

Lindenmayer Systems

History

(1960s) Aristid Lindenmayer, a biologist and botanist, studied the development of plants and tried to model their growth processes. He created L -systems to describe the branching structures in plants.

What is an L -system

An L -System is a type of formal grammar and string rewriting systems. It consists of an alphabet \mathcal{A} of symbols that can be used to make strings, a collection of substitution rules that expand each symbol into a string of symbols and an axiom, i.e. starting point. Once a string is created, we use a mechanism called "Turtle Graphics" to turn the string into a visual image.

Constructing a string This is an example of one of Lindenmayer's original strings used to study the growth of algae. It is called the fibonacci string, can you guess why?

$$\mathcal{A} = \{a, b\}$$

Axiom: a

Rules: $a \rightarrow ab$ and $b \rightarrow a$.

Order	String
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0	a
---	-----

1	ab
---	------

2	$abaa$
---	--------

3	$abaabab$
---	-----------

4	$abaababaaba$
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Turtle Graphics

Now that we have a method for creating strings. How do we convert them into pictures?

One method is Turtle Graphics. Imagine a turtle on the plane, it has three attributes, a location, an orientation, and a pen. The turtle can choose to draw with the pen or not.

The turtle moves with commands relative to its own position.

Symbol	
A, B, C, D, E, F	Draw forward
G, H, I, J, K, L	Move forward
+	Rotate left by the specified angle
-	Rotate right by the specified angle
	Rotate by 180 degrees
[Remember point (push item onto stack)
]	Return point (pops item off the stack)

Example Let's create a new string using the above alphabet.

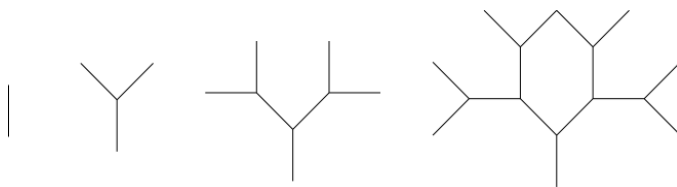
Axiom: F

Rules: $F = F[+F] - F$

Angle: 45

Order	String
0	F
1	$F[+F] - F$
2	$F[+F] - F[+F[+F] - F] - F[+F] - F$

Now we use turtle graphics to create a drawing using the string.

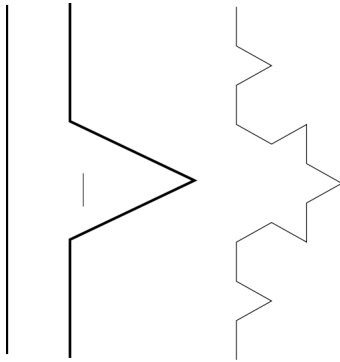


Example Try this on your own. Axiom: F

Rules: $F = F + F - -F + F$

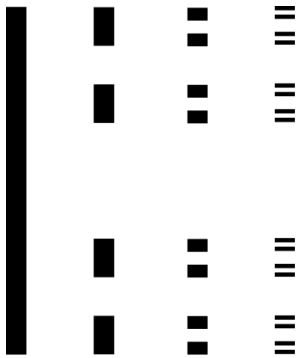
Angle: 60

Order	String
0	F
1	$F + F - -F + F$
2	$F + F - -F + F + F + F - -F + F - -F + F - -F + F + F + F - -F + F$



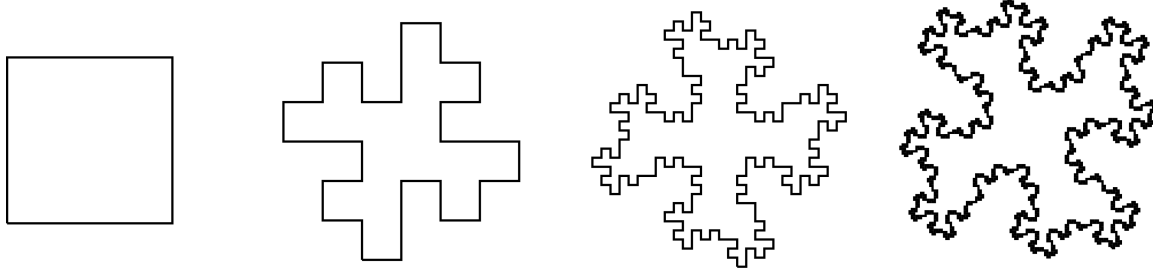
Example

For the next example, I want you to find the corresponding code. (draw vertically)



Example

How would you draw a square using Turtle Graphics?



Axiom: $F + F + F + F$

Rules: $F = F - F + F + F - F - FF + F$

Making a key chain

- Your key chain should be within a 2in by 2in square. But the shape of your key chain can be anything you like.
- You should include a circle for the hole in your key chain that is at least 2 mm in diameter. The circle should be close enough to the boundary that you can use your

lobster clip, but far enough so that it doesn't break.

- Before you finish, make sure your line thickness is .001 inches. Object-¿Fill and Stroke-¿Stroke Style
- Lines to be cut should be in Red (255).
- Lines to be etched should be in black.
- Remember that only closed loops should be cut.