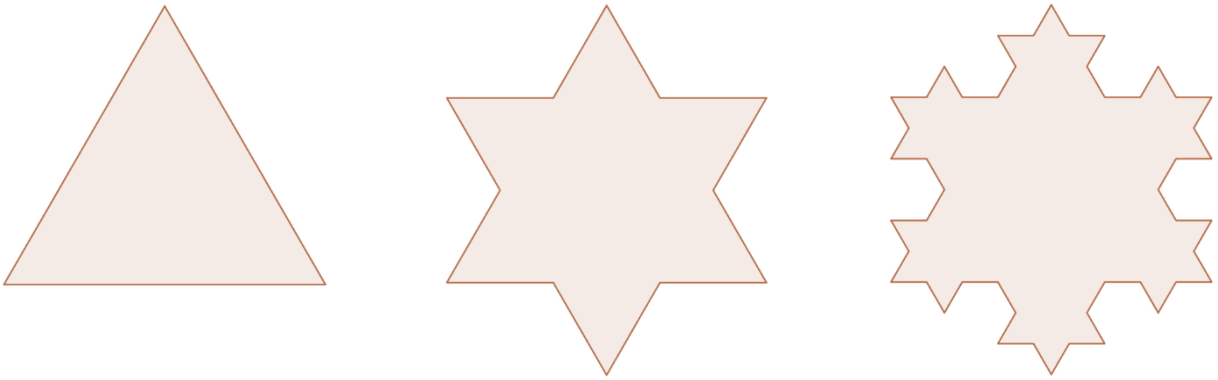
Task Y: <u>Construction of the Koch snowflake</u>

The Koch snowflake is a fractal curve. To construct a dynamic worksheet to create the first few patterns of the Koch snowflake.



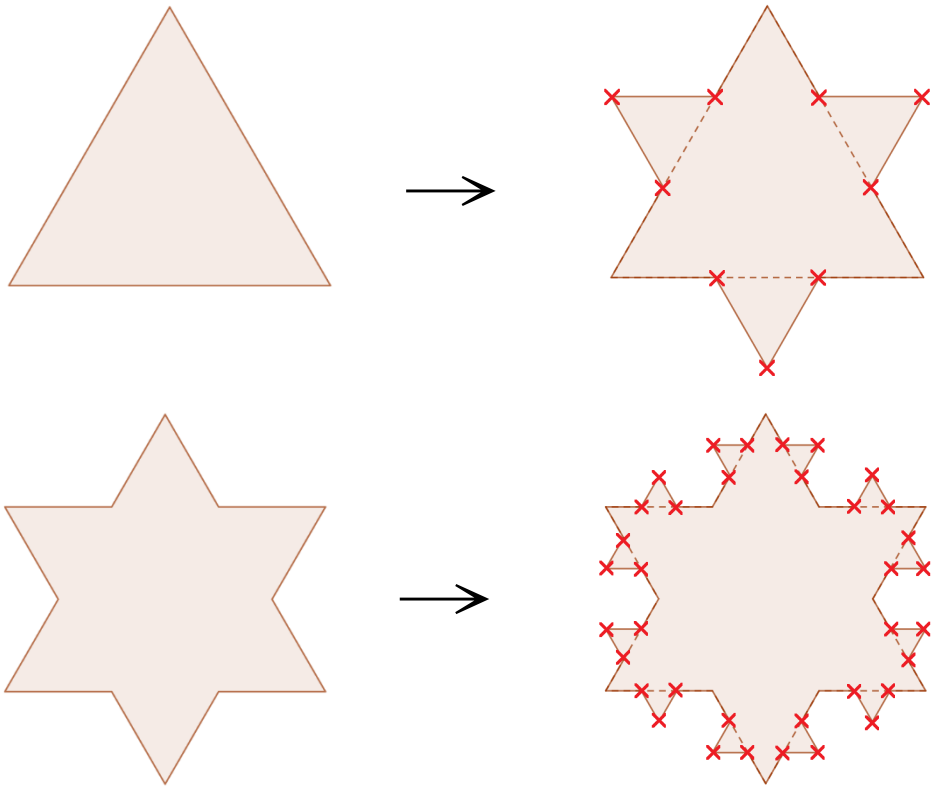
Basic steps for the creation:

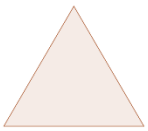
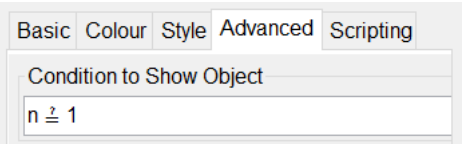
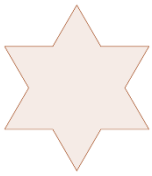
Starting with an equilateral triangle, then recursively altering each line segment as follows:

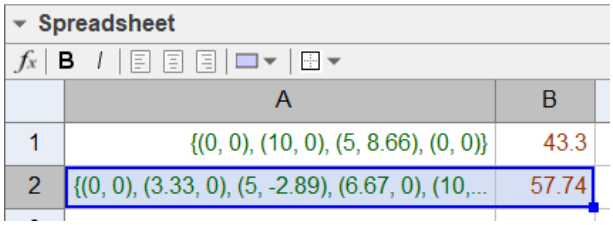
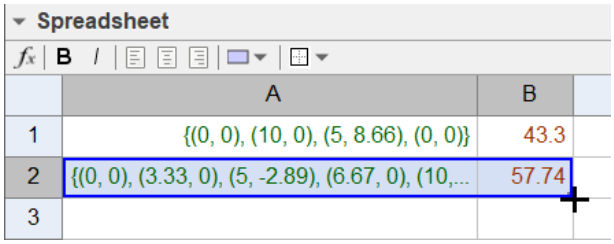
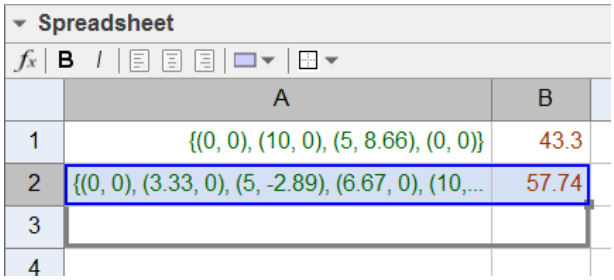
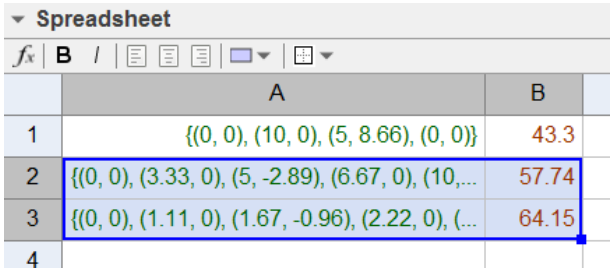
1. Divide the line segment into three segments of equal length.
2. Draw an equilateral triangle that has the middle segment from step 1 as its base and points outward.
3. Remove the line segment that is the base of the triangle from step 2.

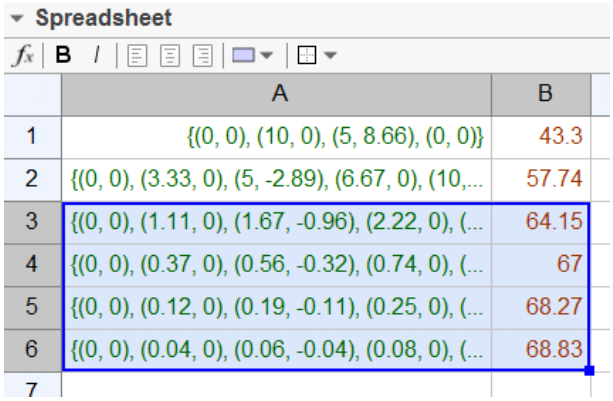
What we do in GeoGebra:

Based on the 2 end points of each line segment of the current pattern, create 3 new points for each line segments and join the points in correct order to get the new pattern.



Steps	Objects to be created	Action
1.	Slider n	 ◆ Select "Slider" button and click on the graphics window ◆ Set the name of the slider as n; min = 1; max = 3; increment = 1 ◆ Click "OK"
2.	Points A, B and C	◆ Click in the Graphics window on (0, 0) and (10, 0) to create points A and B. ◆ Type the following command in the input bar to create point C: **C = Rotate(B, 60°, A)**
3.	An equilateral triangle (the 1st pattern) 	◆ Open the spreadsheet window ◆ In cell A1, input **{A, B, C, A}** ◆ In cell B1, input **=Polygon(A1)** ◆ In the Advanced Tab of the properties of polygon B1, input "n = 1" as a condition to show object. 
4.	The 2nd pattern 	◆ In cell A2, input **Flatten(Sequence(If(i < Length(A1), {A1(i), (2A1(i) + A1(i + 1)) / 3, Rotate(A1(i), 120°, (2A1(i) + A1(i + 1)) / 3), (A1(i) + 2A1(i + 1)) / 3}, {A}), i, 1, Length(A1)))** ◆ In cell B2, input **=Polygon(A2)** ◆ Remark: ■ **A1(i)** is the same as **element(A1,i)** ■ **(2A1(i) + A1(i + 1)) / 3, Rotate(A1(i), 120°, (2A1(i) + A1(i + 1)) / 3), (A1(i) + 2A1(i + 1)) / 3** are the 3 new points created for each line segments ■ The command **If(i < Length(A1), {*the 3 new points*} , {A})** checks that new points will be created for every elements stored in cell A1, except the last element (A) ■ **Sequence(… , i, 1, Length(A1))** will generate a list of objects according to the number of elements in cell A1

5.	The 3rd pattern	◆ Select cell A2 and B2  ◆ Hover the mouse cursor over a small square at the lower right-hand corner of the cell, and the mouse cursor will become a plus sign  ◆ Hold and drag the plus sign down the column to the 3rd row to copy the formula   ◆ In the Advanced Tab of the Object Properties of B2 and B3, input “n = 2” and “n = 3” respectively as the conditions to show objects.
6.	Checking of the first 3 patterns	◆ Move the point on the slider of n to check that the first 3 patterns can be shown correctly.
7.	Adjust the max of slider of n	◆ Change the max of slider of n to 6.

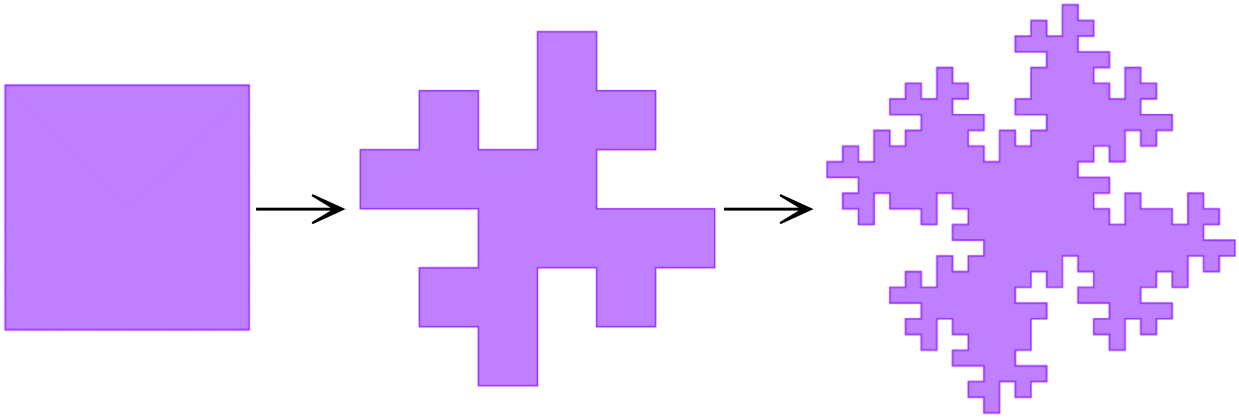
8.	The 4th, 5th and 6th pattern	◆ Similar to step 5, select cell A3 and B3 and copy the formula up to the 6th row.  ◆ In the Advanced Tab of the Object Properties of B4, B5 and B6, input “n = 4”, “n = 5” and “n = 6” respectively as the conditions to show objects.

Spreadsheet

	A	B
1	{(0, 0), (10, 0), (5, 8.66), (0, 0)}	43.3
2	{(0, 0), (3.33, 0), (5, -2.89), (6.67, 0), (10,...	57.74
3	{(0, 0), (1.11, 0), (1.67, -0.96), (2.22, 0), (...	64.15
4	{(0, 0), (0.37, 0), (0.56, -0.32), (0.74, 0), (...	67
5	{(0, 0), (0.12, 0), (0.19, -0.11), (0.25, 0), (...	68.27
6	{(0, 0), (0.04, 0), (0.06, -0.04), (0.08, 0), (...	68.83
7		

Exercise:

Try to construct a GeoGebra file that can create the Minkowski Island up to the 4th pattern.



For the Minkowski Island, each unit of line segment is altered in the following way: