Knitting and Crochet in Mathematics

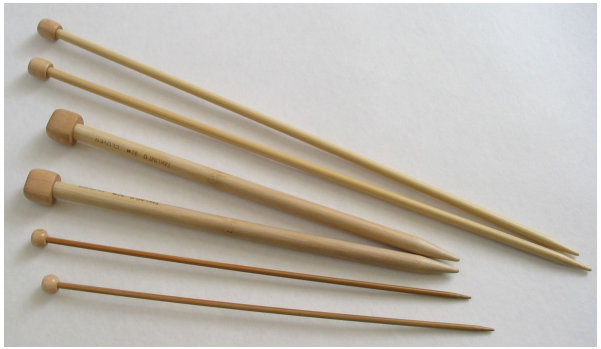
By Andy Fisher and Rachel Vasan

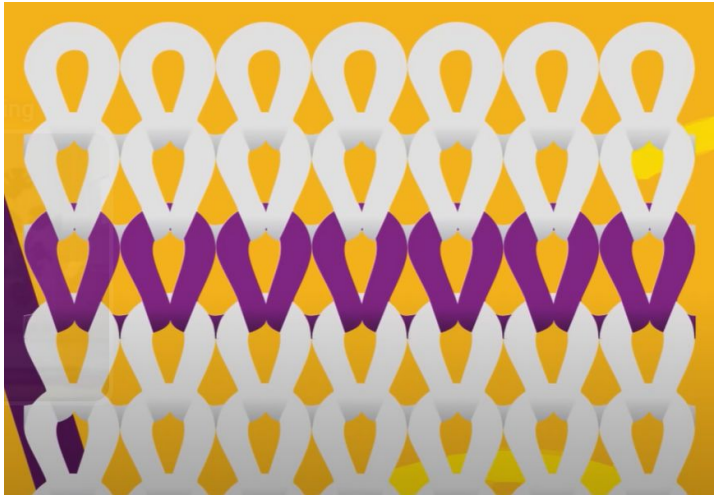
What are we doing today?

1. Introduction
    a. What is knitting?
    b. What is crochet?
    c. How are they different?
2. Basic Mathematics
    a. How does math relate to knitting, crochet, and their differences in a basic sense?
3. Connections between knitting/crochet and math
    a. Crochet and fractals
    b. Crochet and hyperbolic space
    c. Knitting and topology
    d. Machine knitting
4. Knitted/Crocheted mathematical objects

Introduction: What is Knitting?

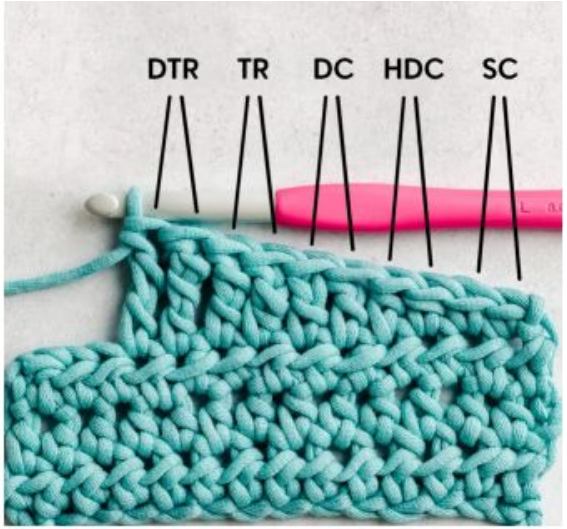
- 2 Needles
- Many Types of Stitches
- Stockinette Stitch
  - Right and Wrong Side
- Many “active/live” Stitches
- Yarn goes in Row

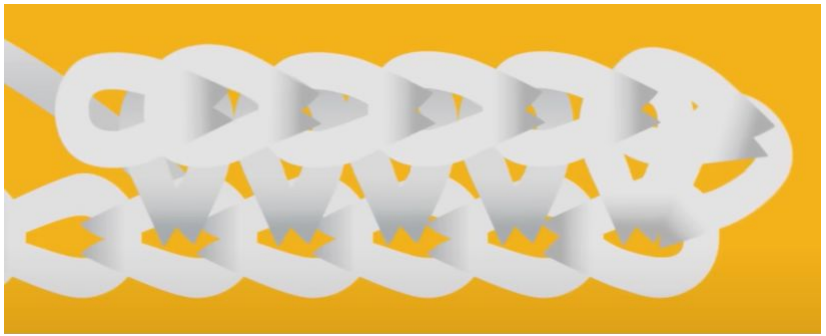




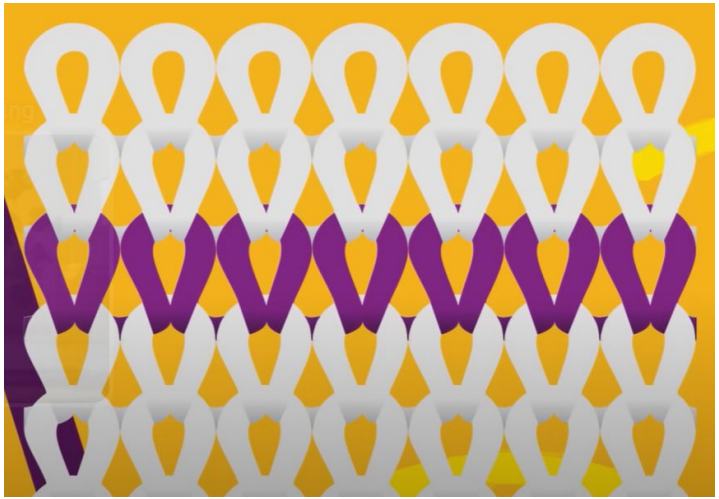
Introduction: What is crochet?

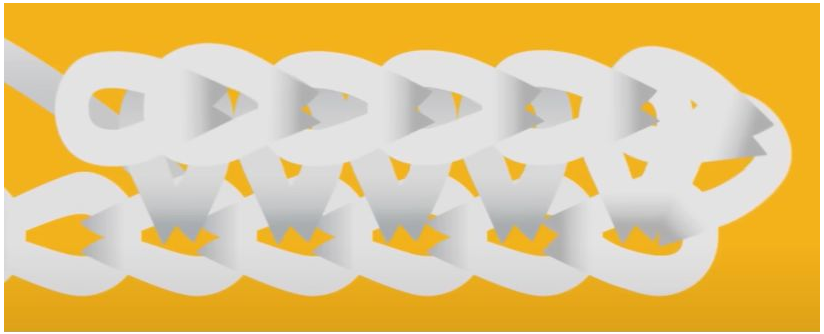
- Uses yarn and a hook
- Lots of variation in stitches:
  - Single crochet
  - Half-double crochet
  - Double crochet
  - Triple crochet
  - Double Triple crochet
- One “active stitch” at a time
- Stitches are looped top to bottom and side to side





Visual: how are knit/crochet stitches constructed differently?



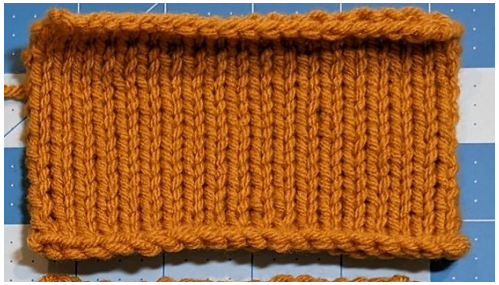


https://youtu.be/U1bk4ZI0Qvc?si=CuhxRp7A7FKI_4Ba&t=76

https://youtu.be/EImnSsCadK8?si=Vi6RcjiKfGI0Cdjw&t=93 (1:48-1:56)

Other differences & Basic Math Principles

- Yarn usage
  - Crochet Uses More
- Size
  - Crochet is Larger
- Time
- Counting Stitches
- Gauge Swatching
- Increases and Decreases
- Scaling Patterns



Fractals

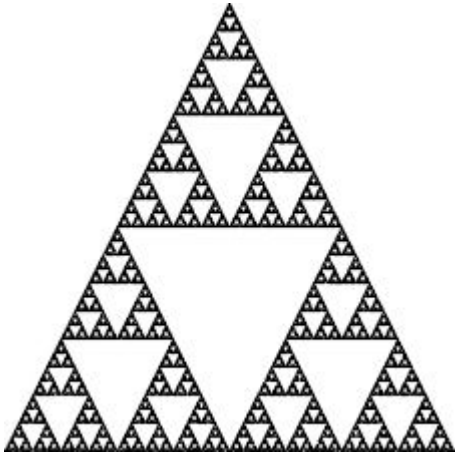
- **Fractal** = a never-ending pattern; infinitely complex patterns that are self-similar across different scales
    - If you “zoom in”, the image you see will look essentially the same

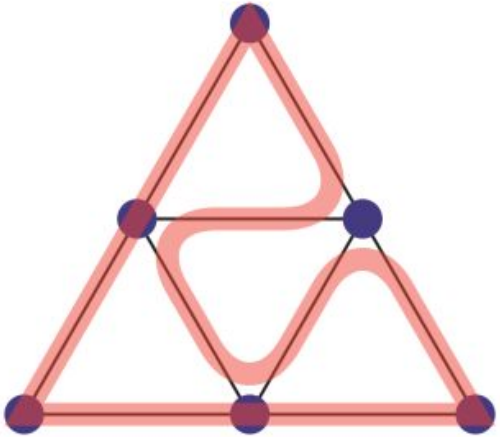
Fractal Crochet

- **Fractal Crochet** = Using crochet to model fractals; developing crochet patterns using the concept of fractals

Fractal Crochet - How do you do it?

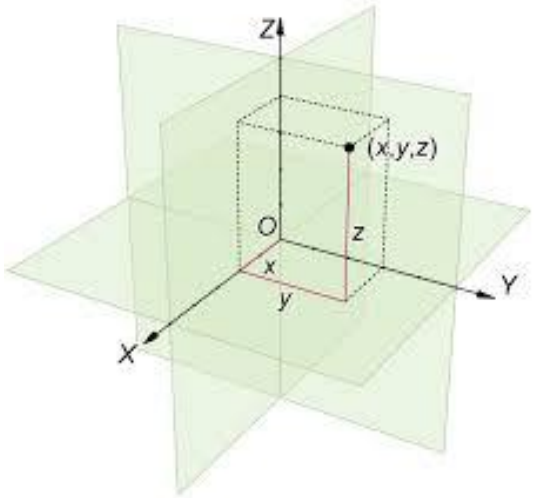
- In a general sense, you can use the concept of fractals to create a crochet pattern by repeating the same set of stitches over and over again
- Example: Sierpinski Triangle

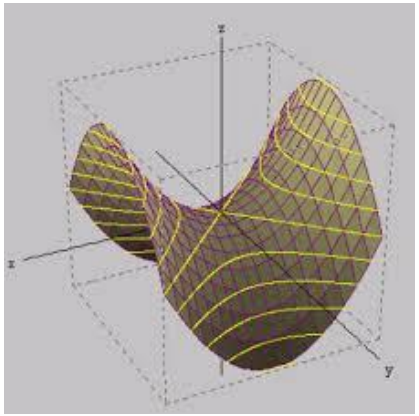




Hyperbolic Space - What is it?

- **Hyperbolic Space** = Non-Euclidean space
- **Euclidean ("Normal") Space** = Space that satisfies Euclid's Parallel Postulate
  - In Euclidean space, if we are given some line *l*, and some point P, there is a unique line – say *t* – such that *t* passes through P and is parallel to *l*
- Properties of hyperbolic planes
  - Every point on a hyperbolic plane is a saddle point
  - Hyperbolic planes have negative Gaussian curvature

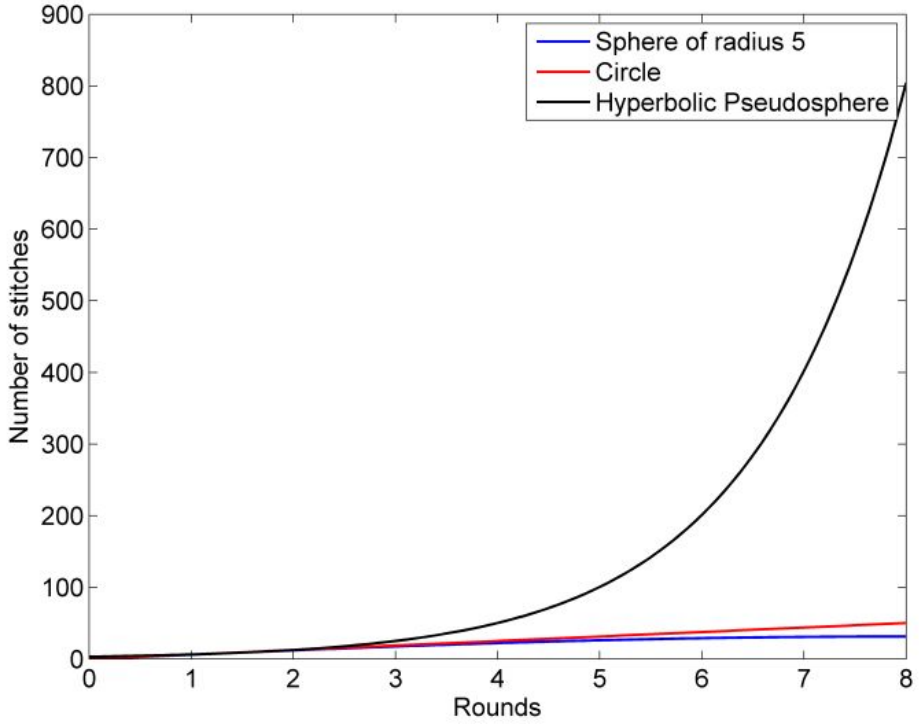




Curvature and Crochet

- Crocheting a flat circle (zero curvature)
  - Linearly increasing stitches in each round
- Crocheting a sphere (pos. curvature)
  - Stitches increase at a slower rate per row
- Crocheting a hyperbolic pseudosphere (neg. curvature)
  - Stitches increase exponentially per row (hyperbolic crochet)

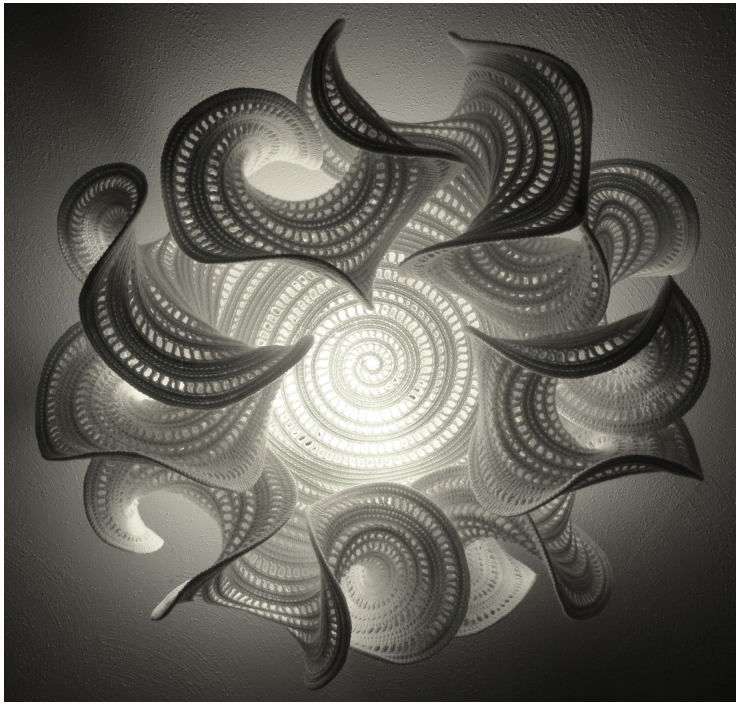
Crochet Curvature and Stitches per Row



Hyperbolic Crochet

- **Hyperbolic Crochet** = using crochet to model hyperbolic space; creating crochet art that mimics hyperbolic space

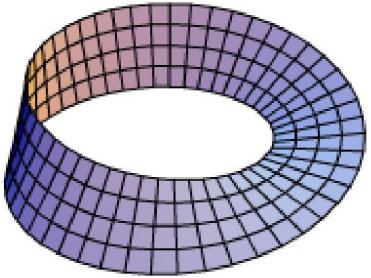
Some Beautiful Hyperbolic Crochet Art by Gabriele Meyer



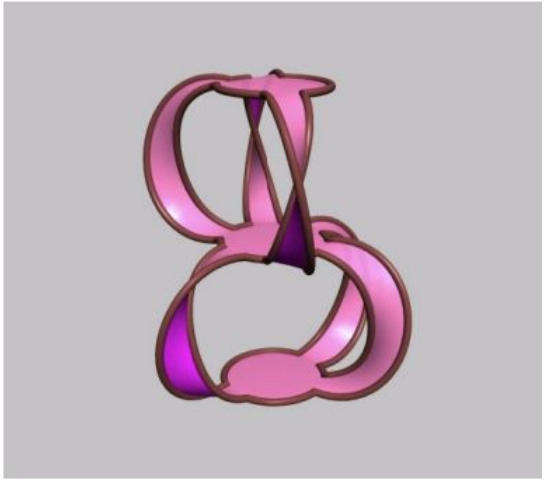
Crochet Coral Reef by Christine and Margaret Wertheim

Knitting and Topology

- Intro to Topology
  - Surface - connected discs/rectangles
  - Knit Rectangles and Connect them
  - Not Simply Connected
- Start With Shape then Generate Pattern
- ⅔ stitches * rows
  - Wider than they are tall

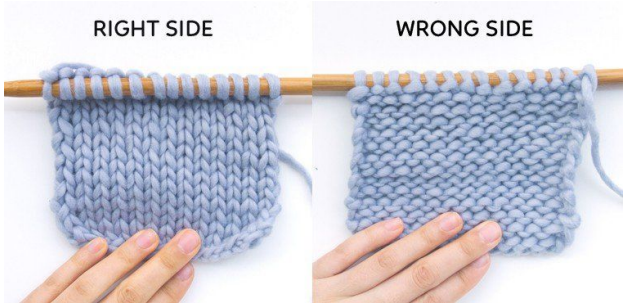


Seifert Surfaces



Continued

- Can be computer generated
- Lie Groups, Homeomorphisms
- Geometric Information
  - Add Metric
- Negatives
  - Front and Back

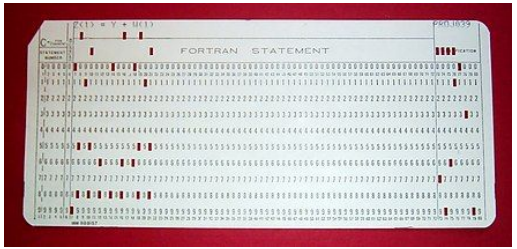


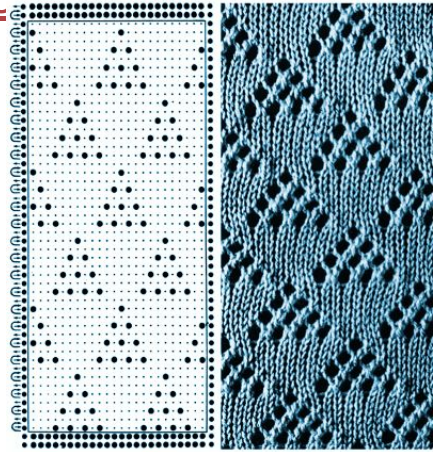
Machine Knitting and the Analytic Engine

- Quick History
- How does a knitting machine work?
  - Flatbed
- https://youtu.be/AwFmx2xWR7w?si=9ijc_k2TGDK_Wzxi&t=33
- https://youtu.be/xYzK15yVjXw?si=VA1-zCDNLFHHtD4e&t=316

Machine Knitting and the Analytic Engine

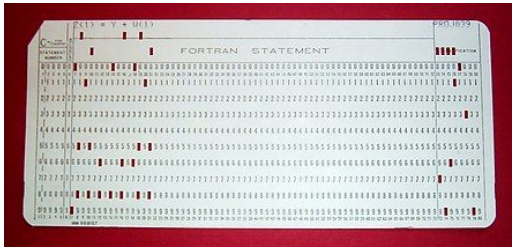
- Lace Knitting
  - Manually Move Stitches
- How does the card work
- First Machine to Use Punch Cards to Automate Instructions
- https://youtu.be/7KFJ-zas4i4?si=IgLIBvSLTm5rU6gu&t=403

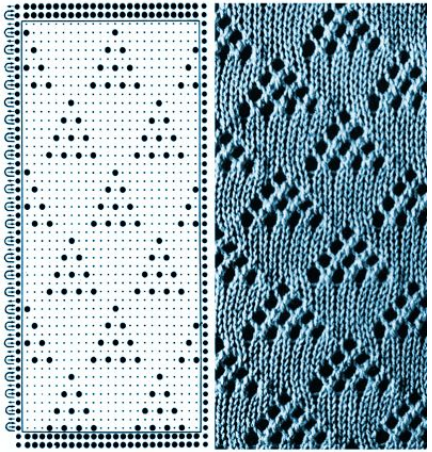




Machine Knitting and the Analytic Engine

- Analytic Engine
  - Charles Babbage
  - Ada Lovelace
  - First Computer
  - Started as a Difference Engine
  - Perform Calculations





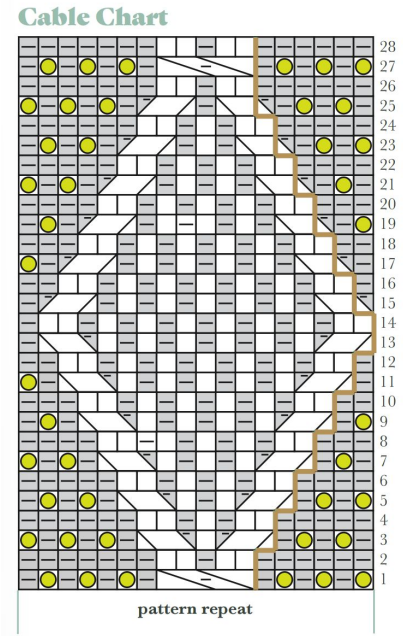
Knitting as Coding

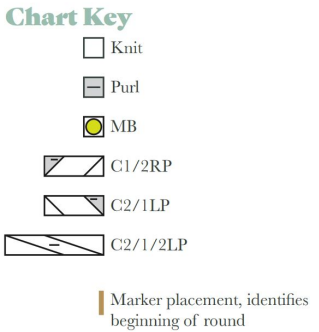
- Similarities
  - Loops
  - Patterns
  - Symbols
  - Testing
- Programs Invented for Hand-Knitting
  - KnitML
  - KEL

Knitting as Coding

Begin Crown Decreases:

Rnd 1: Sl last 2 sts of rnd onto cn, hold back, sl m to RH ndl, *(k2; p2tog from cn, k1), (sl 2 to cn, hold front, p2tog; k2 from cn), p2, (MB, p1) 2x, MB, p2, sl 2 sts to cn, hold back; rep from * 3 times more, (k2; p2tog from cn, k1), (sl 2 to cn, hold front, p2tog; k2 from cn), p2, (MB, p1) 2x, MB, p2 – 80 sts.





Symmetries in Knitting

Fun Things

- Dr. Hinke Osinga
  - University of Bristol
  - Started Knitting at 7
- Math as Tool for Knitters
- Crochet and Knitting to Visualize Mathematical Objects
  - Lorenz Manifold

Fun Mathy Objects

More Fun Mathy Objects

Even More Fun Mathy Objects