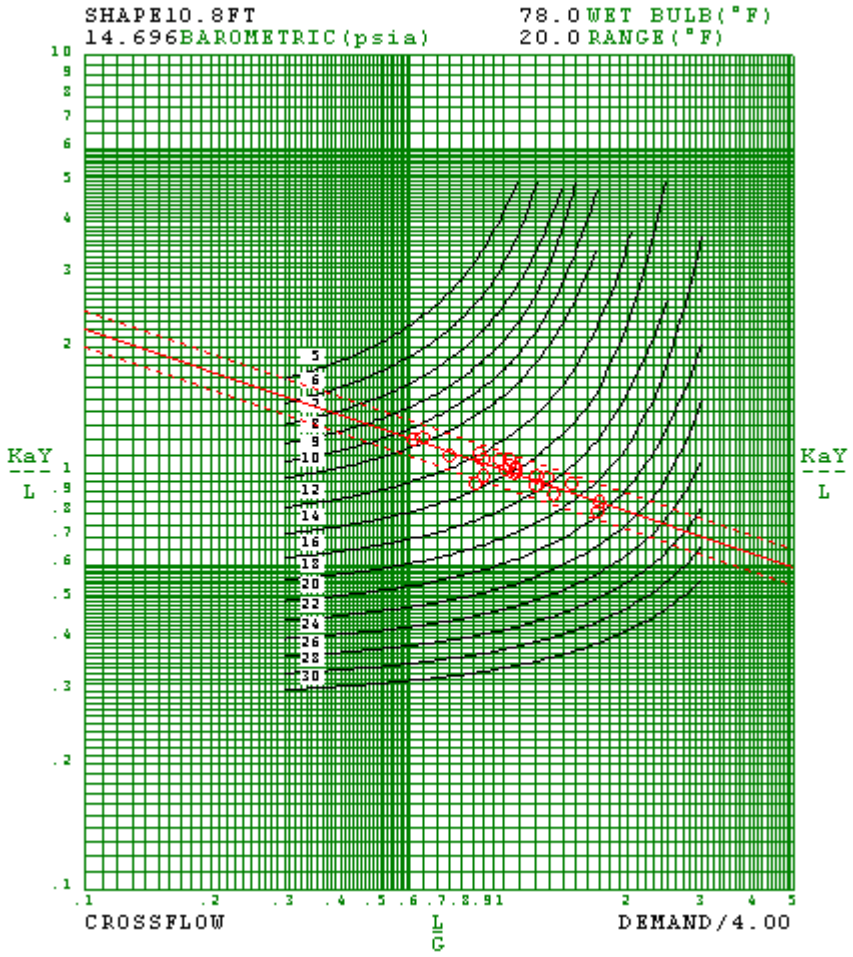

40
30
20
10
0
Y
0
10
20
30
40
50
60
70
X

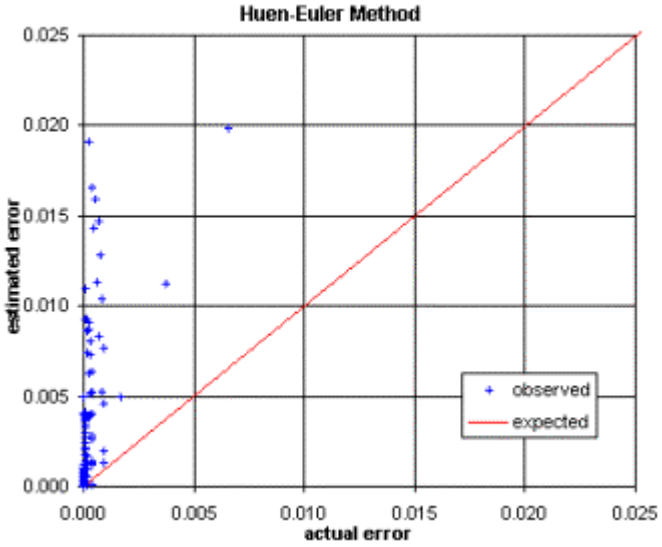

50
40
30
20
10
0
Y
0
20
40
60
80
100
X

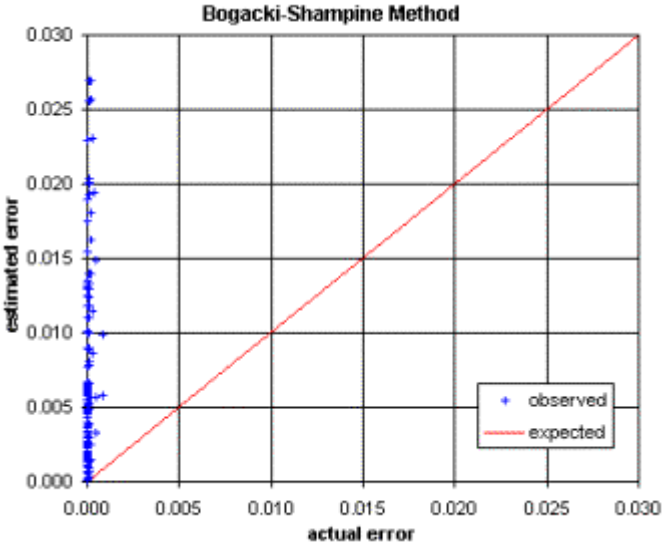

hot air leaves
hot water enters
cold air enters
FILL
cold air enters
cold water leaves

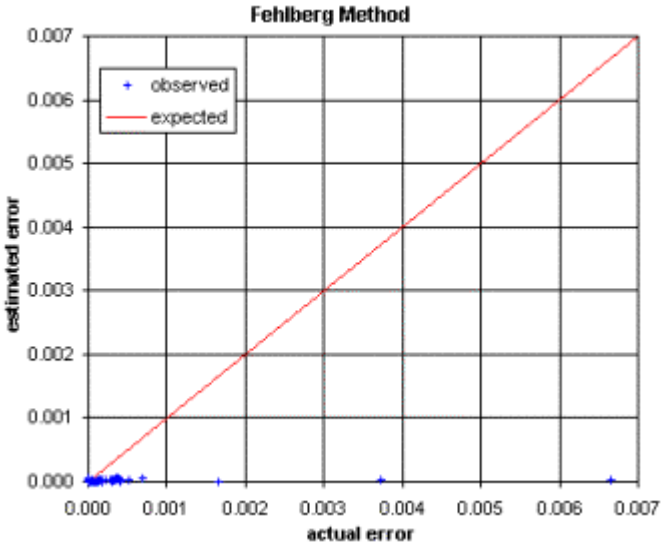


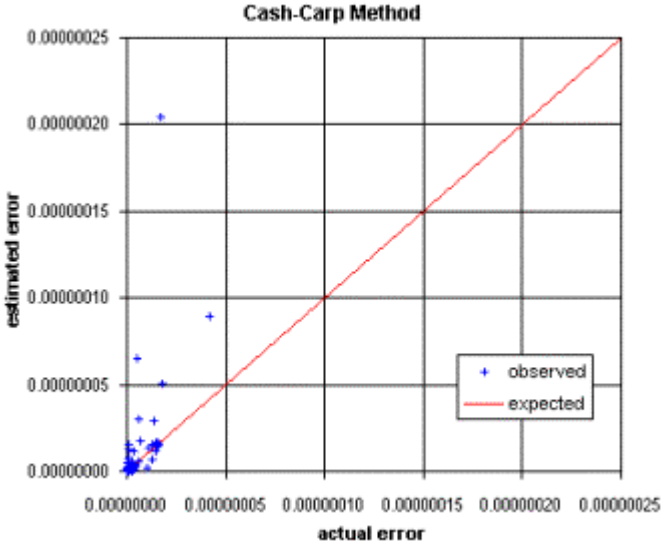
						Tw				
Ta						148	148	148	148	148
78	102	116	124	128	132	115	115	124	130	131
78	92	99	108	115	118	97	104	108	113	121
78	86	92	98	103	108	88	96	99	104	110
78	82	88	92	96	101	84	89	93	98	102
78	80	84	87	91	94	81	85	89	92	97
						11 approach				89
						Hw				
Ha						260.1	260.1	260.1	260.1	260.1
41.6	74.7	107.4	131.5	149.2	165.8	104.7	105.8	132.7	157.3	162.5
41.6	59.3	70.8	86.9	103.7	114.1	66.8	79.0	87.5	100.9	122.9
41.6	50.5	58.7	68.0	77.6	88.2	53.6	64.4	69.2	79.0	93.4
41.6	46.0	52.8	58.6	64.5	73.4	48.0	54.5	59.9	68.0	74.5
41.6	44.0	48.0	51.8	57.5	62.2	45.2	49.3	54.6	59.1	66.2

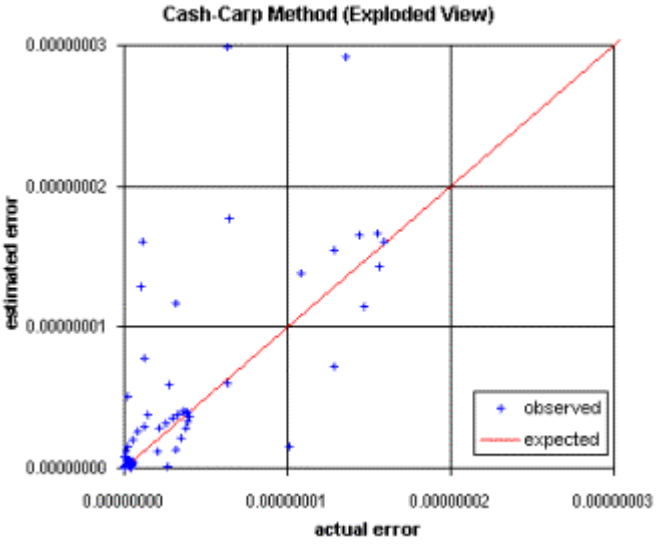

SHAPE10.8FT
14.696BAROMETRIC(psia)
78.0WET BULB(°F)
20.0RANGE(°F)
KaY / L
KaY / L
CROSSFLOW
L / G
DEMAND/4.00


Huen-Euler Method
0.025
0.020
0.015
0.010
0.005
0.000
estimated error
0.000
0.005
0.010
0.015
0.020
0.025
actual error
observed
expected

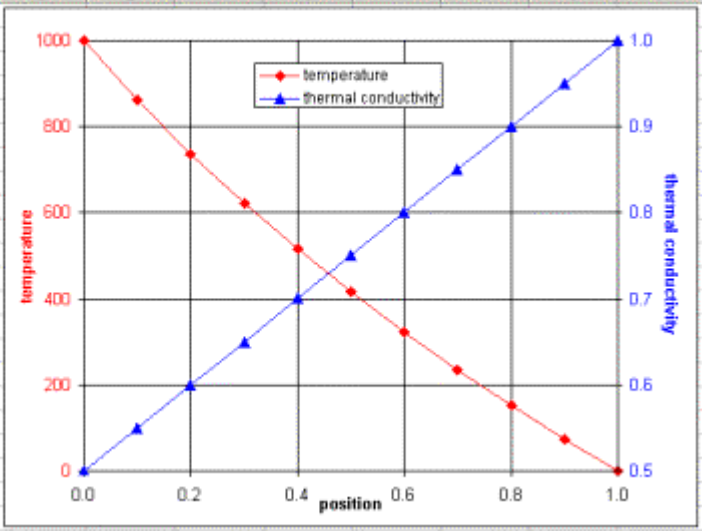

Bogacki-Shampine Method
0.030
0.025
0.020
0.015
0.010
0.005
0.000
estimated error
0.000
0.005
0.010
0.015
0.020
0.025
0.030
actual error
observed
expected


Fehlberg Method
observed
expected
estimated error
actual error
0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007

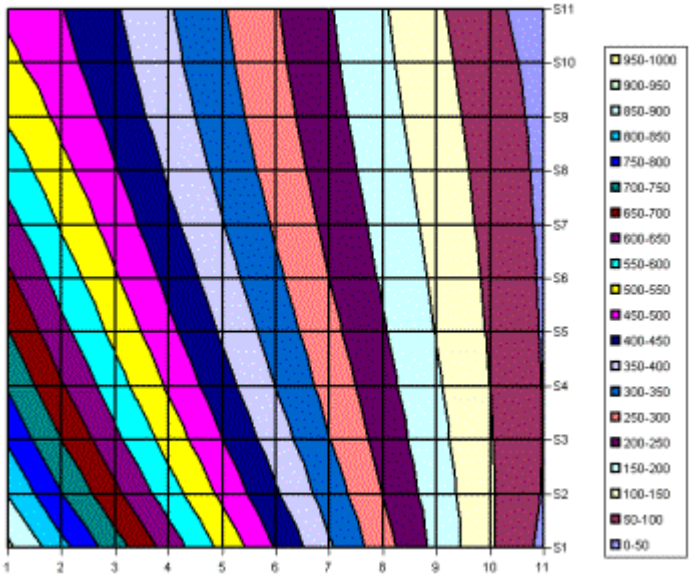

Cash-Carp Method
observed
expected
estimated error
actual error
0.00000000
0.00000005
0.00000010
0.00000015
0.00000020
0.00000025

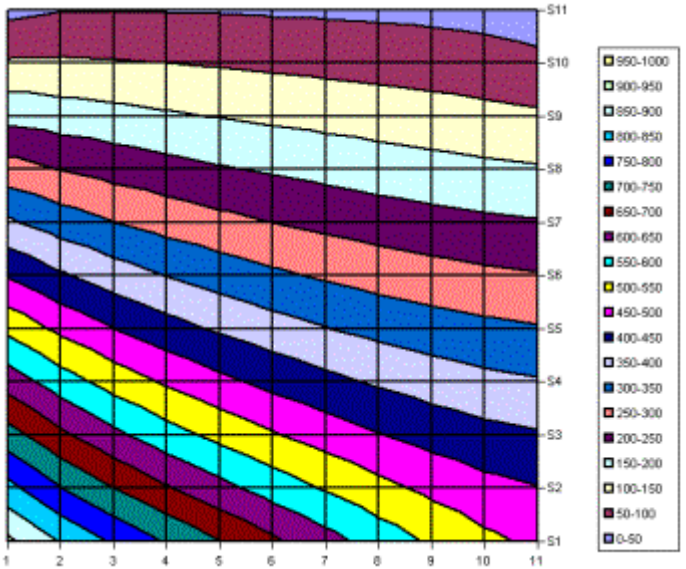


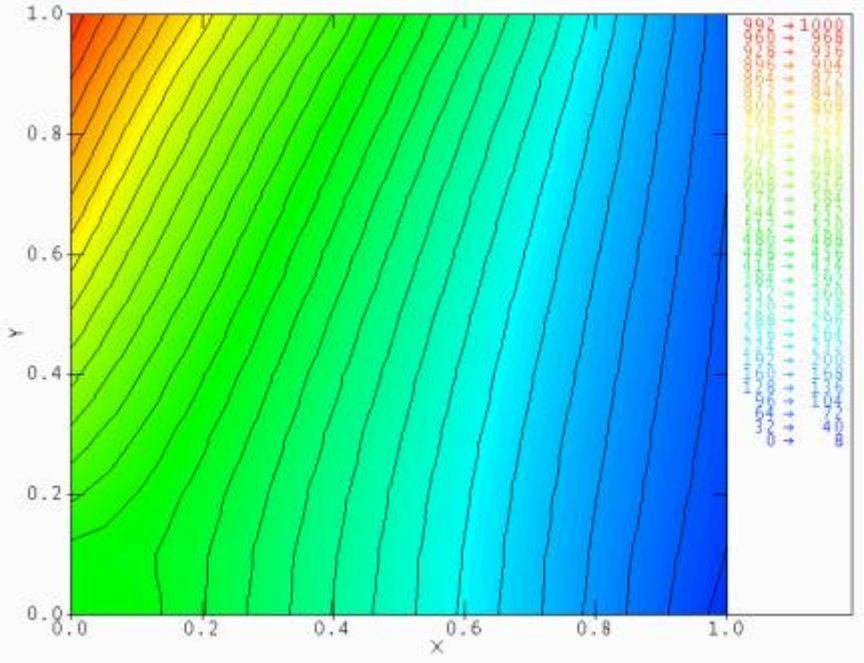
	A	B	C
1	x	T	k
2	0.0	1000	0.50
3	0.1	863	0.55
4	0.2	737	0.60
5	0.3	622	0.65
6	0.4	515	0.70
7	0.5	415	0.75
8	0.6	322	0.80
9	0.7	235	0.85
10	0.8	152	0.90
11	0.9	74	0.95
12	1.0	0	1.00



	A	B	C	D	E	F	G	H	I	J	K	L	M
1						Temperatures							
2		1000	900	800	700	600	500	400	300	200	100	0	
3	1000	911	816	722	629	537	446	357	270	185	105	37	0
4	950	847	751	661	573	489	406	325	248	174	106	47	0
5	900	794	699	612	529	450	374	301	231	165	103	49	0
6	850	746	654	571	493	419	348	281	217	156	99	48	0
7	800	701	614	536	462	393	327	264	204	148	95	46	0
8	750	659	578	505	436	371	309	250	193	140	90	44	0
9	700	618	545	477	413	352	293	237	184	133	86	42	0
10	650	579	514	453	393	335	280	226	175	127	82	39	0
11	600	543	487	432	376	322	269	217	167	120	77	37	0
12	550	511	466	415	363	311	260	209	160	114	71	32	0
13	500	490	452	405	355	304	253	203	154	107	62	23	0
14		500	450	400	350	300	250	200	150	100	50	0	
15						Thermal Conductivities							
16		0.50	0.54	0.57	0.62	0.66	0.71	0.76	0.81	0.87	0.93	1.00	
17	0.50	0.53	0.57	0.61	0.65	0.69	0.73	0.78	0.83	0.88	0.93	0.98	1.00
18	0.52	0.56	0.59	0.63	0.67	0.71	0.75	0.80	0.84	0.89	0.93	0.97	1.00
19	0.54	0.58	0.62	0.65	0.69	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.00
20	0.56	0.60	0.64	0.67	0.71	0.75	0.79	0.82	0.86	0.90	0.93	0.97	1.00
21	0.57	0.62	0.65	0.69	0.73	0.76	0.80	0.83	0.87	0.90	0.94	0.97	1.00
22	0.59	0.63	0.67	0.70	0.74	0.77	0.81	0.84	0.87	0.91	0.94	0.97	1.00
23	0.62	0.65	0.69	0.72	0.75	0.78	0.82	0.85	0.88	0.91	0.94	0.97	1.00
24	0.64	0.67	0.70	0.73	0.76	0.79	0.82	0.86	0.89	0.92	0.95	0.97	1.00
25	0.66	0.69	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.92	0.95	0.98	1.00
26	0.68	0.70	0.72	0.75	0.78	0.81	0.84	0.87	0.90	0.92	0.95	0.98	1.00
27	0.71	0.71	0.73	0.76	0.78	0.81	0.84	0.87	0.90	0.93	0.96	0.98	1.00
28		0.71	0.73	0.76	0.79	0.81	0.84	0.87	0.90	0.93	0.97	1.00	


S11
S10
S9
S8
S7
S6
S5
S4
S3
S2
S1
1
2
3
4
5
6
7
8
9
10
11
950-1000
900-950
850-900
800-850
750-800
700-750
650-700
600-650
550-600
500-550
450-500
400-450
350-400
300-350
250-300
200-250
150-200
100-150
50-100
0-50


S11
S10
S9
S8
S7
S6
S5
S4
S3
S2
S1
1
2
3
4
5
6
7
8
9
10
11
950-1000
900-950
850-900
800-850
750-800
700-750
650-700
600-650
550-600
500-550
450-500
400-450
350-400
300-350
250-300
200-250
150-200
100-150
50-100
0-50

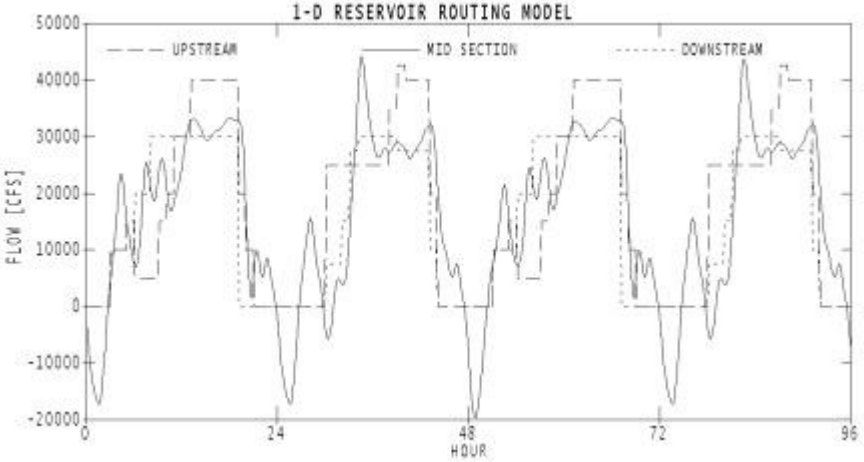


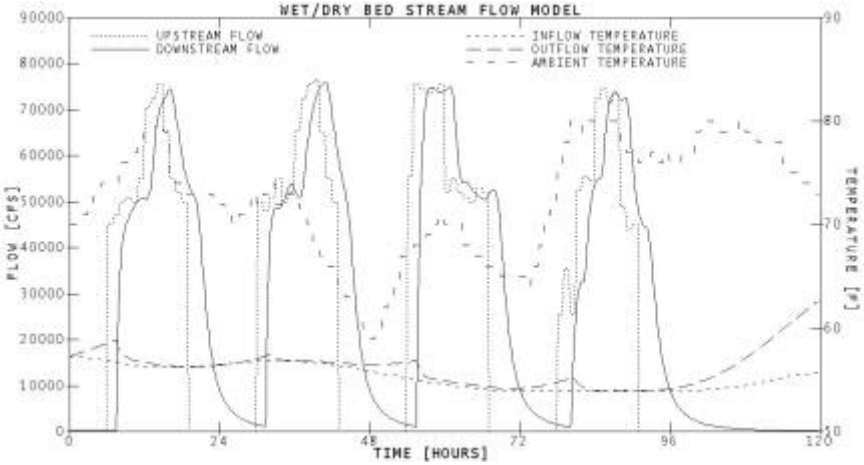
Crank-Nicholson Matrices								properties	
matrix A				matrix B				Δt	1.00
2.0	-0.5	0.0	0.0	0.0	0.5	0.0	0.0	Δx	1.00
-0.5	2.0	-0.5	0.0	0.5	0.0	0.5	0.0	ρ	1.00
0.0	-0.5	2.0	-0.5	0.0	0.5	0.0	0.5	C	1.00
0.0	0.0	-1.0	2.0	0.0	0.0	1.0	0.0	k	1.00
calculated parameter, $\beta=k\Delta t/(\rho C\Delta x^2)$									1.00

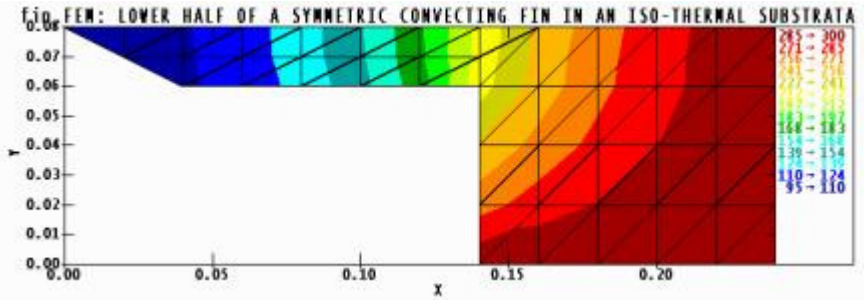
Crank-Nicholson time steps

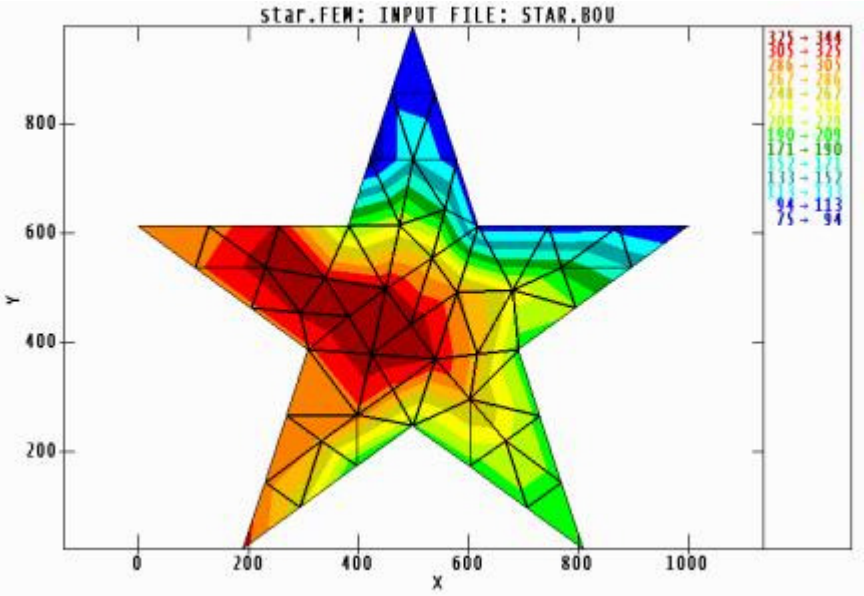
calculated temperatures at each time step

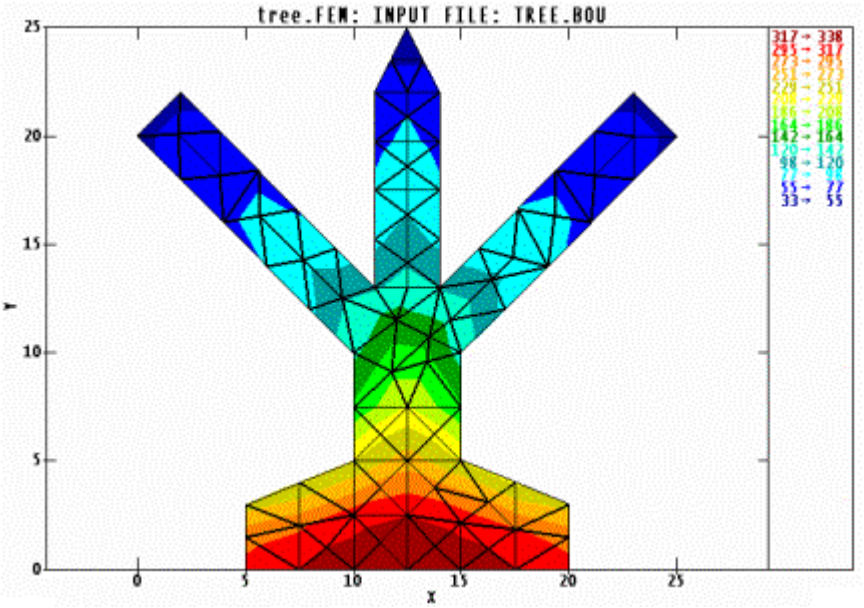
t=0	t=Δt	t=2Δt	t=3Δt	t=4Δt	t=5Δt	t=6Δt	t=7Δt	t=8Δt
100	46.4	38.0	30.8	26.3	22.5	19.3	16.5	14.2
100	85.6	66.3	56.7	48.3	41.5	35.6	30.6	26.2
100	95.9	85.1	73.2	63.1	54.1	46.5	39.9	34.3
100	97.9	90.5	79.1	68.1	58.6	50.3	43.2	37.1

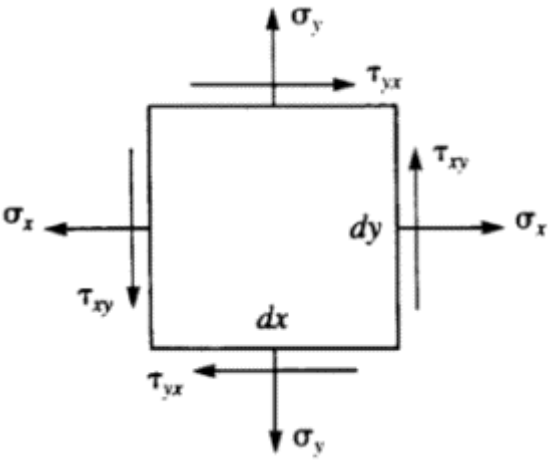

1-D RESERVOIR ROUTING MODEL
UPSTREAM
MID SECTION
DOWNSTREAM
FLOW [CFS]
50000
40000
30000
20000
10000
0
-10000
-20000
0
24
48
72
96
HOUR

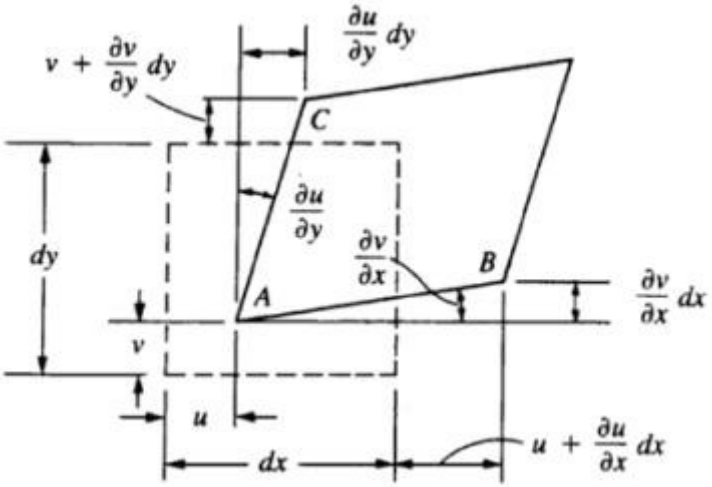

WET/DRY BED STREAM FLOW MODEL
UPSTREAM FLOW
DOWNSTREAM FLOW
INFLOW TEMPERATURE
OUTFLOW TEMPERATURE
AMBIENT TEMPERATURE
FLOW [CFS]
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
TEMPERATURE [F]
90
80
70
60
50
0
24
48
72
96
120
TIME [HOURS]

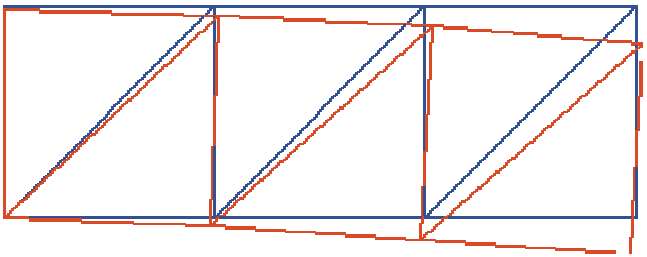

fin.FEM: LOWER HALF OF A SYMMETRIC CONVECTING FIN IN AN ISO-THERMAL SUBSTRATA
Y
X
0.00
0.05
0.10
0.15
0.20
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
285 - 300
271 - 285
256 - 271
241 - 256
227 - 241
212 - 227
198 - 212
184 - 198
169 - 184
154 - 169
139 - 154
125 - 139
110 - 125
95 - 110

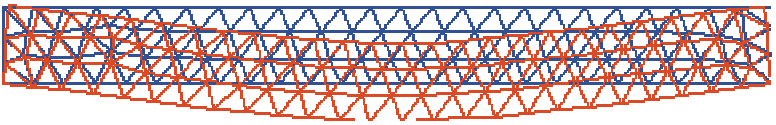

star.FEM: INPUT FILE: STAR.BOU
Y
X
800
600
400
200
0
200
400
600
800
1000
325 - 344
305 - 325
286 - 305
267 - 286
248 - 267
228 - 248
209 - 228
190 - 209
171 - 190
152 - 171
133 - 152
113 - 133
94 - 113
75 - 94

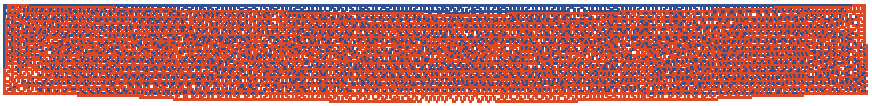

tree.FEM: INPUT FILE: TREE.BOU
317 → 338
295 → 317
273 → 295
251 → 273
229 → 251
207 → 229
186 → 208
164 → 186
142 → 164
120 → 142
98 → 120
77 → 98
55 → 77
33 → 55
Y
X
0
5
10
15
20
25

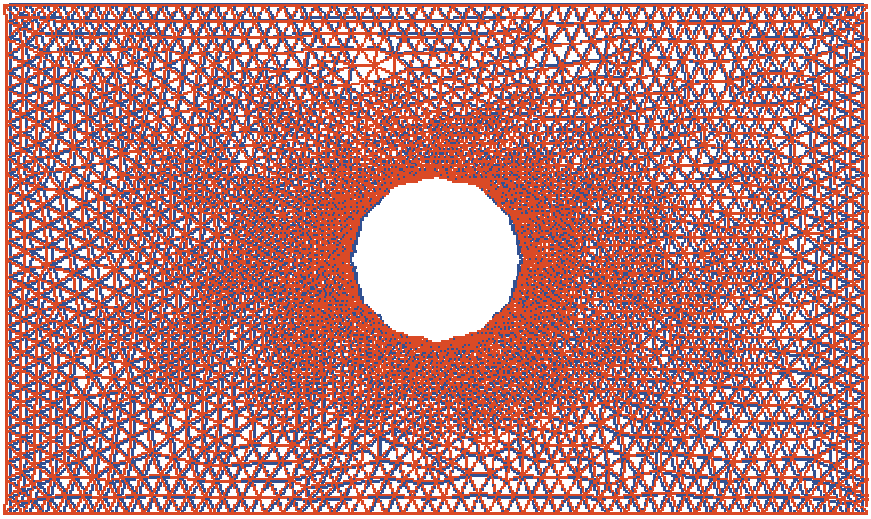

σy
τyx
τxy
σx
dy
σx
τxy
dx
τyx
σy

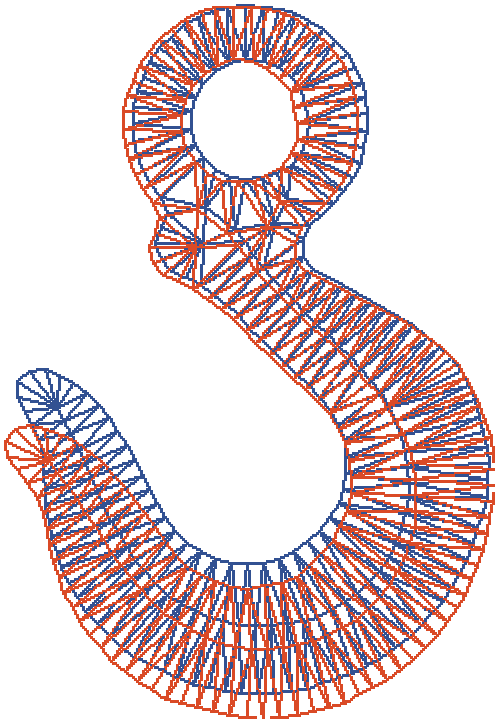

$\frac{\partial u}{\partial y}\,dy$
$v + \frac{\partial v}{\partial y}\,dy$
C
$\frac{\partial u}{\partial y}$
$\frac{\partial v}{\partial x}$
B
A
$\frac{\partial v}{\partial x}\,dx$
dy
v
u
dx
$u + \frac{\partial u}{\partial x}\,dx$

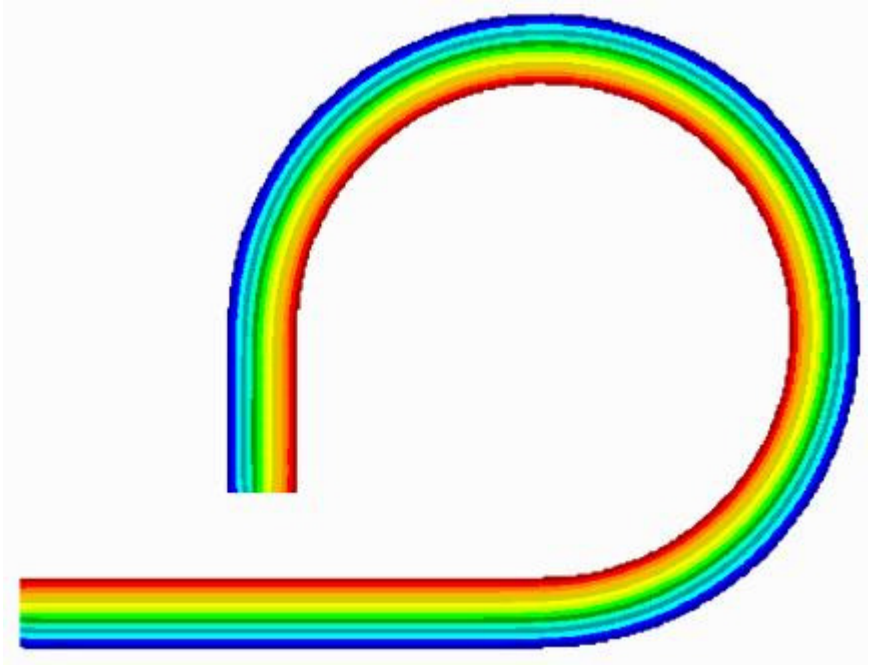


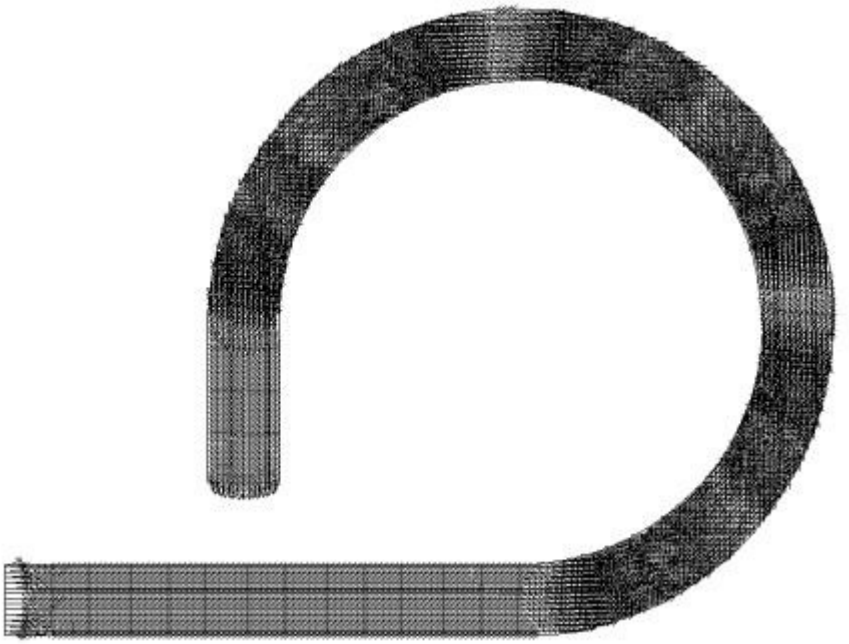


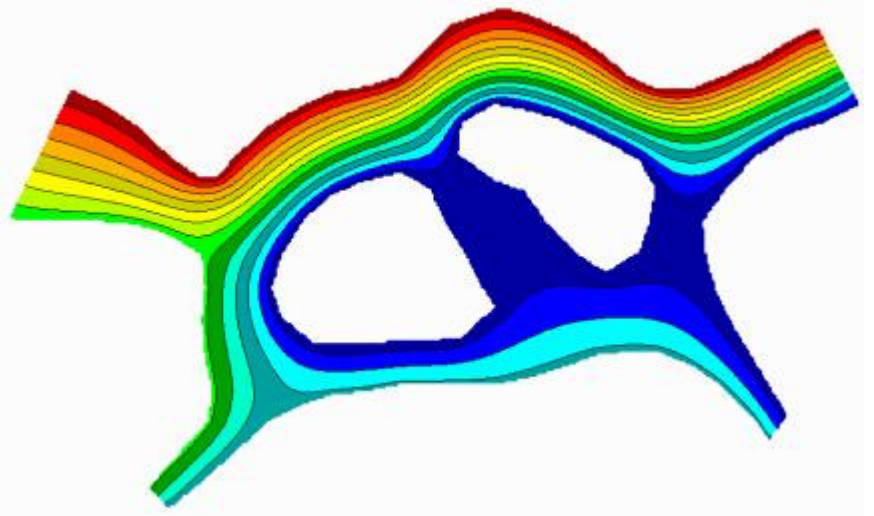


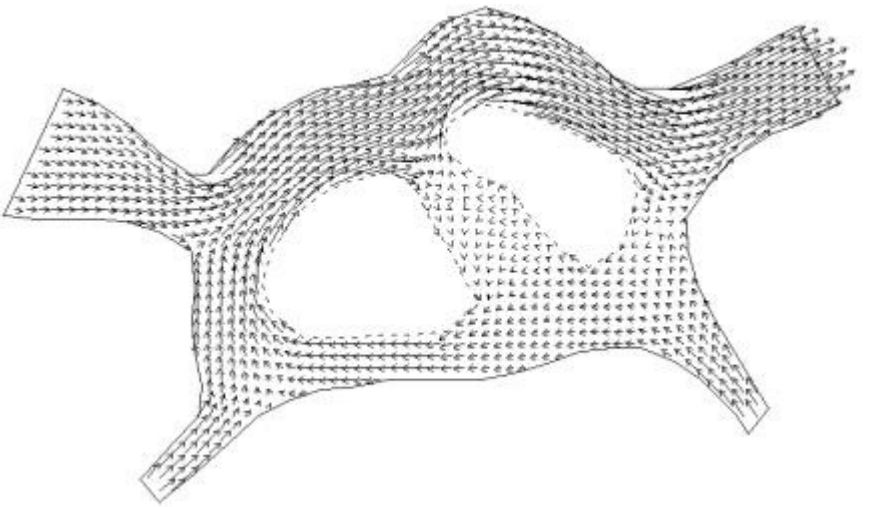


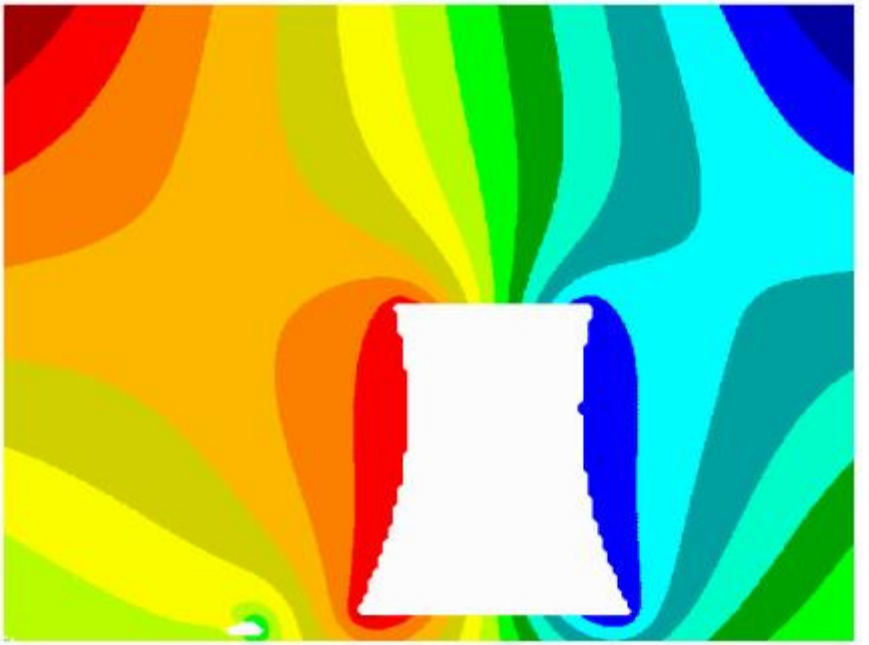


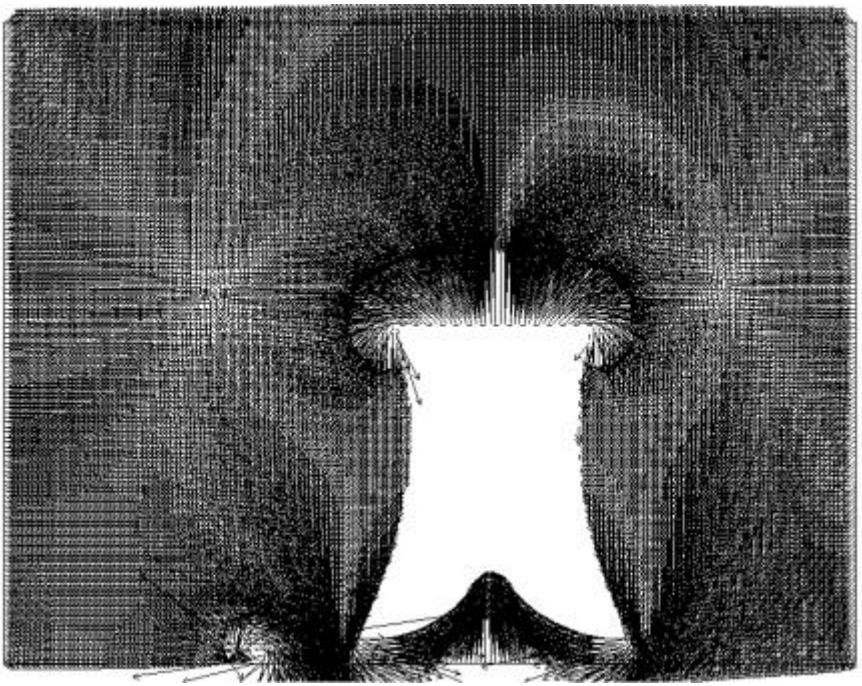


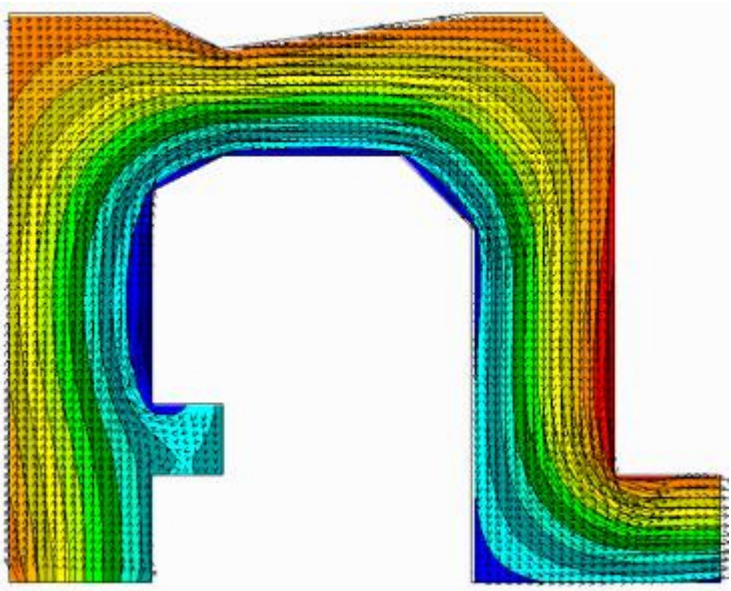


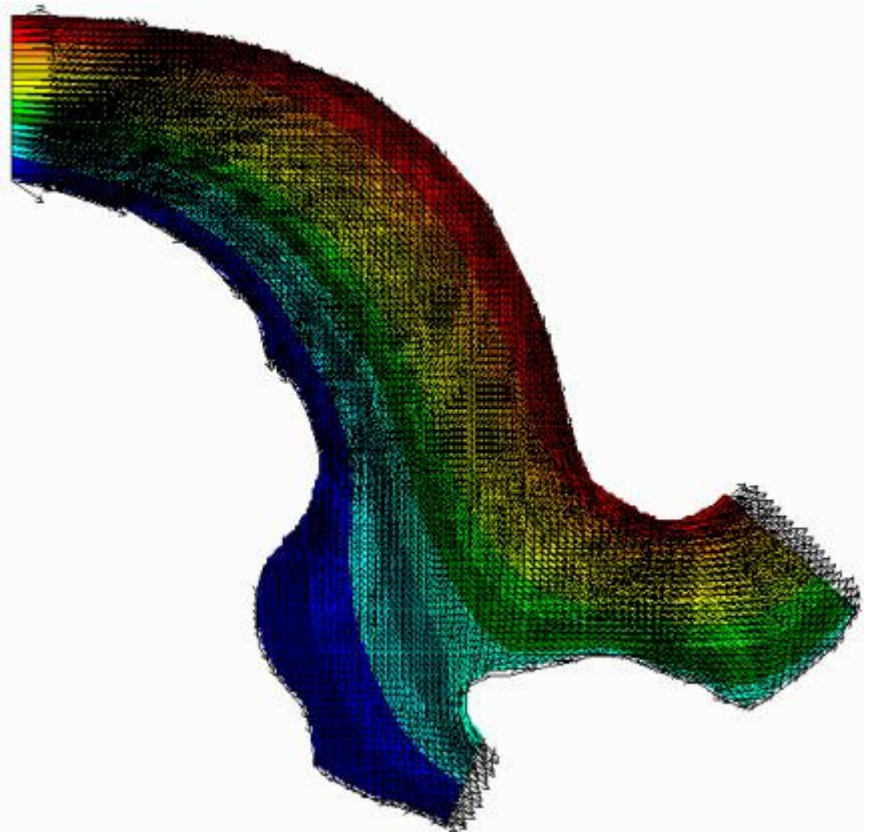




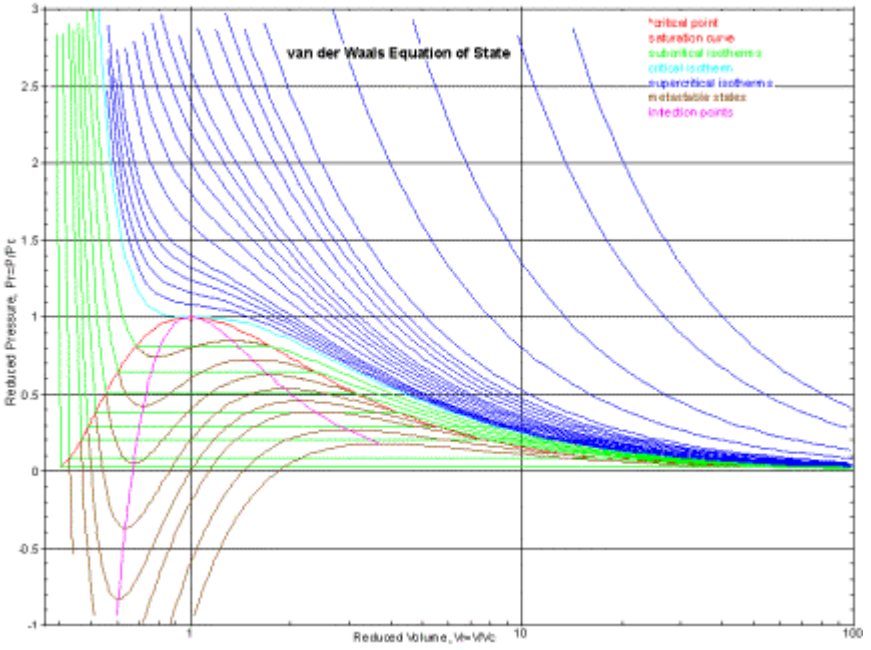


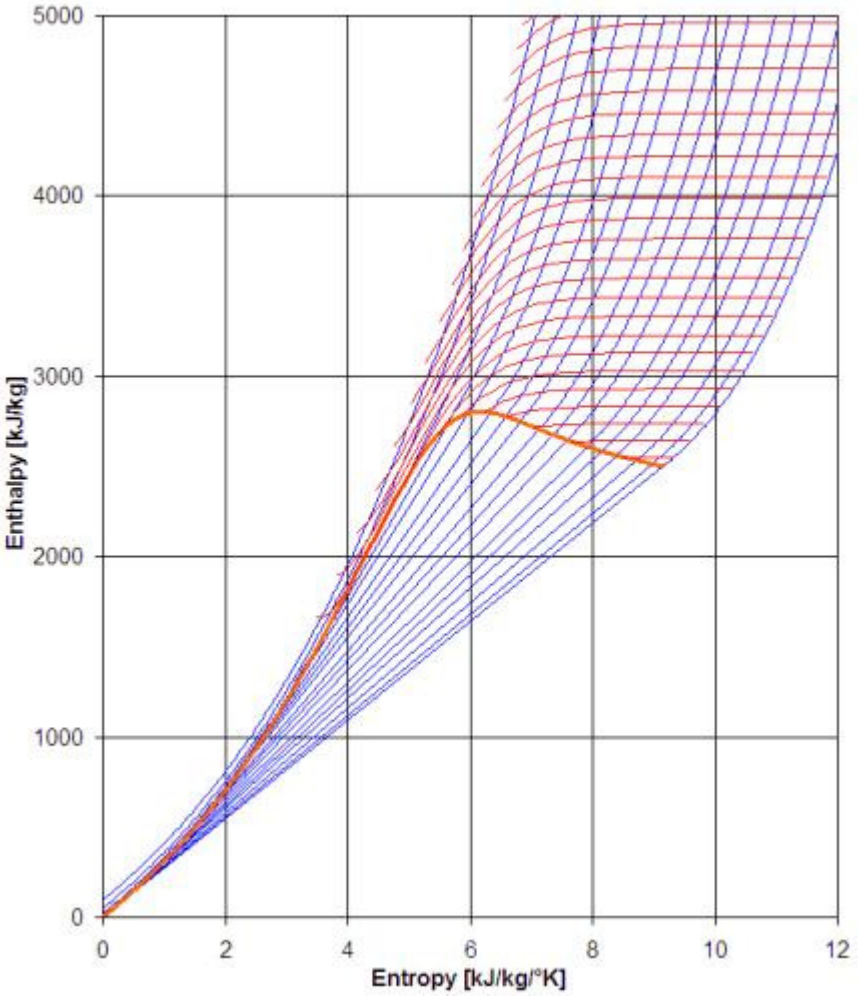






NTRC


van der Waals Equation of State
critical point
saturation curve
subcritical isotherms
critical isotheem
supercritical isotherms
metastable states
inflection points
Reduced Pressure, Pr=P/Pc
Reduced Volume, Vr=V/Vc
3
2.5
2
1.5
1
0.5
0
-0.5
-1
1
10
100


5000
4000
3000
2000
1000
0
Enthalpy [kJ/kg]
0
2
4
6
8
10
12
Entropy [kJ/kg/°K]