

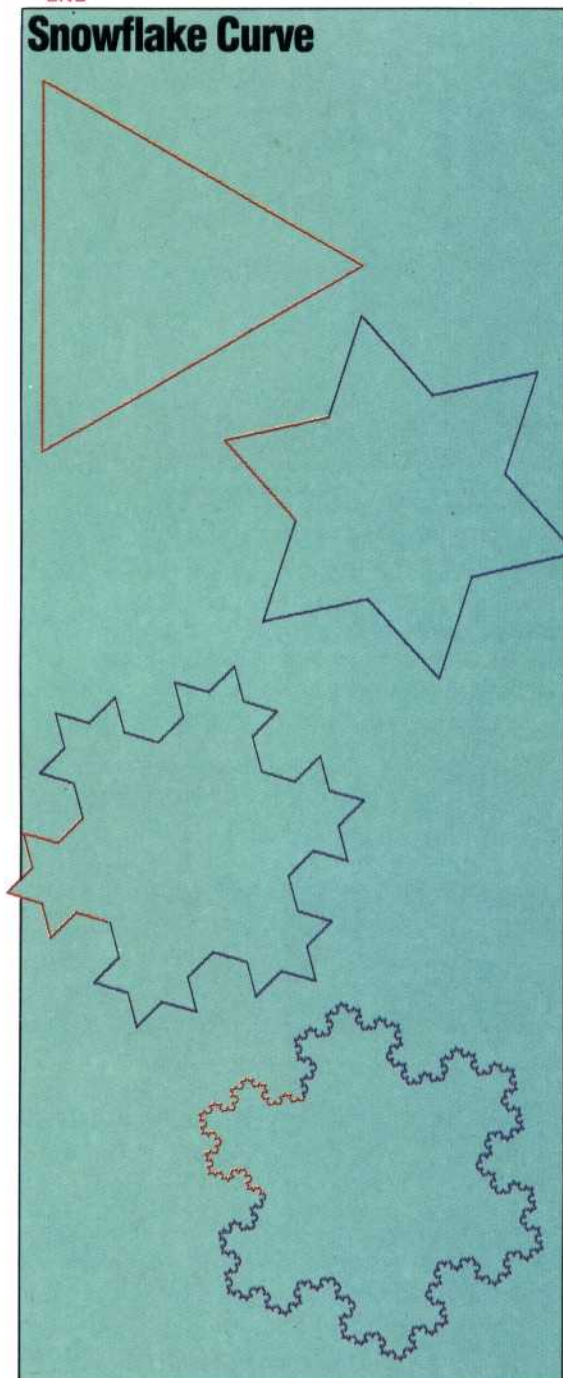


each side of the new shape, and continue the process. The resultant shape is often called the 'snowflake curve' because of its appearance.

```
TO SNOW :SIZE :LEVEL
  REPEAT 3 [SIDE :SIZE :LEVEL RT 120]
END
```

```
TO SIDE :SIZE :LEVEL
  IF :LEVEL = 0 THEN FD :SIZE STOP
  SIDE (:SIZE / 3) (:LEVEL - 1)
  LT 60
  SIDE (:SIZE / 3) (:LEVEL - 1)
  RT 120
  SIDE (:SIZE / 3) (:LEVEL - 1)
  LT 60
  SIDE (:SIZE / 3) (:LEVEL - 1)
END
```

### Snowflake Curve



Notice that SIDE is not state transparent, but instead has been constructed so as to leave the turtle in the correct place for drawing the next side.

If this process of division is continued indefinitely (mathematicians use the phrase 'in the limit'), the result is a curve that has infinite length and yet surrounds a finite (fixed) area! It is possible to prove that this curve is neither one-dimensional nor two-dimensional, but is instead somewhere between the two.

A similar curve may be built up by starting with a square, dividing each side into three equal parts, constructing squares on the middle sections, and so on. Try writing a procedure that does this.

### SPACE-FILLING CURVES

The series of curves shown here was invented by a mathematician called Sierpinski. If the process is continued in the limit, the result is a curve (a one-dimensional line) that passes through every point of the surrounding square (a two-dimensional shape). There are many other 'space-filling curves' that exhibit this strange behaviour.

The procedure used for drawing this curve is fairly complex. The level 1 curve is made up of four sides (shown in blue) that are joined by four diagonals (shown in red). So the main procedure, SIERP, just divides the process into four sections for the procedure ONE.SIDE to handle one at a time.

Consider just one of the sides. This is made up of three lines — a diagonal, a horizontal or vertical line, then another diagonal. At level 2, each diagonal is replaced by another, smaller, set of three lines, and the horizontal or vertical line is replaced by two similar sets of three joined by a line. The same process is carried out to move from level to level.

Here are the procedures for drawing the curves. Notice how the LOGO command MAKE is used to initialise DIAG:

```
TO SIERP :SIDE :LEVEL
  MAKE "DIAG :SIDE / SQRT ( 2 )
  REPEAT 4 [ONE.SIDE :LEVEL RT 45 FD :DIAG RT 45]
END
```

```
TO ONE.SIDE :LEVEL
  IF :LEVEL = 0 STOP
  ONE.SIDE (:LEVEL - 1)
  RT 45
  FD :DIAG
  RT 45
  ONE.SIDE (:LEVEL - 1)
  LT 90
  FD :SIDE
  LT 90
  FD :SIDE
  LT 90
  ONE.SIDE (:LEVEL - 1)
  RT 45
  FD :DIAG
  RT 45
  ONE.SIDE (:LEVEL - 1)
END
```