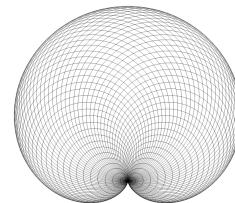# CARDIOID PATTERN STRING ART

Get to the heart of mathematics with cardioid pattern string art!

SUPPLIES & TOOLS:

- Hexagon cork board tile
- Embroidery thread (2 skeins)
- Escutcheon pins (36)
- Compass
- Protractor
- Pen

WHAT IS A CARDIOID PATTERN?

A cardioid is a mathematical shape resembling a heart, or a cross section of an apple. A cardioid shape can be created by following the path of a point on a circle as the circle rolls around another fixed circle, with both of the circles having the same radius. The name was coined by de Castillon in 1741, an Italian mathematician and astronomer.

A cardioid is essentially a drawing of a times table! The shape of the cardioid changes depending upon the points of contact between the circles and the multiplication factor used to move around the circle. The number of "petals" of the cardioid is always n-1, where n is the multiplication factor.

VIDEOS & VISUALIZATIONS

- Times Tables, Mandelbrot and the Heart of Mathematics: https://youtu.be/qhbuKbxJsk8
- How to make mathematical string art: make a cardioid: https://youtu.be/98FkwaSMQ_k
- Cardioid Modular Multiplication Table graph: https://www.desmos.com/calculator/twg4tv0egq
- Demo String Art - Cardioid: https://www.geogebra.org/m/qpmn8rjj

HOW TO MAKE (1/2)

FIRST, DESIGN YOUR CIRCLE:

1. **Find the center:** Use a ruler or a sheet of paper to make a line from one corner of the tile to the opposite corner. Do this again for 2 other corners. This will reveal the center of the circle; mark an x.
2. **Draw a circle:** Take the compass and use a nail to affix the middle of the protractor (the metal hole) to the middle of the circle. Use the M1 hole to draw a circle. Don't make it any bigger - you'll need to write on the outside of the circle! Remove the compass.
3. **Mark your points:** Take the protractor and use a nail to affix the protractor to the middle of the circle. For 36 points, mark a point every 10 degrees on the circle you drew.
4. **Number your points:** Number your points from 0-35 on the outside of the circle.
5. **Nail your points:** Insert a nail into every point on the circle.
   TIP: insert all the nails just a little, then use the protractor to further push down multiple nails at once. The nails should be firmly in the cork, but not sticking out of the back. Make sure they're straight too!

Missed the PNG workshop? Need help?
HOW-TO PICTURES & LINKS AT:
carbondalepubliclibrary.org/png
EMAIL MISS LIZ:
ehartman@carbondale.lib.il.us

WARNING: SHARP!
USE CAUTION!
Work on a flat, solid surface, NOT your lap!

THEN, STRING YOUR ART:

1. **Start at 0:** Tie a thread end to point 0. Don't leave too much tail; you'll need the whole thread to draw the pattern.
2. **Begin multiplying: Drawing a cardioid pattern entails drawing lines from a <u>start point (x)</u> to an <u>end point (y)</u>, where y is the start point multiplied by a given factor. We're using 2, so, y=x*2. After reaching an end point, you draw back to the next start point, which is just the next number in the start point series (0, 1, 2, 3...)**
   To "draw" these lines, loop the thread from start point to end point to start point to end point... Make sure the thread has tension, or it will become unraveled as you work - but don't pull too tight, or the nails will pull out.
   TIP: Keep your thumb on your current starting point to keep track and to secure the thread as you work.
   a. First line: Easy! The start and end point are the same: if x=0, then y=0. Then, loop your string from this endpoint (0) to the next starting point (1).
   b. Second line: if x=1, then y=2. So, thread your string from 1 to 2. Then, since this endpoint is the same as the next starting point (2), we can move on:
   c. Third line: if x=2, then y=4. So, thread your string from 2 to 4. Then, loop your string from this endpoint (4) to the next starting point (3).
   d. Fourth line: if x=3, then y=6. So, thread your string from 3 to 6. Then, loop your string from this endpoint (6) to the next starting point (4).
   e. Keep going! Eventually, at start point 18, the end point series will start over, meaning each end point will be 36-y. So, if x=18, then y=36, which is point 0.
   f. When you reach start point 0 again, you've drawn your cardioid! Tie off the string and cut off the ends.
   g. Repeat this process with another skein of embroidery thread to accentuate your design.

CARDIOID PATTERN STRING ART TIMES TABLE

36 points start point series	MULTIPLICATION FACTOR: 2	number restart:
START POINT (x):	END POINT (y):	
0	0	
1	2	
2	4	
3	6	
4	8	
5	10	
6	12	
7	14	
8	16	
9	18	
10	20	
11	22	
12	24	
13	26	
14	28	
15	30	
16	32	
17	34	
18	36	*0*
19	38	*2*
20	40	*4*
21	42	*6*
22	44	*8*
23	46	*10*
24	48	*12*
25	50	*14*
26	52	*16*
27	54	*18*
28	56	*20*
29	58	*22*
30	60	*24*
31	62	*26*
32	64	*28*
33	66	*30*
34	68	*32*
35	70	*34*

Spreadsheet (with multiplication factor and number restart formulas):
https://docs.google.com/spreadsheets/d/1dZSRsaK-Hycqrza674iGfxd5oc9bsvO9VVpZn-5Rgd0/edit?usp=sharing