Interesting Macro（Excel）

2024.1.14
Sohun

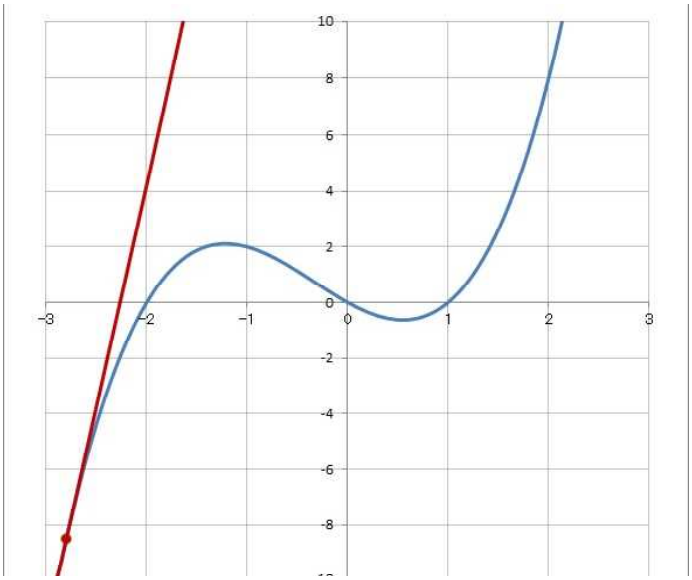
1　Moving tangent on graphs of cubic functions

（１）Experiment overview

The simulation will be performed using the spreadsheet software "Excel".
Draw a graph of the cubic function $y=x^3+x^2-2x$ on the xy-coordinate plane.
Observe how the tangent line changes as the x-coordinate of the tangent changes.
Similar observations can be made more easily using graph drawing software such as "Grapes".
However , there is something interesting about drawing in "Excel" , which everyone owns and uses frequently on a daily basis. Use "Excel" macro（VBA）.

（２）Experimental result（**Excel version simulation**）

【Experiment day】
January 14 , 2024
【PC used】
Lavie LS150/F
【Excel used】
Excel 2010
【Macro used(VBA)】
Self-made file
『movingtangent.xlsm
(Excel version)』
【Remarks】
The state of the tangent line was observed as the x-coordinate of the contact point changed from -2.8 to 2.1 in 0.01 increments.

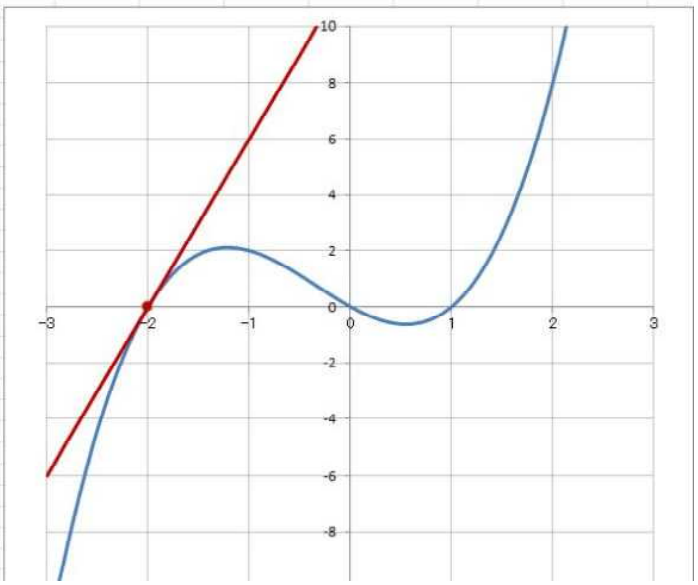


① When the x-coordinate of the contact point is -2.0

x	$y=x^3+x^2-2x$	$y=(3t^2+2t-2)x-2t^3-t^2$
-3	-12	-6
-2.9	-10.179	-5.4
-2.8	-8.512	-4.8
-2.7	-6.993	-4.2
-2.6	-5.616	-3.6
-2.5	-4.375	-3
-2.4	-3.264	-2.4
-2.3	-2.277	-1.8
-2.2	-1.408	-1.2
-2.1	-0.651	-0.6
-2	0	0
-1.9	0.551	0.6
-1.8	1.008	1.2
-1.7	1.377	1.8
-1.6	1.664	2.4
-1.5	1.875	3
-1.4	2.016	3.6
-1.3	2.093	4.2
-1.2	2.112	4.8
-1.1	2.079	5.4
-1	2	6
-0.9	1.881	6.6
-0.8	1.728	7.2
-0.7	1.547	7.8
-0.6	1.344	8.4
-0.5	1.125	9
-0.4	0.896	9.6

Contact(-2 0)

Button to move tangent line



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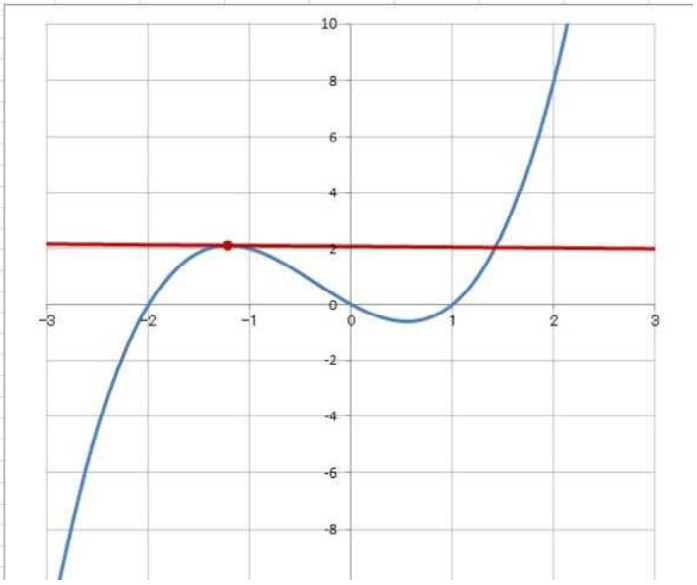
（２）Experimental result（**Excel version simulation**）

② When the x-coordinate of the contact point is -1.21

x	$y=x^3+x^2-2x$	$y=(3t^2+2t-2)x-2t^3-t^2$
-3	-12	2.162122
-2.9	-10.179	2.159352
-2.8	-8.512	2.156582
-2.7	-6.993	2.153812
-2.6	-5.616	2.151042
-2.5	-4.375	2.148272
-2.4	-3.264	2.145502
-2.3	-2.277	2.142732
-2.2	-1.408	2.139962
-2.1	-0.651	2.137192
-2	0	2.134422
-1.9	0.551	2.131652
-1.8	1.008	2.128882
-1.7	1.377	2.126112
-1.6	1.664	2.123342
-1.5	1.875	2.120572
-1.4	2.016	2.117802
-1.3	2.093	2.115032
-1.2	2.112	2.112262
-1.1	2.079	2.109492
-1	2	2.106722
-0.9	1.881	2.103952
-0.8	1.728	2.101182
-0.7	1.547	2.098412
-0.6	1.344	2.095642
-0.5	1.125	2.092872

Contact(-1.21　2.112539)

Button to move tangent line

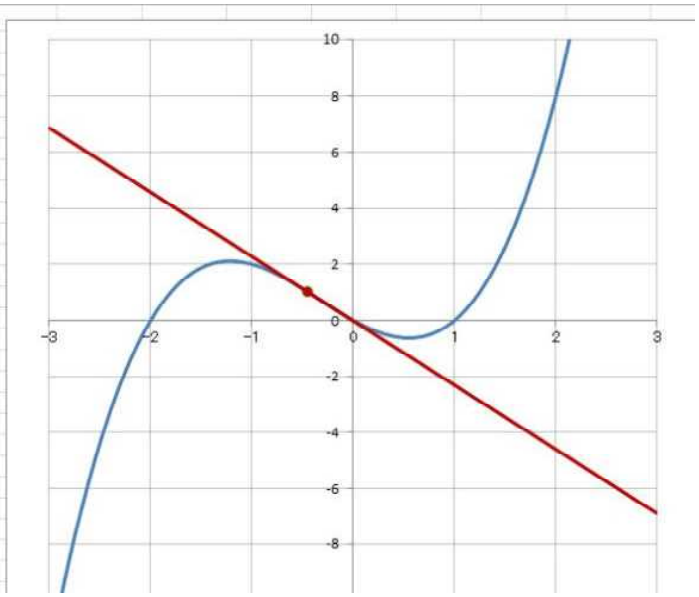


③ When the x-coordinate of the contact point is -0.45

x	$y=x^3+x^2-2x$	$y=(3t^2+2t-2)x-2t^3-t^2$
-3	-12	6.85725
-2.9	-10.179	6.628
-2.8	-8.512	6.39875
-2.7	-6.993	6.1695
-2.6	-5.616	5.94025
-2.5	-4.375	5.711
-2.4	-3.264	5.48175
-2.3	-2.277	5.2525
-2.2	-1.408	5.02325
-2.1	-0.651	4.794
-2	0	4.56475
-1.9	0.551	4.3355
-1.8	1.008	4.10625
-1.7	1.377	3.877
-1.6	1.664	3.64775
-1.5	1.875	3.4185
-1.4	2.016	3.18925
-1.3	2.093	2.96
-1.2	2.112	2.73075
-1.1	2.079	2.5015
-1	2	2.27225
-0.9	1.881	2.043
-0.8	1.728	1.81375
-0.7	1.547	1.5845
-0.6	1.344	1.35525
-0.5	1.125	1.126

Contact(-0.45　1.011375)

Button to move tangent line



Interesting Macro（Excel）

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1　Moving tangent on graphs of cubic functions

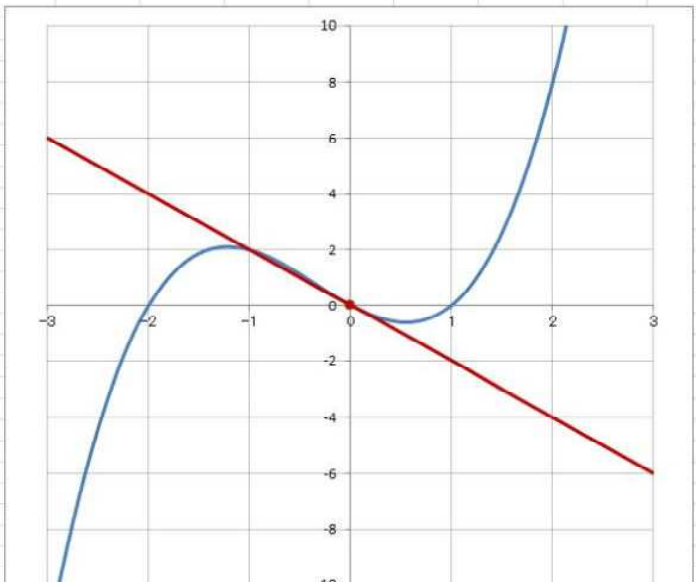
（２）Experimental result（Excel version simulation）

④ When the x-coordinate of the contact point is 0.0

x	$y=x^3+x^2-2x$	$y=(3t^2+2t-2)x-2t^3-t^2$
-3	-12	6
-2.9	-10.179	5.8
-2.8	-8.512	5.6
-2.7	-6.993	5.4
-2.6	-5.616	5.2
-2.5	-4.375	5
-2.4	-3.264	4.8
-2.3	-2.277	4.6
-2.2	-1.408	4.4
-2.1	-0.651	4.2
-2	0	4
-1.9	0.551	3.8
-1.8	1.008	3.6
-1.7	1.377	3.4
-1.6	1.664	3.2
-1.5	1.875	3
-1.4	2.016	2.8
-1.3	2.093	2.6
-1.2	2.112	2.4
-1.1	2.079	2.2
-1	2	2
-0.9	1.881	1.8
-0.8	1.728	1.6
-0.7	1.547	1.4
-0.6	1.344	1.2
-0.5	1.125	1
-0.4	0.896	0.8

Contact(0 0)

Button to move tangent line

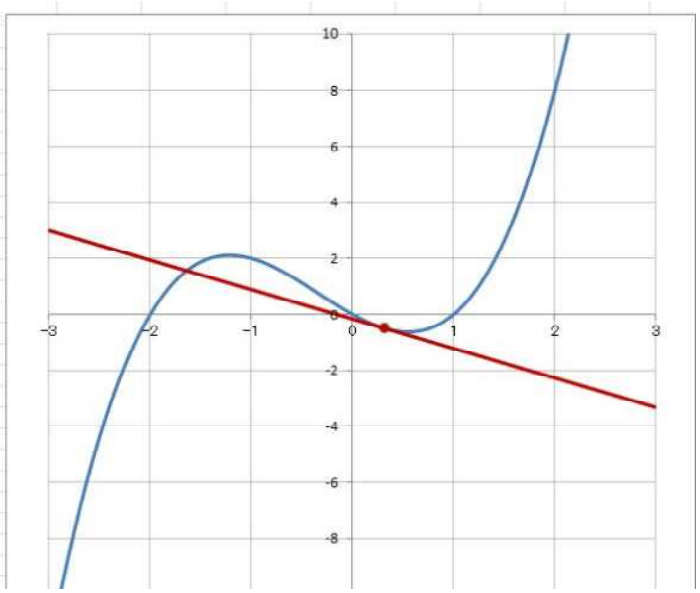


⑤ When the x-coordinate of the contact point is 0.32

x	$y=x^3+x^2-2x$	$y=(3t^2+2t-2)x-2t^3-t^2$
-3	-12	2.990464
-2.9	-10.179	2.885184
-2.8	-8.512	2.779904
-2.7	-6.993	2.674624
-2.6	-5.616	2.569344
-2.5	-4.375	2.464064
-2.4	-3.264	2.358784
-2.3	-2.277	2.253504
-2.2	-1.408	2.148224
-2.1	-0.651	2.042944
-2	0	1.937664
-1.9	0.551	1.832384
-1.8	1.008	1.727104
-1.7	1.377	1.621824
-1.6	1.664	1.516544
-1.5	1.875	1.411264
-1.4	2.016	1.305984
-1.3	2.093	1.200704
-1.2	2.112	1.095424
-1.1	2.079	0.990144
-1	2	0.884864
-0.9	1.881	0.779584
-0.8	1.728	0.674304
-0.7	1.547	0.569024
-0.6	1.344	0.463744
-0.5	1.125	0.358464
-0.4	0.896	0.253184

Contact(0.32 -0.504832)

Button to move tangent line



Interesting Macro（Excel）

2024.1.14
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1　Moving tangent on graphs of cubic functions

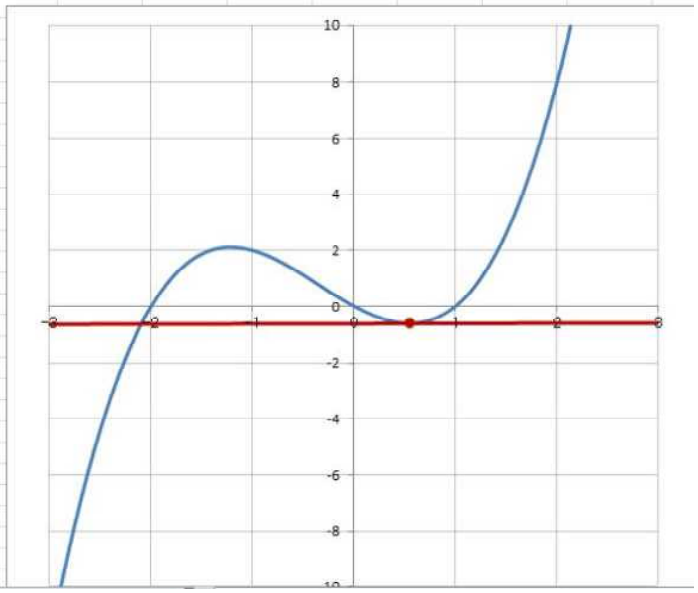
（２）Experimental result（**Excel version simulation**）

⑥ When the x-coordinate of the contact point is 0.55

x	$y=x^3+x^2-2x$	$y=(3t^2+2t-2)x-2t^3-t^2$
-3	-12	-0.65775
-2.9	-10.179	-0.657
-2.8	-8.512	-0.65625
-2.7	-6.993	-0.6555
-2.6	-5.616	-0.65475
-2.5	-4.375	-0.654
-2.4	-3.264	-0.65325
-2.3	-2.277	-0.6525
-2.2	-1.408	-0.65175
-2.1	-0.651	-0.651
-2	0	-0.65025
-1.9	0.551	-0.6495
-1.8	1.008	-0.64875
-1.7	1.377	-0.648
-1.6	1.664	-0.64725
-1.5	1.875	-0.6465
-1.4	2.016	-0.64575
-1.3	2.093	-0.645
-1.2	2.112	-0.64425
-1.1	2.079	-0.6435
-1	2	-0.64275
-0.9	1.881	-0.642
-0.8	1.728	-0.64125
-0.7	1.547	-0.6405
-0.6	1.344	-0.63975
-0.5	1.125	-0.639
-0.4	0.896	-0.63825

Contact(0.55　-0.631125)

Button to move tangent line

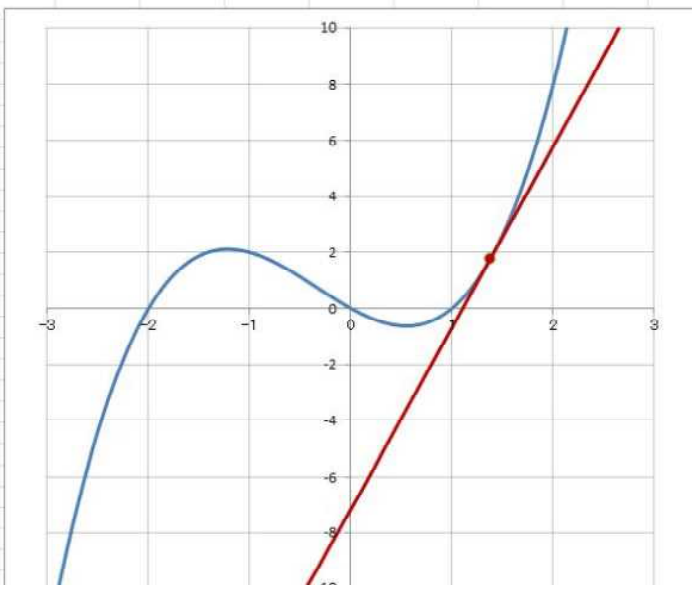


⑦ When the x-coordinate of the contact point is 1.38

x	$y=x^3+x^2-2x$	$y=(3t^2+2t-2)x-2t^3-t^2$
-3	-12	-26.580144
-2.9	-10.179	-25.932824
-2.8	-8.512	-25.285504
-2.7	-6.993	-24.638184
-2.6	-5.616	-23.990864
-2.5	-4.375	-23.343544
-2.4	-3.264	-22.696224
-2.3	-2.277	-22.048904
-2.2	-1.408	-21.401584
-2.1	-0.651	-20.754264
-2	0	-20.106944
-1.9	0.551	-19.459624
-1.8	1.008	-18.812304
-1.7	1.377	-18.164984
-1.6	1.664	-17.517664
-1.5	1.875	-16.870344
-1.4	2.016	-16.223024
-1.3	2.093	-15.575704
-1.2	2.112	-14.928384
-1.1	2.079	-14.281064
-1	2	-13.633744
-0.9	1.881	-12.986424
-0.8	1.728	-12.339104
-0.7	1.547	-11.691784
-0.6	1.344	-11.044464
-0.5	1.125	-10.397144
-0.4	0.896	-9.749824

Contact(1.38　1.772472)

Button to move tangent line



Interesting Macro（Excel）

2024.1.15
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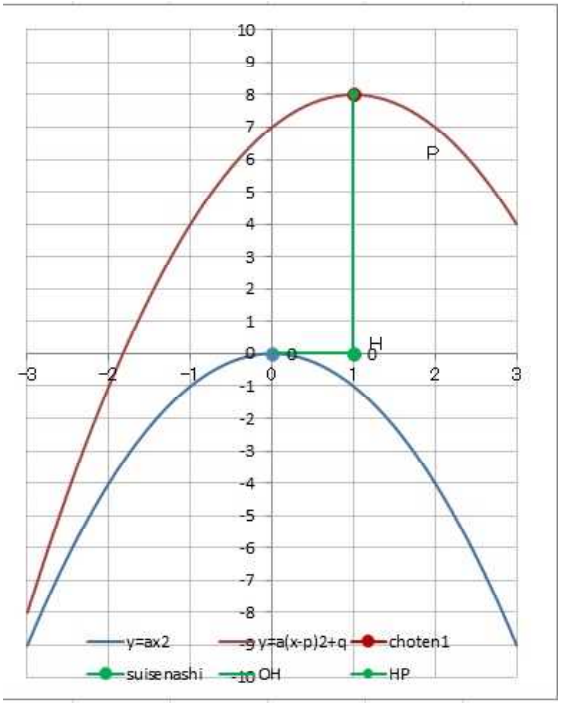
2　Translation of graph of quadratic function

（１）Experiment overview

The simulation will be performed using the spreadsheet software "Excel".
Draw the graphs of the quadratic functions $y=-(x-1)^2+8$ and $y=-x^2$ on the xy-coordinate plane.
Observe that the former is the latter translated by +1 in the x-axis direction and +8 in the y-axis direction. Although it is easier to observe graphs using graph drawing software such as "Grapes" , it is interesting to draw them using "Excel " , which everyone owns and uses frequently in a daily basis. Use "Excel" macro（VBA）.

（２）Experimental result（**Excel version simulation**）



【Experiment day】
January 15 , 2024
【PC used】
Lavie LS150/F
【Excel used】
Excel 2010
【Macro used（VBA）】
Self-made file
『translationquadratic.xlsm（Excel version）』

【Remarks】
First , translate the graph of $y=-x^2$ by +1 in the x-axis direction , then translate by +8 in the y-axis direction.
We observed the parallel movement in 0.05 increments.
The graph of $y=-x^2$ overlaps the graph of $y=-(x-1)^2+8$.

① When the vertex coordinates are（0,0）

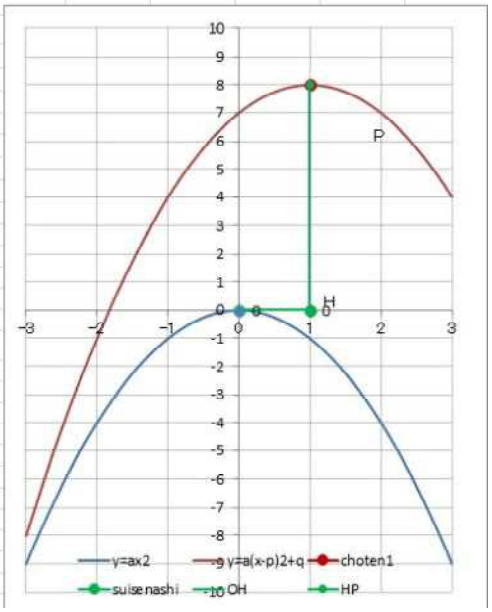
x	$y=ax^2$	$y=a(x-p)^2+q$
-3	-9	-8
-2.9	-8.41	-7.21
-2.8	-7.84	-6.44
-2.7	-7.29	-5.69
-2.6	-6.76	-4.96
-2.5	-6.25	-4.25
-2.4	-5.76	-3.56
-2.3	-5.29	-2.89
-2.2	-4.84	-2.24
-2.1	-4.41	-1.61
-2	-4	-1
-1.9	-3.61	-0.41
-1.8	-3.24	0.16
-1.7	-2.89	0.71
-1.6	-2.56	1.24
-1.5	-2.25	1.75
-1.4	-1.96	2.24
-1.3	-1.69	2.71
-1.2	-1.44	3.16
-1.1	-1.21	3.59
-1	-1	4
-0.9	-0.81	4.39
-0.8	-0.64	4.76
-0.7	-0.49	5.11
-0.6	-0.36	5.44
-0.5	-0.25	5.75

a =	-1	
p =	0	← Please enter 0
q =	0	← Please enter 0

	x	y
Origin	0	0
Perpendicular foot	1	0
Vertex	1	8

Enter the number in the thick frame , then click the [button]

Button to move the quadratic function graph in porallel



Interesting Macro（Excel）

2024.1.15
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2 Translation of graph of quadratic function

（２）Experimental result（**Excel version simulation**）

② When the vertex coordinates are（0.6,0）

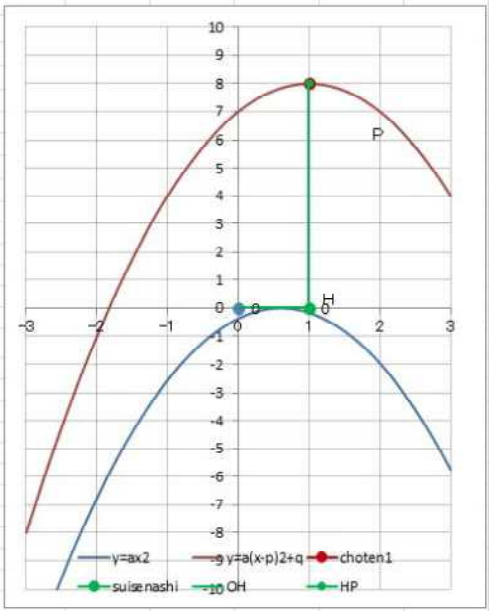
x	$y=ax^2$	$y=a(x-p)^2+q$
-3	-12.96	-8
-2.9	-12.25	-7.21
-2.8	-11.56	-6.44
-2.7	-10.89	-5.69
-2.6	-10.24	-4.96
-2.5	-9.61	-4.25
-2.4	-9	-3.56
-2.3	-8.41	-2.89
-2.2	-7.84	-2.24
-2.1	-7.29	-1.61
-2	-6.76	-1
-1.9	-6.25	-0.41
-1.8	-5.76	0.16
-1.7	-5.29	0.71
-1.6	-4.84	1.24
-1.5	-4.41	1.75
-1.4	-4	2.24
-1.3	-3.61	2.71
-1.2	-3.24	3.16
-1.1	-2.89	3.59
-1	-2.56	4
-0.9	-2.25	4.39
-0.8	-1.96	4.76
-0.7	-1.69	5.11
-0.6	-1.44	5.44
-0.5	-1.21	5.75

a =	-1	
p =	0.6	← Please enter 0
q =	0	← Please enter 0

	x	y
Origin	0	0
Perpendicular foot	1	0
Vertex	1	8

Enter the number in the thick frame , then click the [button]

Button to move the quadratic function graph in porallel



③ When the vertex coordinates are（1,0）

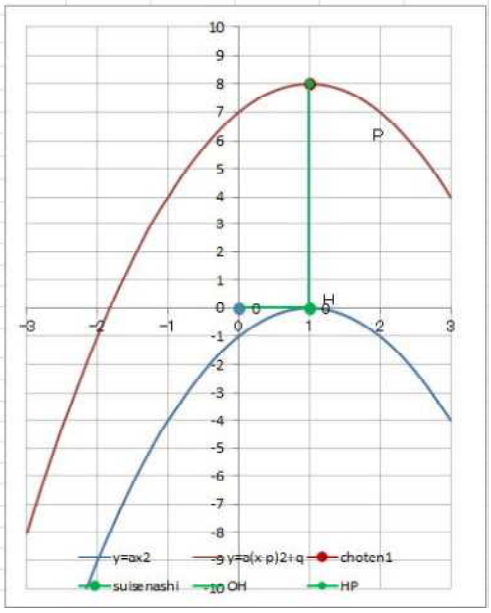
x	$y=ax^2$	$y=a(x-p)^2+q$
-3	-16	-8
-2.9	-15.21	-7.21
-2.8	-14.44	-6.44
-2.7	-13.69	-5.69
-2.6	-12.96	-4.96
-2.5	-12.25	-4.25
-2.4	-11.56	-3.56
-2.3	-10.89	-2.89
-2.2	-10.24	-2.24
-2.1	-9.61	-1.61
-2	-9	-1
-1.9	-8.41	-0.41
-1.8	-7.84	0.16
-1.7	-7.29	0.71
-1.6	-6.76	1.24
-1.5	-6.25	1.75
-1.4	-5.76	2.24
-1.3	-5.29	2.71
-1.2	-4.84	3.16
-1.1	-4.41	3.59
-1	-4	4
-0.9	-3.61	4.39
-0.8	-3.24	4.76
-0.7	-2.89	5.11
-0.6	-2.56	5.44
-0.5	-2.25	5.75

a =	-1	
p =	1	← Please enter 0
q =	0	← Please enter 0

	x	y
Origin	0	0
Perpendicular foot	1	0
Vertex	1	8

Enter the number in the thick frame , then click the [button]

Button to move the quadratic function graph in porallel



Interesting Macro（Excel）

2024.1.15
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2 Translation of graph of quadratic function

（２）Experimental result（**Excel version simulation**）

④ When the vertex coordinates are（1,1.3）

x	$y=ax^2$	$y=a(x-p)^2+q$
-3	-14.7	-8
-2.9	-13.91	-7.21
-2.8	-13.14	-6.44
-2.7	-12.39	-5.69
-2.6	-11.66	-4.96
-2.5	-10.95	-4.25
-2.4	-10.26	-3.56
-2.3	-9.59	-2.89
-2.2	-8.94	-2.24
-2.1	-8.31	-1.61
-2	-7.7	-1
-1.9	-7.11	-0.41
-1.8	-6.54	0.16
-1.7	-5.99	0.71
-1.6	-5.46	1.24
-1.5	-4.95	1.75
-1.4	-4.46	2.24
-1.3	-3.99	2.71
-1.2	-3.54	3.16
-1.1	-3.11	3.59
-1	-2.7	4
-0.9	-2.31	4.39
-0.8	-1.94	4.76
-0.7	-1.59	5.11
-0.6	-1.26	5.44
-0.5	-0.95	5.75

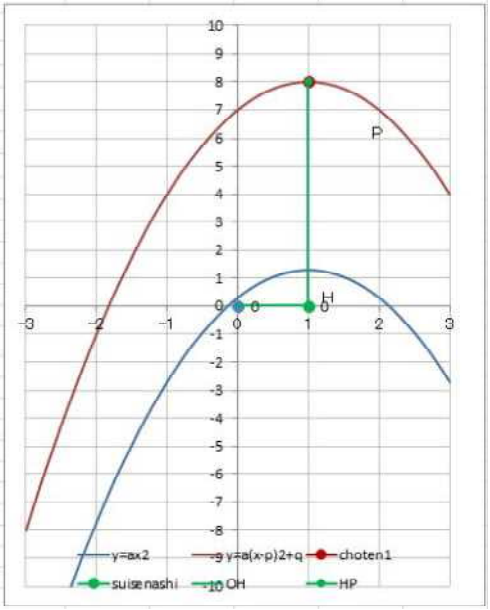
a =	-1
p =	1
q =	1.3

← Please enter 0
← Please enter 0

	x	y
Origin	0	0
Perpendicular foot	1	0
Vertex	1	8

Enter the number in the thick frame , then click the [button]

Button to move the quadratic function graph in porallel



⑤ When the vertex coordinates are（1,3.6）

x	$y=ax^2$	$y=a(x-p)^2+q$
-3	-12.4	-8
-2.9	-11.61	-7.21
-2.8	-10.84	-6.44
-2.7	-10.09	-5.69
-2.6	-9.36	-4.96
-2.5	-8.65	-4.25
-2.4	-7.96	-3.56
-2.3	-7.29	-2.89
-2.2	-6.64	-2.24
-2.1	-6.01	-1.61
-2	-5.4	-1
-1.9	-4.81	-0.41
-1.8	-4.24	0.16
-1.7	-3.69	0.71
-1.6	-3.16	1.24
-1.5	-2.65	1.75
-1.4	-2.16	2.24
-1.3	-1.69	2.71
-1.2	-1.24	3.16
-1.1	-0.81	3.59
-1	-0.4	4
-0.9	-0.01	4.39
-0.8	0.36	4.76
-0.7	0.71	5.11
-0.6	1.04	5.44
-0.5	1.35	5.75

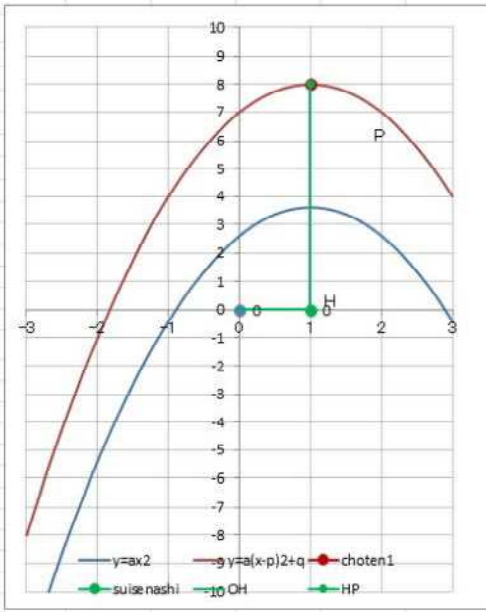
a =	-1
p =	1
q =	3.6

← Please enter 0
← Please enter 0

	x	y
Origin	0	0
Perpendicular foot	1	0
Vertex	1	8

Enter the number in the thick frame , then click the [button]

Button to move the quadratic function graph in porallel



Interesting Macro（Excel）

2024.1.15
Sohun

2 Translation of graph of quadratic function

（２）Experimental result（**Excel version simulation**）

⑥ When the vertex coordinates are（1,5.9）

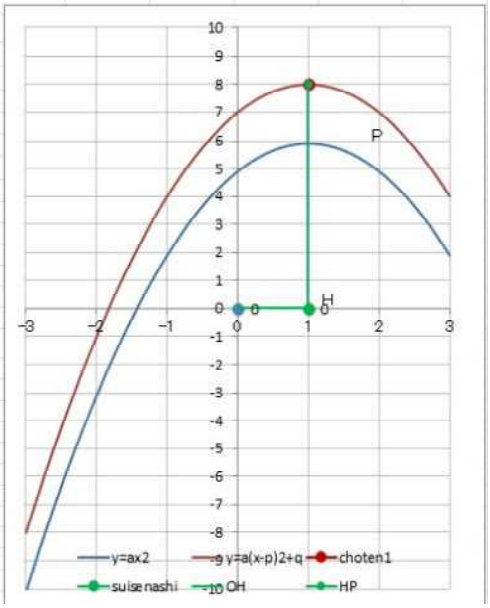
x	y=ax²	y=a(x−p)²+q
−3	−10.1	−8
−2.9	−9.31	−7.21
−2.8	−8.54	−6.44
−2.7	−7.79	−5.69
−2.6	−7.06	−4.96
−2.5	−6.35	−4.25
−2.4	−5.66	−3.56
−2.3	−4.99	−2.89
−2.2	−4.34	−2.24
−2.1	−3.71	−1.61
−2	−3.1	−1
−1.9	−2.51	−0.41
−1.8	−1.94	0.16
−1.7	−1.39	0.71
−1.6	−0.86	1.24
−1.5	−0.35	1.75
−1.4	0.14	2.24
−1.3	0.61	2.71
−1.2	1.06	3.16
−1.1	1.49	3.59
−1	1.9	4
−0.9	2.29	4.39
−0.8	2.66	4.76
−0.7	3.01	5.11
−0.6	3.34	5.44
−0.5	3.65	5.75

a =	−1	
p =	1	← Please enter 0
q =	5.9	← Please enter 0

	x	y
Origin	0	0
Perpendicular foot	1	0
Vertex	1	8

Enter the number in the thick frame , then click the [button]

Button to move the quadratic function graph in porallel



⑦ When the vertex coordinates are（1,8）

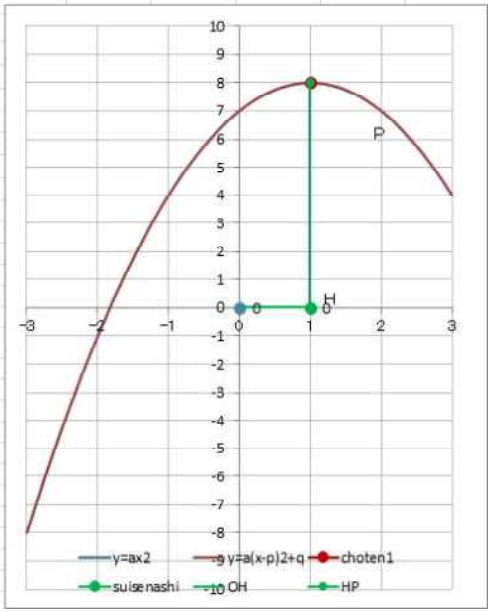
x	y=ax²	y=a(x−p)²+q
−3	−8	−8
−2.9	−7.21	−7.21
−2.8	−6.44	−6.44
−2.7	−5.69	−5.69
−2.6	−4.96	−4.96
−2.5	−4.25	−4.25
−2.4	−3.56	−3.56
−2.3	−2.89	−2.89
−2.2	−2.24	−2.24
−2.1	−1.61	−1.61
−2	−1	−1
−1.9	−0.41	−0.41
−1.8	0.16	0.16
−1.7	0.71	0.71
−1.6	1.24	1.24
−1.5	1.75	1.75
−1.4	2.24	2.24
−1.3	2.71	2.71
−1.2	3.16	3.16
−1.1	3.59	3.59
−1	4	4
−0.9	4.39	4.39
−0.8	4.76	4.76
−0.7	5.11	5.11
−0.6	5.44	5.44
−0.5	5.75	5.75

a =	−1	
p =	1	← Please enter 0
q =	8	← Please enter 0

	x	y
Origin	0	0
Perpendicular foot	1	0
Vertex	1	8

Enter the number in the thick frame , then click the [button]

Button to move the quadratic function graph in porallel



Interesting Macro（Excel）

2024.1.16
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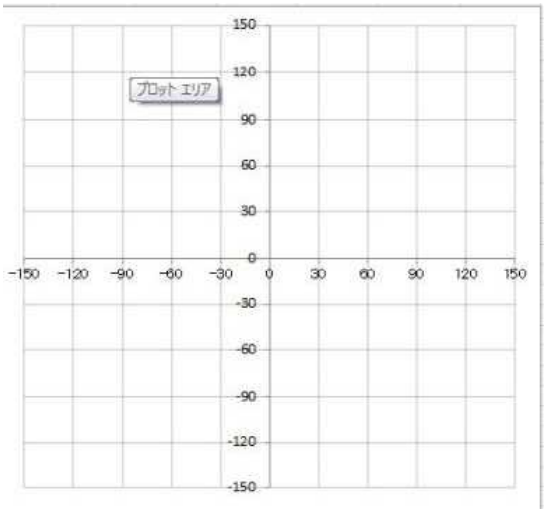
3　Archimedes spiral line

（１）Experiment overview

The simulation will be performed using the spreadsheet software "Excel".
The polar equation of Archimedes spiral line is r=a θ（a:coefficient）.
With x=rcos θ , y=rsin θ , draw a trajectory , using parametric variables converted to orthogonal coordinates. You can observe more easily this using graph drawing software such as "Grapes". However , there is someting interesting about drawing in "Excel" , which everyone owns and uses frequently on a daily basis. Use "Excel" macro（VBA）.

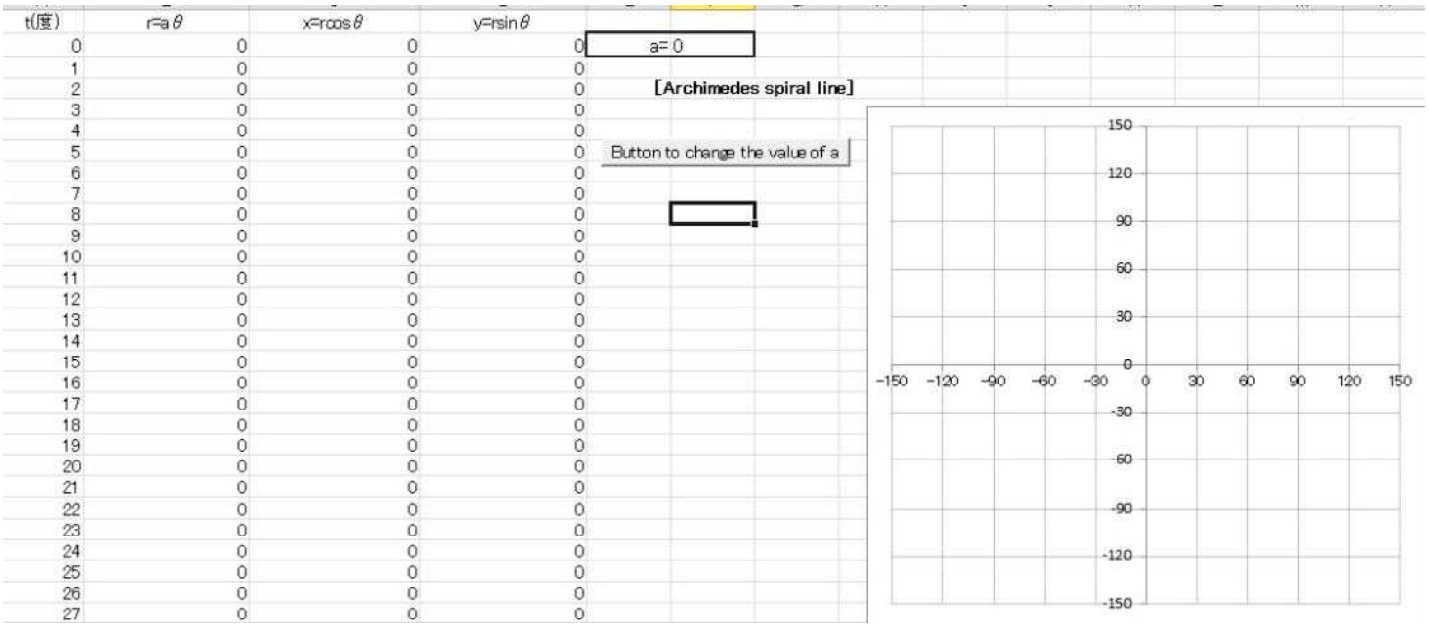
（２）Experimental result（Excel version simulation）



【Experiment day】
January 16 , 2024
【PC used】
Lavie LS150/F
【Excel used】
Excel 2010
【Macro used(VBA)】
Self-made file
『archimedesspiral.xlsm （Excel version）』

【Remarks】
I changed the value of a in the polar equation r=a θ of Archimedes spiral line from 0 to 10.05 in 0.05 increments and obseved them.

① When the value of a is 0



Interesting Macro（Excel）

2024.1.16
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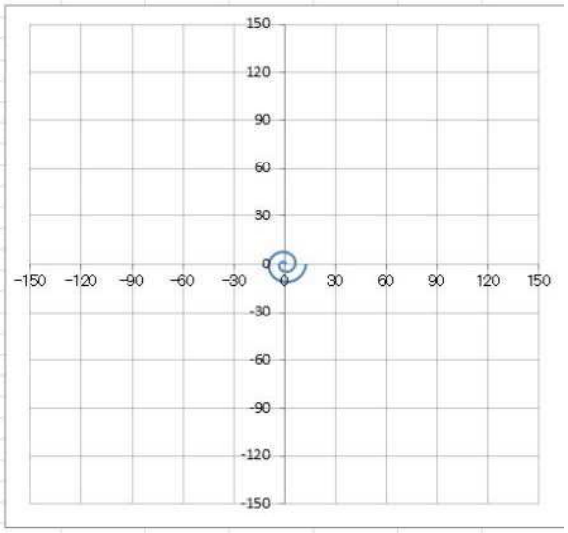
3 Archimedes spiral line

（２）Experimental result（Excel version simulation）

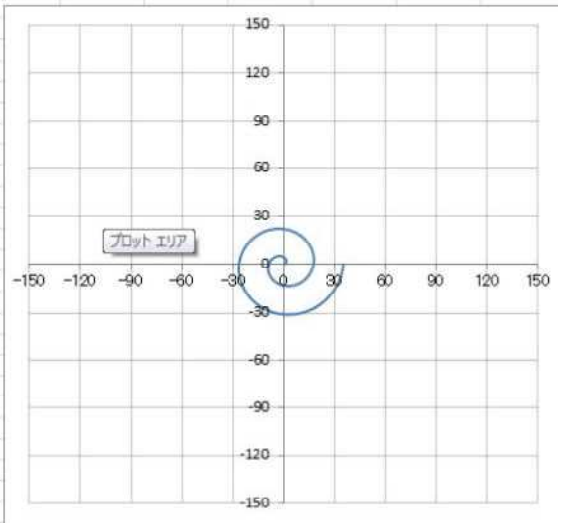
② When the value of a is 1

t(度)	r=aθ	x=rcosθ	y=rsinθ	
0	0	0	0	a=1
1	0.017453293	0.017450634	0.000304602	
2	0.034906585	0.034885321	0.001218222	[Archimedes spiral line]
3	0.052359878	0.05228812	0.002740304	
4	0.06981317	0.069643109	0.004869921	
5	0.087266463	0.086934387	0.007605773	Button to change the value of a
6	0.104719755	0.104146089	0.010946195	
7	0.122173048	0.121262388	0.014889149	
8	0.13962634	0.138267506	0.019432231	
9	0.157079633	0.155145722	0.024572668	
10	0.174532925	0.171881378	0.030307324	
11	0.191986218	0.18845889	0.036632697	
12	0.20943951	0.204862754	0.043544923	
13	0.226892803	0.221077555	0.051039775	
14	0.244346095	0.237087972	0.05911267	
15	0.261799388	0.25287879	0.067758668	
16	0.27925268	0.268434905	0.07697247	
17	0.296705973	0.283741333	0.086748431	
18	0.314159265	0.298783216	0.097080552	
19	0.331612558	0.313545833	0.107962488	
20	0.34906585	0.328014604	0.119387552	
21	0.366519143	0.342175098	0.131348714	
22	0.383972435	0.356013043	0.143838606	
23	0.401425728	0.369514331	0.156849528	
24	0.41887902	0.382665026	0.170373447	
25	0.436332313	0.395451373	0.184402004	
26	0.453785606	0.407859801	0.198926516	
27	0.471238898	0.419876933	0.213937983	



③ When the value of a is 2.8

t(度)	r=aθ	x=rcosθ	y=rsinθ	
0	0	0	0	a=2.8
1	0.048869219	0.048861776	0.000852885	
2	0.097738438	0.097676898	0.003411022	[Archimedes spiral line]
3	0.146607657	0.146406736	0.007672852	
4	0.195476876	0.195000704	0.013635778	
5	0.244346095	0.243416285	0.021296165	Button to change the value of a
6	0.293215314	0.29160905	0.030649346	
7	0.342084533	0.339534687	0.041689617	
8	0.390953752	0.387149017	0.05441024	
9	0.439822972	0.434408021	0.068803471	
10	0.488692191	0.481267858	0.084860508	
11	0.53756141	0.527684892	0.102571553	
12	0.586430629	0.573615712	0.121925784	
13	0.635299848	0.619017154	0.142911371	
14	0.684169067	0.663846322	0.165515478	
15	0.733038286	0.708060612	0.189724269	
16	0.781907505	0.751617734	0.215522917	
17	0.830776724	0.794475732	0.242895607	
18	0.879645943	0.836593006	0.271825545	
19	0.928515162	0.877926333	0.302294968	
20	0.977384381	0.918440891	0.334285146	
21	1.0262536	0.958090274	0.367776398	
22	1.075122819	0.99683652	0.402748097	
23	1.123992038	1.034640126	0.439178678	
24	1.172861257	1.071462074	0.477045651	
25	1.221730476	1.107263844	0.51632561	
26	1.270599695	1.142007442	0.556994246	
27	1.319468915	1.175655411	0.599026352	



Interesting Macro（Excel）

2024.1.16
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3 Archimedes spiral line

（２）Experimental result（Excel version simulation）

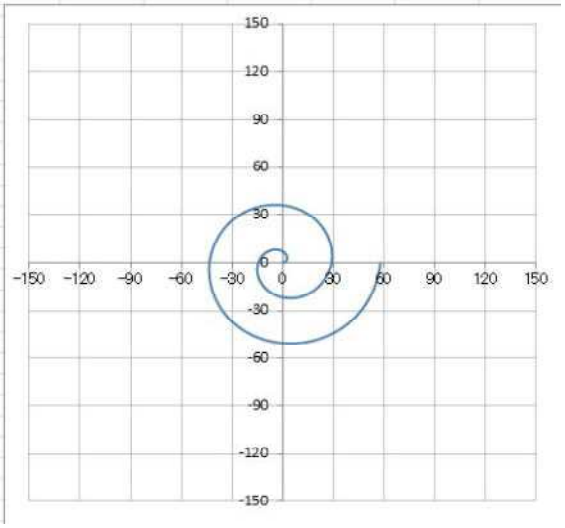
④ When the value of a is 4.6

t(度)	r=aθ	x=rcosθ	y=rsinθ
0	0	0	0
1	0.080285146	0.080272918	0.001401169
2	0.160570291	0.160472476	0.005603822
3	0.240855437	0.240525353	0.0126054
4	0.321140582	0.3208583	0.022401635
5	0.401425728	0.39898818 2	0.034986557
6	0.481710874	0.479072011	0.050352497
7	0.561996019	0.557806986	0.068490066
8	0.642281165	0.636030529	0.089388261
9	0.72256631	0.71367032	0.113034274
10	0.802851456	0.790654338	0.139413692
11	0.883136602	0.866910895	0.168510408
12	0.963421747	0.94236867	0.200306644
13	1.043706893	1.016956753	0.234782966
14	1.123992038	1.090604671	0.271918285
15	1.204277184	1.163242434	0.311689871
16	1.284562329	1.234800563	0.354073364
17	1.364847475	1.305210132	0.399042783
18	1.445132621	1.374402796	0.446570539
19	1.525417766	1.442310834	0.496627447
20	1.605702912	1.508867177	0.54918274
21	1.685988057	1.57400545	0.604204083
22	1.766273203	1.637659997	0.661657588
23	1.846558349	1.699765922	0.721507827
24	1.926843494	1.760259122	0.783717855
25	2.00712864	1.819076316	0.848249217
26	2.087413785	1.876155082	0.915061975
27	2.167698931	1.93143389	0.984114721

a= 4.6

[Archimedes spiral line]

Button to change the value of a



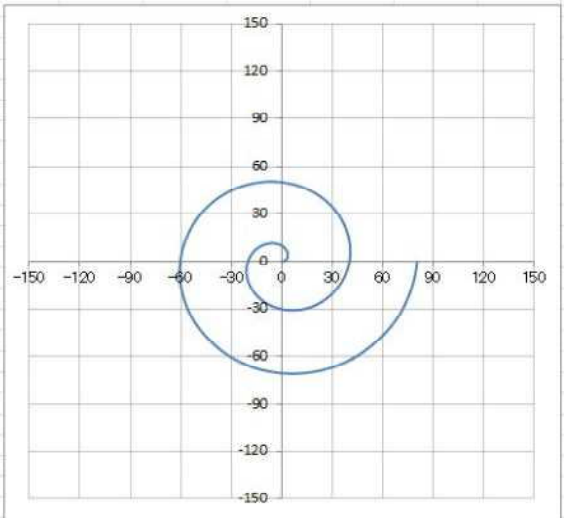
⑤ When the value of a is 6.4

t(度)	r=aθ	x=rcosθ	y=rsinθ
0	0	0	0
1	0.111701072	0.11168406	0.001949453
2	0.223402144	0.223266054	0.007796622
3	0.335103216	0.334643969	0.017537947
4	0.446804289	0.445715896	0.031167492
5	0.558505361	0.556380079	0.04867695
6	0.670206433	0.666534972	0.070055648
7	0.781907505	0.776079265	0.095290554
8	0.893608577	0.88491204	0.124366277
9	1.005309649	0.992932619	0.157265077
10	1.117010721	1.100040619	0.193966876
11	1.228711793	1.206136897	0.234449263
12	1.340412866	1.311121628	0.278687505
13	1.452113938	1.414896352	0.326654561
14	1.56381501	1.517363021	0.378321092
15	1.675516082	1.618424256	0.433655472
16	1.787217154	1.717983393	0.492623811
17	1.898918226	1.815944531	0.555189959
18	2.010619298	1.912212585	0.621315532
19	2.12232037	2.006693334	0.690859926
20	2.234021443	2.099293464	0.764080334
21	2.345722515	2.189920626	0.840631768
22	2.457423587	2.278483474	0.920567078
23	2.569124659	2.364891718	1.003836977
24	2.680825731	2.449056169	1.090390059
25	2.792526803	2.530888787	1.180172823
26	2.904227875	2.610302723	1.273129704
27	3.015928947	2.687212369	1.36920309

a= 6.4

[Archimedes spiral line]

Button to change the value of a



Interesting Macro（Excel）

2024.1.16
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3 Archimedes spiral line

（２）Experimental result（Excel version simulation）

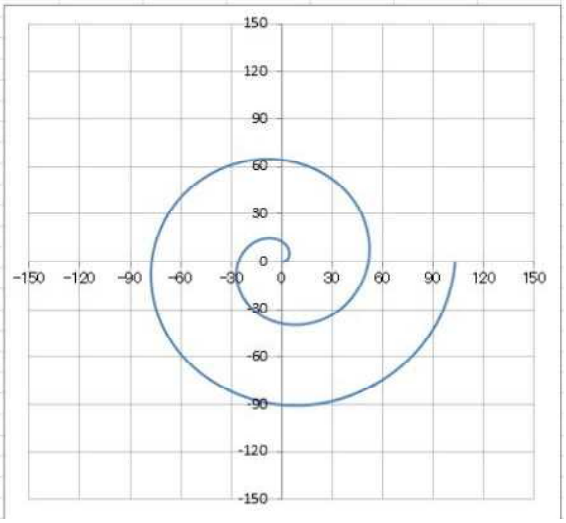
⑥ When the value of a is 8.2

t(度)	r=aθ	x=rcosθ	y=rsinθ
0	0	0	0
1	0.143116999	0.143095201	0.002497736
2	0.286233997	0.286059631	0.009989422
3	0.429350996	0.428762585	0.022470495
4	0.572467995	0.571073491	0.039933349
5	0.715584993	0.712861976	0.062367342
6	0.858701992	0.853997933	0.0897588
7	1.001818991	0.994351584	0.122091023
8	1.144935989	1.133793551	0.159344292
9	1.288052988	1.272194918	0.20149588
10	1.431169987	1.409427299	0.24852006
11	1.574286985	1.545362899	0.300388118
12	1.717403984	1.679874586	0.357068366
13	1.860520983	1.81283595	0.418526157
14	2.003637981	1.94412137	0.484723699
15	2.14675498	2.073606078	0.555621074
16	2.289871979	2.201166222	0.631174257
17	2.432988977	2.32667893	0.711337135
18	2.576105976	2.450022375	0.796060526
19	2.719222975	2.571075834	0.885292405
20	2.862339973	2.689719751	0.978977928
21	3.005456972	2.805835802	1.077059452
22	3.148573971	2.91930695	1.179476569
23	3.291690969	3.030017513	1.286166127
24	3.434807968	3.137853217	1.397062262
25	3.577924967	3.242701259	1.51208643
26	3.721041965	3.344450364	1.631197434
27	3.864158964	3.442990647	1.754291459

a= 8.2

[Archimedes spiral line]

Button to change the value of a



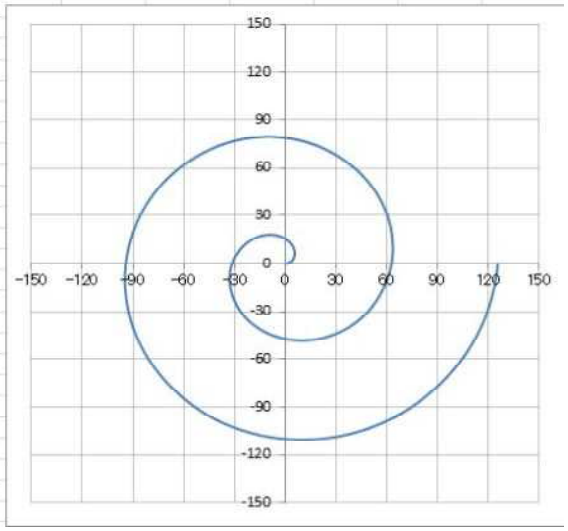
⑦ When the value of a is 10

t(度)	r=aθ	x=rcosθ	y=rsinθ
0	0	0	0
1	0.174532925	0.174506343	0.00304602
2	0.34906585	0.348853209	0.012182222
3	0.523598776	0.522881202	0.027409043
4	0.698131701	0.696431087	0.048699206
5	0.872664626	0.869343874	0.076057734
6	1.047197551	1.041460893	0.109461951
7	1.221730476	1.212623883	0.148891491
8	1.396263402	1.382675062	0.194322307
9	1.570796327	1.551457217	0.245726683
10	1.745329252	1.718813779	0.303073244
11	1.919862177	1.884588902	0.366326973
12	2.094395102	2.048627544	0.435449227
13	2.268928028	2.210775549	0.510397752
14	2.443460953	2.37087972	0.591126706
15	2.617993878	2.5287879	0.677586676
16	2.792526803	2.684349051	0.769724704
17	2.967059728	2.837413329	0.867484311
18	3.141592654	2.987832165	0.970805519
19	3.316125579	3.135456334	1.079624885
20	3.490658504	3.280146098	1.193875522
21	3.665191429	3.421750978	1.313487137
22	3.839724354	3.560130427	1.43838606
23	4.01425728	3.695143309	1.568495277
24	4.188790205	3.826650265	1.703734466
25	4.36332313	3.95451373	1.844020037
26	4.537856055	4.078598005	1.989265163
27	4.71238898	4.198769326	2.139379828

a= 10

[Archimedes spiral line]

Button to change the value of a



Interesting Macro（Excel）

2024.1.18
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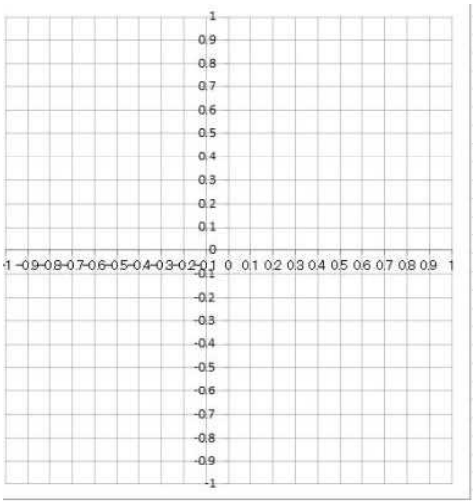
4 Positive leaf curve

（１）Experiment overview

The simulation will be performed using the spreadsheet software "Excel".
The polar equation of a positive leaf curve is r=sina θ（a:coefficient）
Draw a trajectory using parametric variables converted to orthogonal coordinates with x=rcos θ , y=rsin θ . It can be observed more easily using graph drawing software such as "Grapes". However , there is something interesting about drawing in "Excel" , which everyone owns and uses frequently on a daily basis. Use "Excel" macro（VBA）.

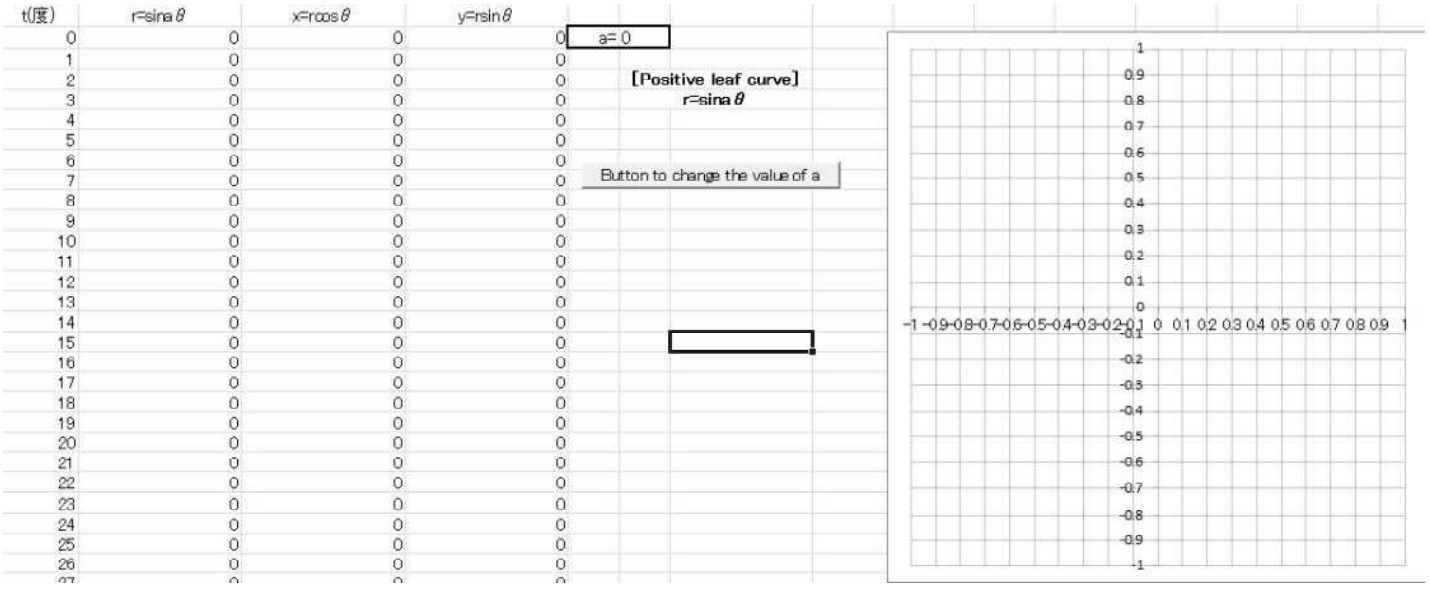
（２）Experimental result（Excel version simulation）



【Experiment day】
January 18 , 2024
【PC used】
Lavie LS150/F
【Excel used】
Excel 2010
【Macro used（VBA）】
Self-made file
『positiveleaf.xlsm（Excel version）』

【Remarks】
The value of a in the polar equation r=sina θ of a positive leaf curve was changed from 0 to 10.5 in 0.05 increments , and the positive leaf curve was observed.
When the value of a is an even number , the number of leaves is 2a , and when the value of a is odd , the number of leaves is a. Also , when the first decimal place of the value of a is 5 , the number of leaves is 2a.
When the value of a is an even number , the positive leaf curve is symmetrical about the x-axis and the y-axis and the leaves do not overlap. When the value of a is an odd number , the positive leaf curve is symmetrical about the y-axis , and the leaves overlap neatly in pairs. In the positive leaf curve , when the first decimal place of the value of a is 5 , the leaves are biased and the leaves patially overlap. A positive leaf curve when the first decimal of the value of a is other than 5 has a leaf that is being drawn.

① When the value of a is 0



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4 Positive leaf curve

（２）Experimental result（Excel version simulation）

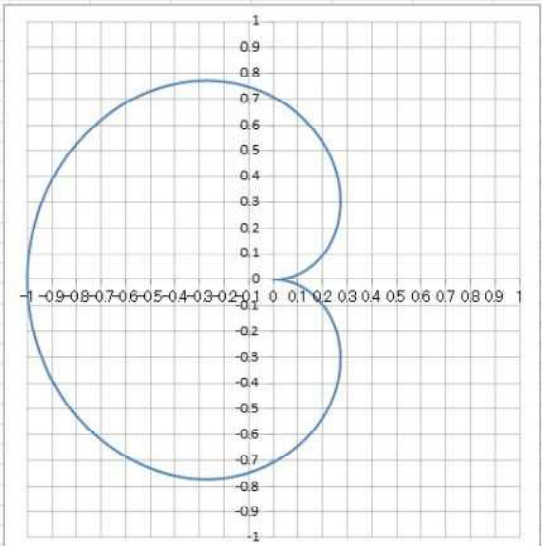
② When the value of a is 0.5

t(度)	r=sinaθ	x=rcosθ	y=rsinθ
0	0	0	0
1	0.008726535	0.008725206	0.000152299
2	0.017452406	0.017441775	0.00060908
3	0.026176948	0.026141074	0.001369996
4	0.034899497	0.034814483	0.002434466
5	0.043619387	0.043453402	0.003801168
6	0.052335956	0.052049254	0.005470597
7	0.06104854	0.060593493	0.007439945
8	0.069756474	0.069077609	0.009708225
9	0.078459096	0.077493134	0.012273707
10	0.087155743	0.085831651	0.015134436
11	0.095845753	0.094084796	0.018288232
12	0.104528463	0.102244266	0.02173269
13	0.113203214	0.110801823	0.025465182
14	0.121869343	0.118249303	0.029482863
15	0.130526192	0.12607862	0.033782664
16	0.139173101	0.133781771	0.038361306
17	0.147809411	0.141350843	0.04321529
18	0.156434465	0.148778017	0.048340908
19	0.165047606	0.156055577	0.053734244
20	0.173648178	0.163175911	0.059391175
21	0.182235525	0.170133152	0.065307372
22	0.190808995	0.17691502	0.071478308
23	0.199367934	0.183519151	0.077899258
24	0.207911691	0.189936781	0.084565303
25	0.216439614	0.196160908	0.091471333
26	0.224951054	0.202184668	0.098612052

a= 0.5

[Positive leaf curve]
r=sinaθ

Button to change the value of a



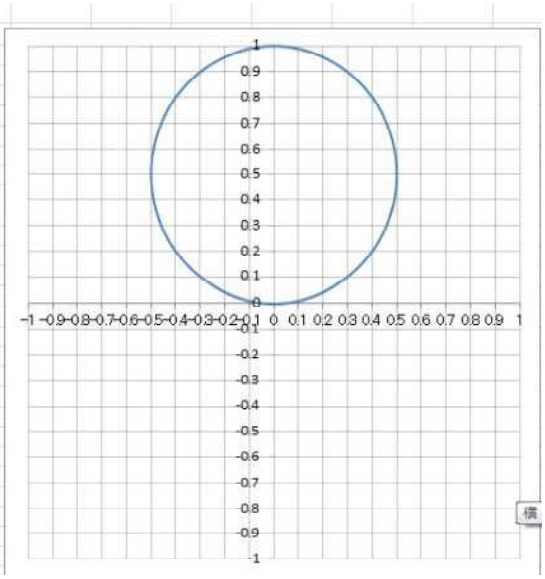
③ When the value of a is 1

t(度)	r=sinaθ	x=rcosθ	y=rsinθ
0	0	0	0
1	0.017452406	0.017449748	0.000304586
2	0.034899497	0.034878237	0.001217975
3	0.052335956	0.052264232	0.002739052
4	0.069756474	0.06958655	0.004865966
5	0.087155743	0.086824089	0.007596123
6	0.104528463	0.103955845	0.01092 62
7	0.121869343	0.120960948	0.014852137
8	0.139173101	0.137818678	0.019369152
9	0.156434465	0.154506497	0.024471742
10	0.173648178	0.171010072	0.03015369
11	0.190808995	0.187303297	0.036406073
12	0.207911691	0.203368322	0.043227271
13	0.224951054	0.219185573	0.050602977
14	0.241921896	0.234735781	0.058526204
15	0.258819045	0.25	0.066987298
16	0.275637356	0.264959632	0.075975952
17	0.292371705	0.279596452	0.085481214
18	0.309016994	0.293892626	0.095491503
19	0.325568154	0.307830738	0.105994623
20	0.342020143	0.321393805	0.116977778
21	0.35836795	0.334565303	0.128427587
22	0.374606593	0.347329185	0.1403301
23	0.390731128	0.3596699	0.152670615
24	0.406736643	0.371572413	0.165434697
25	0.422618262	0.383022222	0.178606195
26	0.438371147	0.394005377	0.192169262

a= 1

[Positive leaf curve]
r=sinaθ

Button to change the value of a



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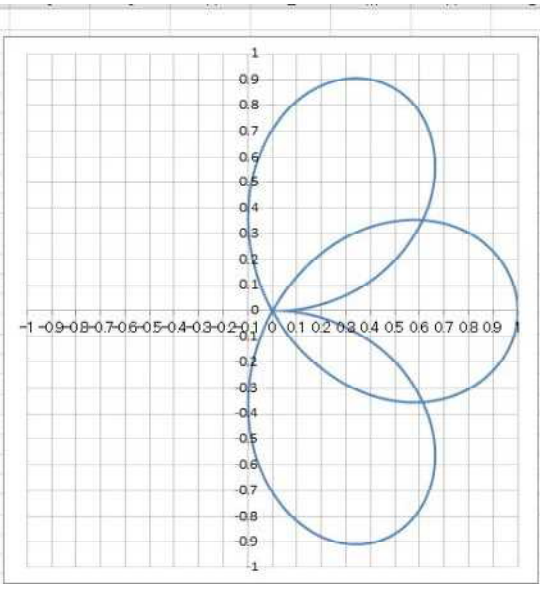
4 Positive leaf curve

（２）Experimental result（Excel version simulation）

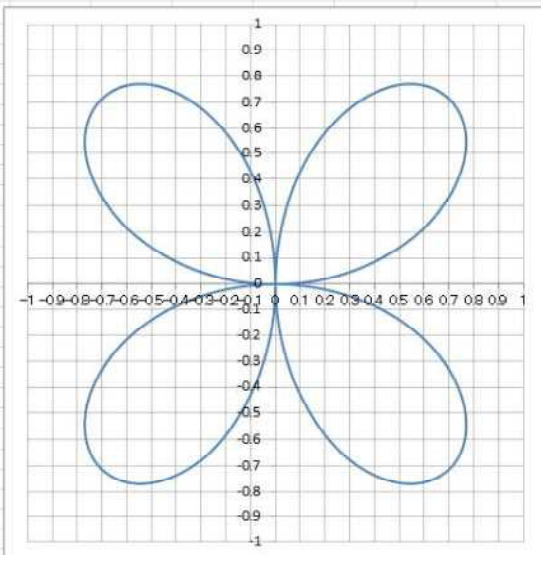
④ When the value of a is 1.5

t(度)	r=sinaθ	x=rcosθ	y=rsinθ	
0	0	0	0	a=1.5
1	0.026176948	0.026172961	0.000456851	
2	0.052335956	0.052304075	0.001826499	[Positive leaf curve]
3	0.078459096	0.07835157	0.004106232	r=sinaθ
4	0.104528463	0.104273837	0.007291537	
5	0.130526192	0.130029501	0.011376107	
6	0.156434465	0.155577501	0.016351854	
7	0.182235525	0.18067717	0.022206824	Button to change the value of a
8	0.207911691	0.205888309	0.028935715	
9	0.233445364	0.230571264	0.036518901	
10	0.258819045	0.254887002	0.044943456	
11	0.284015345	0.278797183	0.054192683	
12	0.309016994	0.302264232	0.064248246	
13	0.333806859	0.325251411	0.075090205	
14	0.35836795	0.347722289	0.086697054	
15	0.382683432	0.369643811	0.099045761	
16	0.406736643	0.390980355	0.112111813	
17	0.430511097	0.411699809	0.125869263	
18	0.4539905	0.431770623	0.14029078	
19	0.47715876	0.451162471	0.155347697	
20	0.5	0.46984631	0.171010072	
21	0.522496565	0.487794433	0.187246739	
22	0.544639035	0.50498052	0.204025374	
23	0.566406237	0.52137969	0.221312548	
24	0.587785252	0.536968547	0.2390738	
25	0.608761429	0.551725224	0.257273697	
26	0.629320391	0.565629421	0.275875902	



⑤ When the value of a is 2

t(度)	r=sinaθ	x=rcosθ	y=rsinθ	
0	0	0	0	a=2
1	0.034899497	0.034894181	0.00060908	
2	0.069756474	0.06971388	0.002434466	[Positive leaf curve]
3	0.104528463	0.104365211	0.005470597	r=sinaθ
4	0.139173101	0.138834082	0.009708225	
5	0.173648178	0.172987394	0.015134436	
6	0.207911691	0.206772729	0.02173269	
7	0.241921896	0.240118646	0.029482863	Button to change the value of a
8	0.275637356	0.272954872	0.038361306	
9	0.309016994	0.305212482	0.048340908	
10	0.342020143	0.336824089	0.059391175	
11	0.374606593	0.367724015	0.071478308	
12	0.406736643	0.397848472	0.084565309	
13	0.438371147	0.427135723	0.098612052	
14	0.469471563	0.455526251	0.11357545	
15	0.5	0.482962913	0.129409523	
16	0.529919264	0.509391091	0.146065545	
17	0.559192903	0.534758833	0.163492182	
18	0.587785252	0.55901694	0.181635632	
19	0.615661475	0.582119361	0.20043977	
20	0.64278761	0.604022774	0.21984631	
21	0.669130606	0.624687237	0.239794963	
22	0.69465837	0.644076026	0.260223606	
23	0.7193398	0.662155777	0.281060452	
24	0.743144825	0.67889658	0.302264232	
25	0.766044443	0.694272044	0.323744371	
26	0.788010754	0.708259374	0.345441178	



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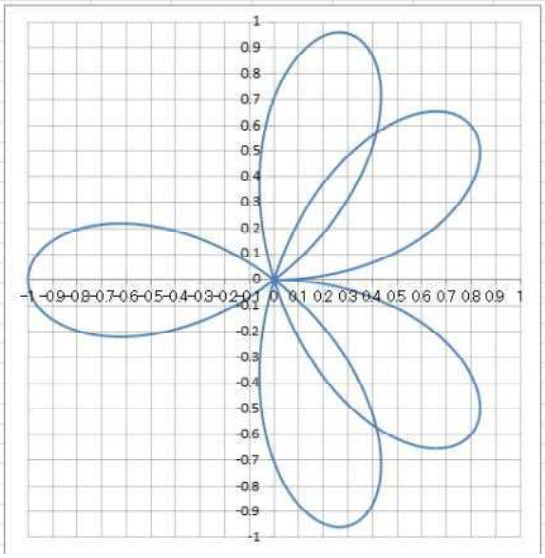
4 Positive leaf curve

（２）Experimental result（Excel version simulation）

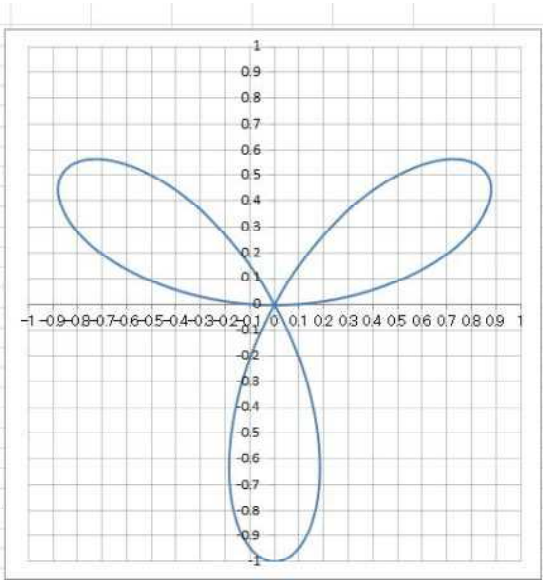
⑥ When the value of a is 2.5

t(度)	r=sinaθ	x=rcosθ	y=rsinθ	
0	0	0	0	a= 2.5
1	0.043619387	0.043612744	0.000761263	
2	0.087155743	0.08710265	0.003041692	[Positive leaf curve]
3	0.130526192	0.130347311	0.006831213	r=sinaθ
4	0.173648178	0.173225179	0.012113085	
5	0.216439614	0.215615996	0.018863955	
6	0.258819045	0.257401207	0.027053957	
7	0.3007058	0.298464384	0.036646818	Button to change the value of a
8	0.342020143	0.338691627	0.047600004	
9	0.382683432	0.377971964	0.059864878	
10	0.422618262	0.416197741	0.073386891	
11	0.461748613	0.453264891	0.088105789	
12	0.5	0.4890738	0.103955845	
13	0.537299608	0.523528654	0.120866113	
14	0.573576436	0.556538765	0.138760699	
15	0.608761429	0.588018386	0.157559052	
16	0.64278761	0.617887108	0.177176277	
17	0.675590208	0.646070129	0.197523461	
18	0.707106781	0.672498512	0.218508012	
19	0.737277337	0.697109417	0.240034022	
20	0.766044443	0.71984631	0.26200263	
21	0.79335334	0.74065915	0.28431241	
22	0.819152044	0.75950455	0.306859757	
23	0.843391446	0.776345919	0.329539291	
24	0.866025404	0.791153574	0.352244266	
25	0.887010833	0.803904825	0.374866976	
26	0.906307787	0.814504043	0.397299104	



⑦ When the value of a is 3

t(度)	r=sinaθ	x=rcosθ	y=rsinθ	
0	0	0	0	a= 3
1	0.052335956	0.052327865	0.000913388	
2	0.104528463	0.104464787	0.003647991	[Positive leaf curve]
3	0.156434465	0.156220077	0.008187147	r=sinaθ
4	0.207911691	0.207405228	0.014503186	
5	0.258819045	0.25783416	0.022557566	
6	0.309016994	0.307324167	0.032301072	
7	0.35836795	0.355696729	0.043674067	Button to change the value of a
8	0.406736643	0.40277831	0.0566068	
9	0.4539905	0.448401123	0.071019761	
10	0.5	0.492403877	0.086824089	
11	0.544639035	0.534632482	0.103922027	
12	0.587785252	0.574940734	0.122207426	
13	0.629320391	0.61319095	0.141566285	
14	0.669130606	0.649254568	0.161877345	
15	0.707106781	0.683012702	0.183012702	
16	0.743144825	0.714356655	0.204838475	
17	0.777145961	0.743188379	0.22721549	
18	0.809016994	0.769420884	0.25	
19	0.838670568	0.792978601	0.273044429	
20	0.866025404	0.813797681	0.296198133	
21	0.891006524	0.831826251	0.319306181	
22	0.913545458	0.847024599	0.342220152	
23	0.933580426	0.859365314	0.364778934	
24	0.951056516	0.86883336	0.386829535	
25	0.965925826	0.875426098	0.408217894	
26	0.978147601	0.87915324	0.428791605	



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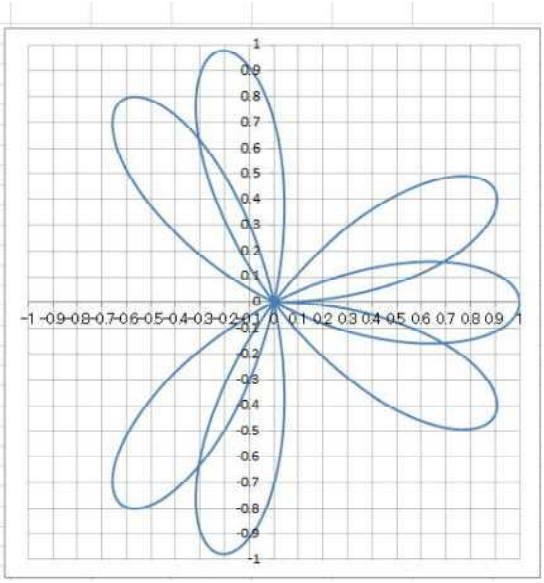
4 Positive leaf curve

（２）Experimental result（Excel version simulation）

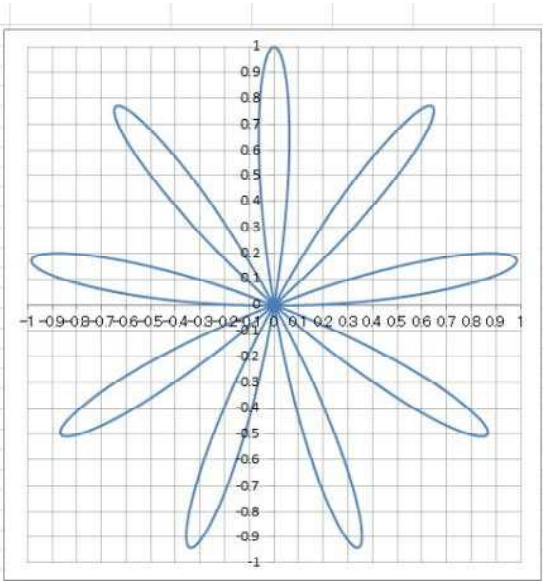
⑧ When the value of a is 3.5

t(度)	r=sinaθ	x=rcosθ	y=rsinθ	
0	0	0	0	a= 3.5
1	0.06104854	0.061039242	0.001065444	
2	0.121868343	0.121795104	0.00425317 9	[Positive leaf curve]
3	0.182235525	0.181985778	0.00953747	r=sinaθ
4	0.241921896	0.241332586	0.016875618	
5	0.3007058	0.299561523	0.026206237	
6	0.35836795	0.356404772	0.037459651	
7	0.414693243	0.411602182	0.050538393	Button to change the value of a
8	0.469471563	0.464902698	0.065337813	
9	0.522498565	0.51606574	0.081736783	
10	0.573576436	0.564862521	0.09960503	
11	0.622514637	0.611077289	0.118781392	
12	0.669130606	0.654508497	0.139120076	
13	0.713250449	0.694969886	0.160446441	
14	0.75470958	0.732291 48	0.182580772	
15	0.79335334	0.766320481	0.205334954	
16	0.829037573	0.796922063	0.228513724	
17	0.86162916	0.823980064	0.251915986	
18	0.891006524	0.847397561	0.275336158	
19	0.917060074	0.867097335	0.298565556	
20	0.939692621	0.883022222	0.321393805	
21	0.958819735	0.895135337	0.34361 0262	
22	0.974370065	0.903420192	0.365005451	
23	0.986285602	0.907880683	0.385372486	
24	0.994521895	0.90854086	0.404506497	
25	0.999048222	0.905445183	0.422216023	
26	0.999847695	0.898657156	0.438304381	
27	0.99691 7394	0.888259848	0.45259 0999	



⑨ When the value of a is 9

t(度)	r=sinaθ	x=rcosθ	y=rsinθ	
0	0	0	0	a= 9
1	0.156434465	0.156410639	0.002730158	
2	0.309016994	0.30882875	0.010784538	[Positive leaf curve]
3	0.4539905	0.453368322	0.023760027	r=sinaθ
4	0.587785252	0.586353437	0.041001827	
5	0.707106781	0.704416026	0.061628417	
6	0.809016994	0.804585115	0.084565303	
7	0.891006524	0.884365097	0.10858638	Button to change the value of a
8	0.951056516	0.9418009	0.132361485	
9	0.987688341	0.975528258	0.154508497	
10	1	0.984807753	0.173648178	
11	0.987688341	0.969541724	0.18845962	
12	0.951056516	0.93027365	0.197735768	
13	0.891006524	0.868170065	0.200432857	
14	0.809016994	0.784985732	0.195718925	
15	0.707106781	0.683012702	0.183012702	
16	0.587785252	0.565015448	0.162015573	
17	0.4539905	0.434153274	0.132733976	
18	0.309016994	0.293892626	0.095491503	
19	0.156434465	0.147911693	0.05093008	
20	1.22515E-16	1.15126E-16	4.19025E-17	
21	-0.156434465	-0.146044155	-0.056061086	
22	-0.309016994	-0.286515568	-0.115759804	
23	-0.4539905	-0.417900458	-0.17738822	
24	-0.587785252	-0.536968547	-0.2390738	
25	-0.707106781	-0.640656382	-0.298836239	
26	-0.809016994	-0.727139658	-0.354649708	
27	-0.891006524	-0.793892626	-0.404508497	



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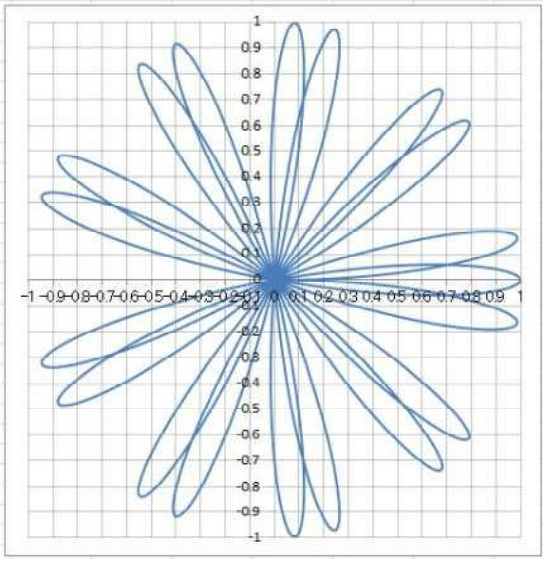
4 Positive leaf curve

（２）Experimental result（Excel version simulation）

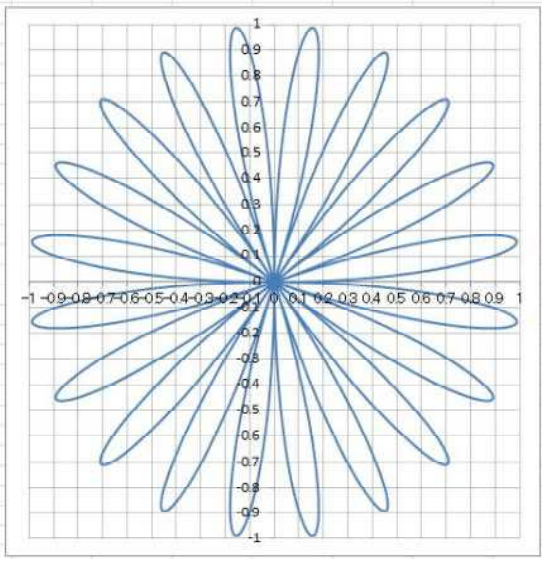
⑩ When the value of a is 9.5

t(度)	r=sinaθ	x=rcosθ	y=rsinθ	
0	0	0	0	a= 9.5
1	0.165047606	0.165022468	0.002680478	
2	0.325568154	0.325369827	0.011362165	[Positive leaf curve]
3	0.47715876	0.476504831	0.02497256	r=sinaθ
4	0.615661475	0.614161755	0.042946374	
5	0.737277337	0.734471774	0.064257954	
6	0.838670568	0.834076243	0.087664946	
7	0.917060074	0.910224448	0.111761509	Button to change the value of a
8	0.970295726	0.960852875	0.135039065	
9	0.996917334	0.984643627	0.15595223	
10	0.996194698	0.981060262	0.172987394	
11	0.96814764	0.950360041	0.184731279	
12	0.913545458	0.893582298	0.189936781	
13	0.838865822	0.812513382	0.187583495	
14	0.731353702	0.709629371	0.176930474	
15	0.608761429	0.588018386	0.157559052	
16	0.469471563	0.451285081	0.1294089	
17	0.317304656	0.309439952	0.092770909	
18	0.156434465	0.148778017	0.048340908	
19	-0.008726535	-0.008251101	-0.002841062	
20	-0.173648178	-0.163175911	-0.059391175	
21	-0.333806859	-0.31163555	-0.11962568	
22	-0.48480962	-0.449507652	-0.18161288	
23	-0.622514637	-0.573027744	-0.243235846	
24	-0.743144825	-0.67889658	-0.302264232	
25	-0.843391446	-0.764372235	-0.356432627	
26	-0.920504853	-0.827344202	-0.405522768	
27	-0.97236992	-0.866387943	-0.441446706	



⑪ When the value of a is 10

t(度)	r=sinaθ	x=rcosθ	y=rsinθ	
0	0	0	0	a= 10
1	0.173648178	0.17362173	0.003030579	
2	0.342020143	0.341811794	0.011936331	[Positive leaf curve]
3	0.5	0.499314767	0.026167978	r=sinaθ
4	0.64278761	0.641221811	0.044838597	
5	0.766044443	0.763129413	0.066765172	
6	0.866025404	0.861281226	0.090524305	
7	0.939692621	0.932688294	0.114519723	
8	0.984807753	0.975223672	0.137058749	Button to change the value of a
9	1	0.987688341	0.156434465	
10	0.984807753	0.96984631	0.171010072	
11	0.939692621	0.922427621	0.179301805	
12	0.866025404	0.847100671	0.180056806	
13	0.766044443	0.746410774	0.172322505	
14	0.64278761	0.623694071	0.155504397	
15	0.5	0.482962913	0.129409523	
16	0.342020143	0.328770063	0.094273528	
17	0.173648178	0.166060578	0.050769814	
18	1.22515E-16	1.16519E-16	3.78592E-17	
19	-0.173648178	-0.164187578	-0.056534317	
20	-0.342020143	-0.321393805	-0.116977778	
21	-0.5	-0.466790213	-0.179183975	
22	-0.64278761	-0.595982294	-0.240792477	
23	-0.766044443	-0.705147628	-0.29931741	
24	-0.866025404	-0.791153574	-0.352244266	
25	-0.939692621	-0.85165074	-0.397131262	
26	-0.984807753	-0.885139345	-0.431711304	
27	-1	-0.891006524	-0.4539905	



Interesting Macro（Excel）

2024.1.19
Sohun

5 Perfect number

（１）Experiment overview

Search for perfect numbers using the spreadsheet software "Excel".

A perfect number is an integer greater than or equal to 2 , and the sum of its divisors , excluding itself , is equal to itself. For example , the divisors of 6 are 1 , 2 , 3 , and 6 , and the sum of the divisors , excluding itself , is 1+2+3=6 , so 6 is a perfect number.

Research for perfect numbers using "Excel" macro（VBA）.

（２）Experimental result（Excel version simulation）

【Experiment day】
January 19 , 2024
【PC used】
Lavie NX850/N
【Excel used】
Excel 2019
【Macro used（VBA）】
Self-made file
『perfectnumber.xlsm（Excel version）』

【Remarks】

To find a perfect number , examine each integer greater than or equal to 2 to see if it satisfies the definition of a perfect number. 2 is not satisfied. 3 is not satisfied. 4 is not satisfied because it is 1+2. ・・・. However , the brute force method takes a considerable amount of time.

It is known that when n is a natural number and 2^n-1 is a prime number , $2^{n-1}(2^n-1)$ is a perfect number.

So , can all perfect numbers be expressed in the form $2^{n-1}(2^n-1)$? It has been proven that all even perfect numbers are collect. However , the odd perfect number has not yet been found.

① When n=2 , (2^n-1) is a prime number.
$2^{n-1}(2^n-1)=6$ is a perfect number.

① When n=3 , (2^n-1) is a prime number.
$2^{n-1}(2^n-1)=28$ is a perfect number.

③ When n=5 , (2^n-1) is a prime number.
$2^{n-1}(2^n-1)$
=496 is a perfect number.

④ When n=7 , (2^n-1) is a prime number.
$2^{n-1}(2^n-1)$
=8,128 is a perfect number.

⑤ When n=13 , (2^n-1) is a prime number.
$2^{n-1}(2^n-1)$
=33,550,336 is a perfect number.

⑥ When n=17 , (2^n-1) is a prime number.
$2^{n-1}(2^n-1)$
＝ 8,589,869,056 is a perfect number.

⑦ When n=19 , (2^n-1) is a prime number.
$2^{n-1}(2^n-1)$
＝ 137,438,691,328 is a perfect number.

⑧ When n=31 , (2^n-1) is a prime number.
$2^{n-1}(2^n-1)$
＝ 2,305,843,008,139,950,000 is a perfect ・・・.

n	2^n-1	Prime ?	$2^{n-1}(2^n-1)$	Perfect ?
2	3	Prime	6	Perfect
3	7	Prime	28	Perfect
4	15		120	
5	31	Prime	496	Perfect
6	63		2016	
7	127	Prime	8128	Perfect
8	255		32640	
9	511		130816	
10	1023		523776	
11	2047		2096128	
12	4095		8386560	
13	8191	Prime	33550336	Perfect
14	16383		134209536	
15	32767		536854528	
16	65535		2147450880	
17	131071	Prime	8589869056	Perfect
18	262143		34359607296	
19	524287	Prime	137438691328	Perfect
20	1048575		549755289600	
21	2097151		2199022206976	
22	4194303		8796090925056	
23	8388607		35184367894528	
24	16777215		140737479966720	
25	33554431		562949936644096	
26	67108863		2251799780130820	
27	134217727		9007199187632130	
28	268435455		36028796884746200	
29	536870911		144115187807420000	
30	1073741823		576460751766553000	
31	2147483647	Prime	2305843008139950000	Perfect