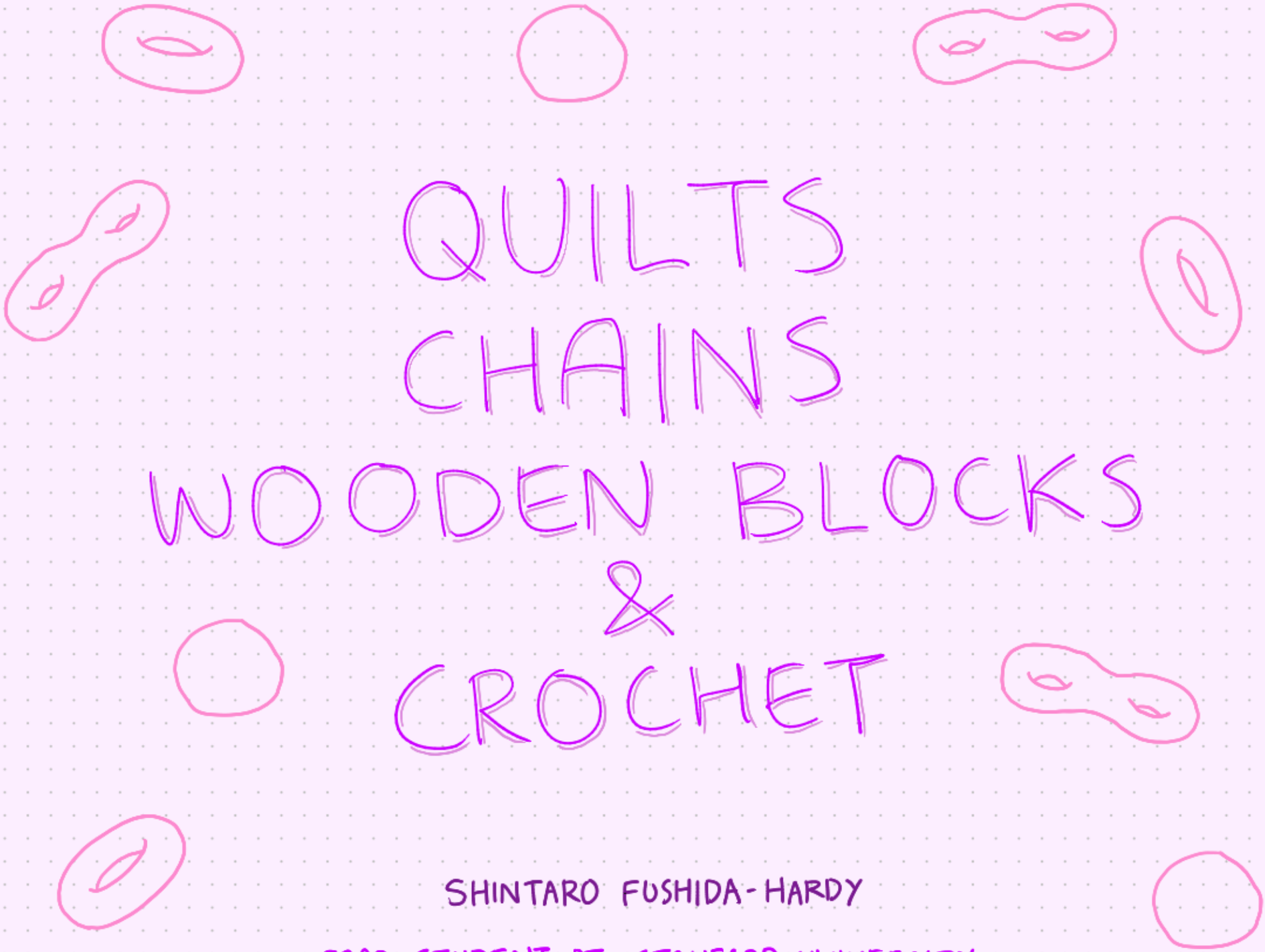


SHINTARO FUSHIDA-HARDY

GRAD STUDENT AT STANFORD UNIVERSITY

QUILTS

THE PERSISTENCE OF MEMORY

SALVADOR DALI.

QUILTS

UNTITLED 2023

ME!

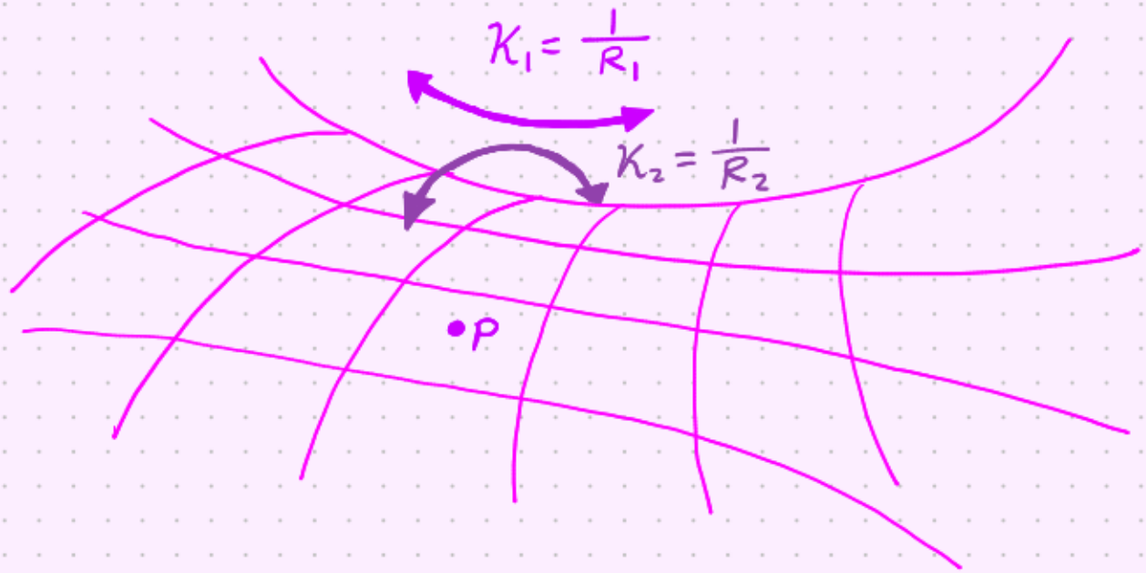
QUILTS

HYPERBOLIC SPACE

$\longleftrightarrow$

CONSTANT NEGATIVE CURVATURE

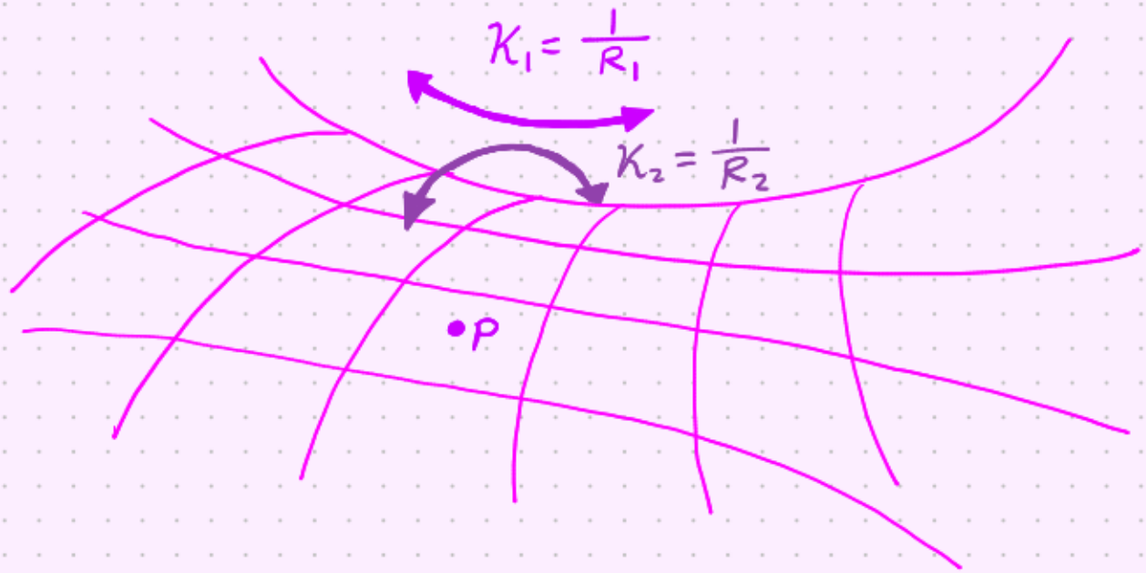
$K(p) = \kappa_1 \kappa_2$

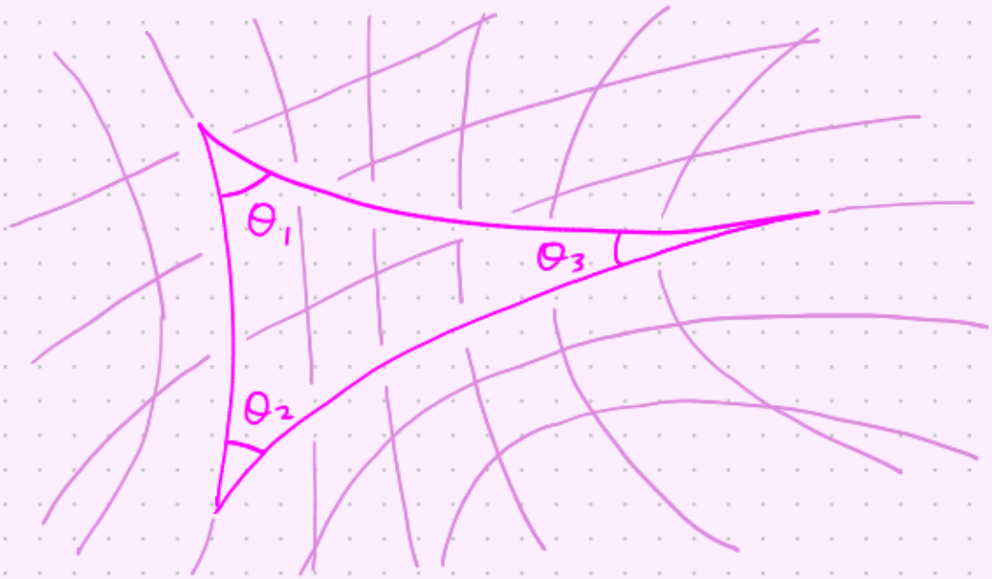


QUILTS

HYPERBOLIC SPACE
$\longleftrightarrow$
CONSTANT NEGATIVE CURVATURE

$K(p) = \kappa_1 \kappa_2$

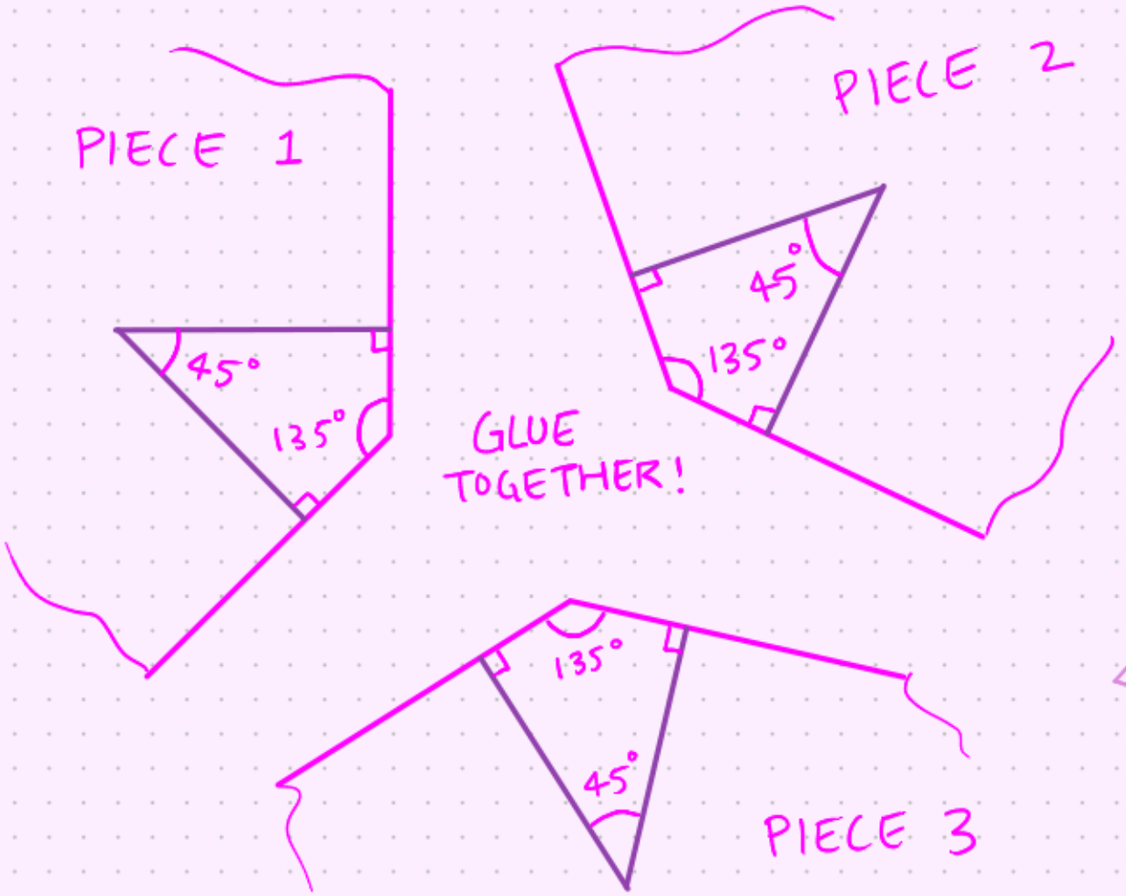




HYPERBOLIC
$\Rightarrow$
$\theta_1 + \theta_2 + \theta_3 < 180°$

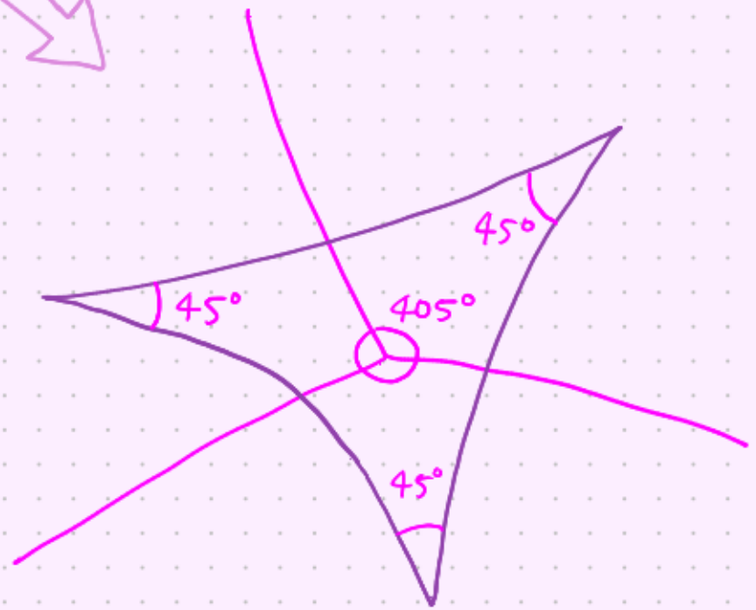
WHAT ABOUT THE CONVERSE?

QUILTS

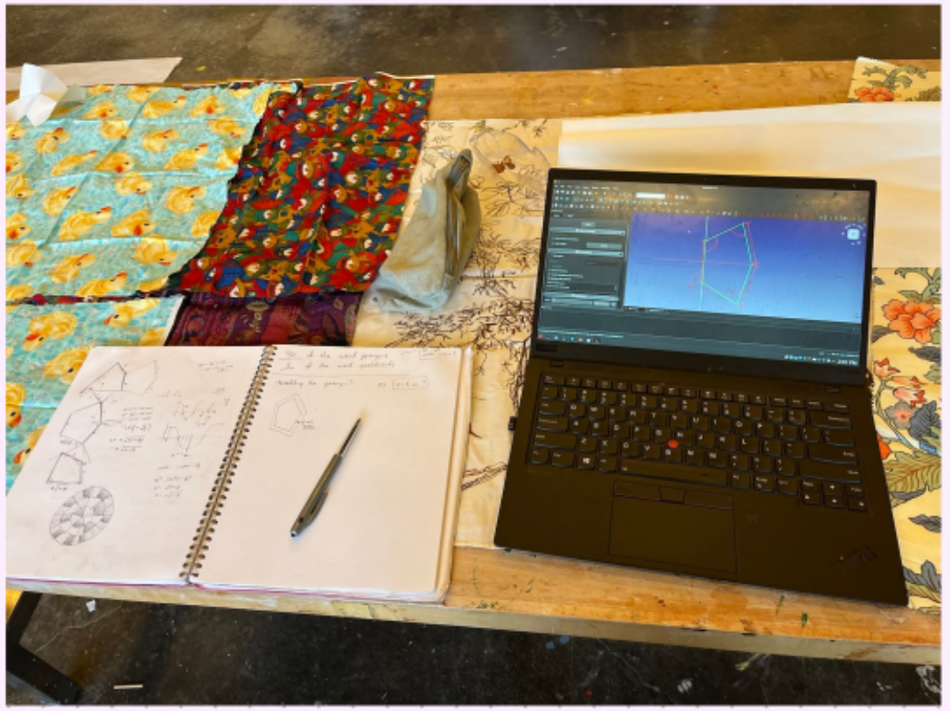


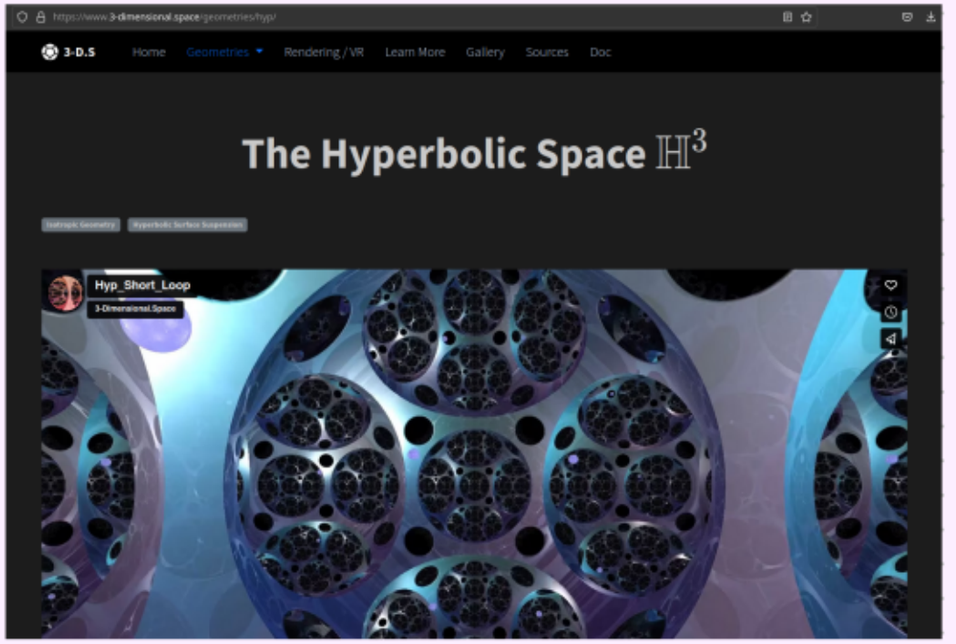
DISCRETE APPROXIMATION OF HYPERBOLIC SPACE:

"TILING" OR "QUILT" OF POLYGONS WITH VERTEX ANGLES > 360°



QUILTS

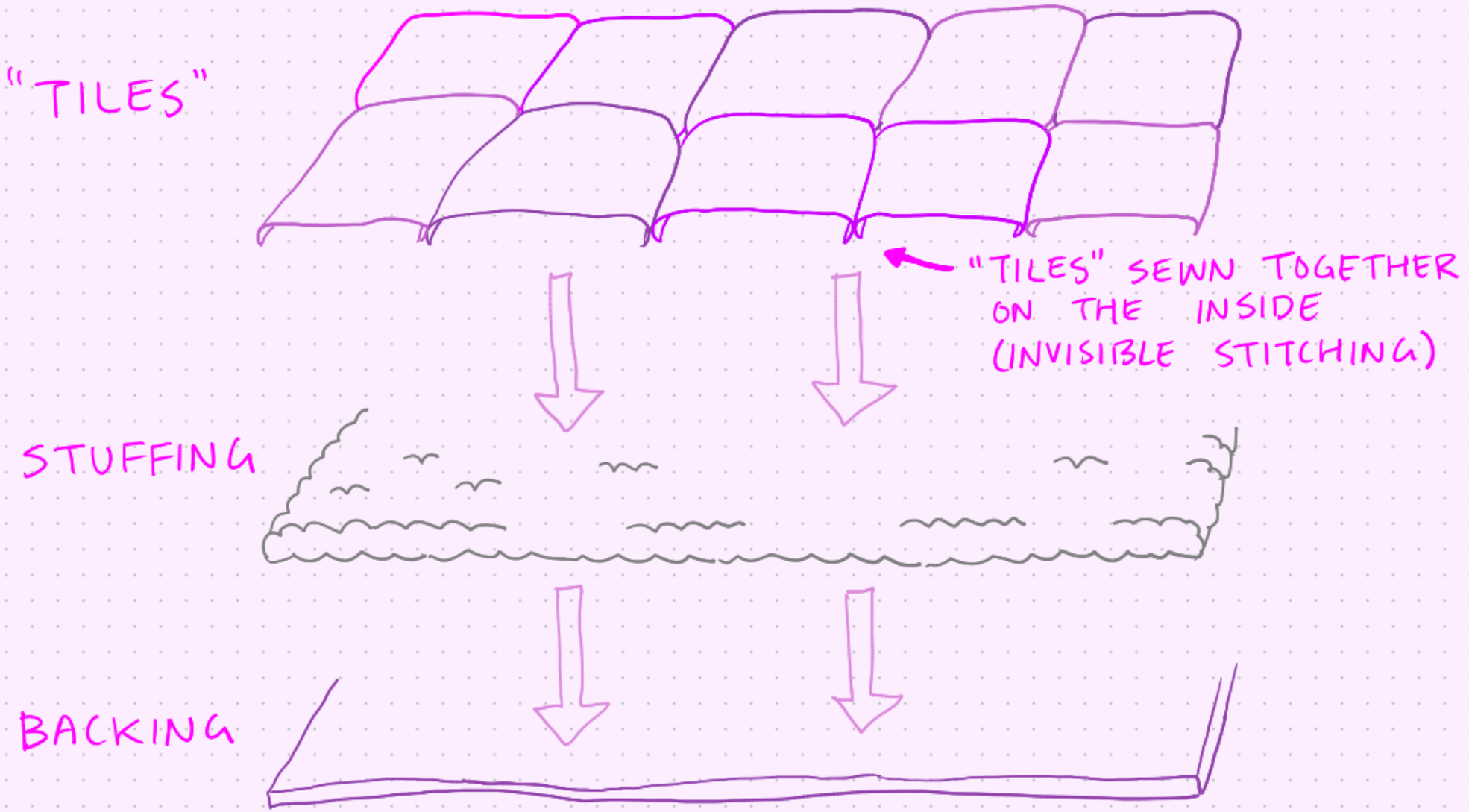




COOL VISUALISATIONS (1 dim higher) STEVE ET AL

QUILTS

ANATOMY OF A QUILT



LAYERS ARE CAREFULLY SEWN TOGETHER AT THE END

QUILTS

HYPERBOLIC QUILT CLOCK OBSERVATION: NO FINAL STITCHING NEEDED!

MORE FORMALLY: SOME RIGIDITY INDUCED BY ONLY FIXING THE BOUNDARY. WHY?!

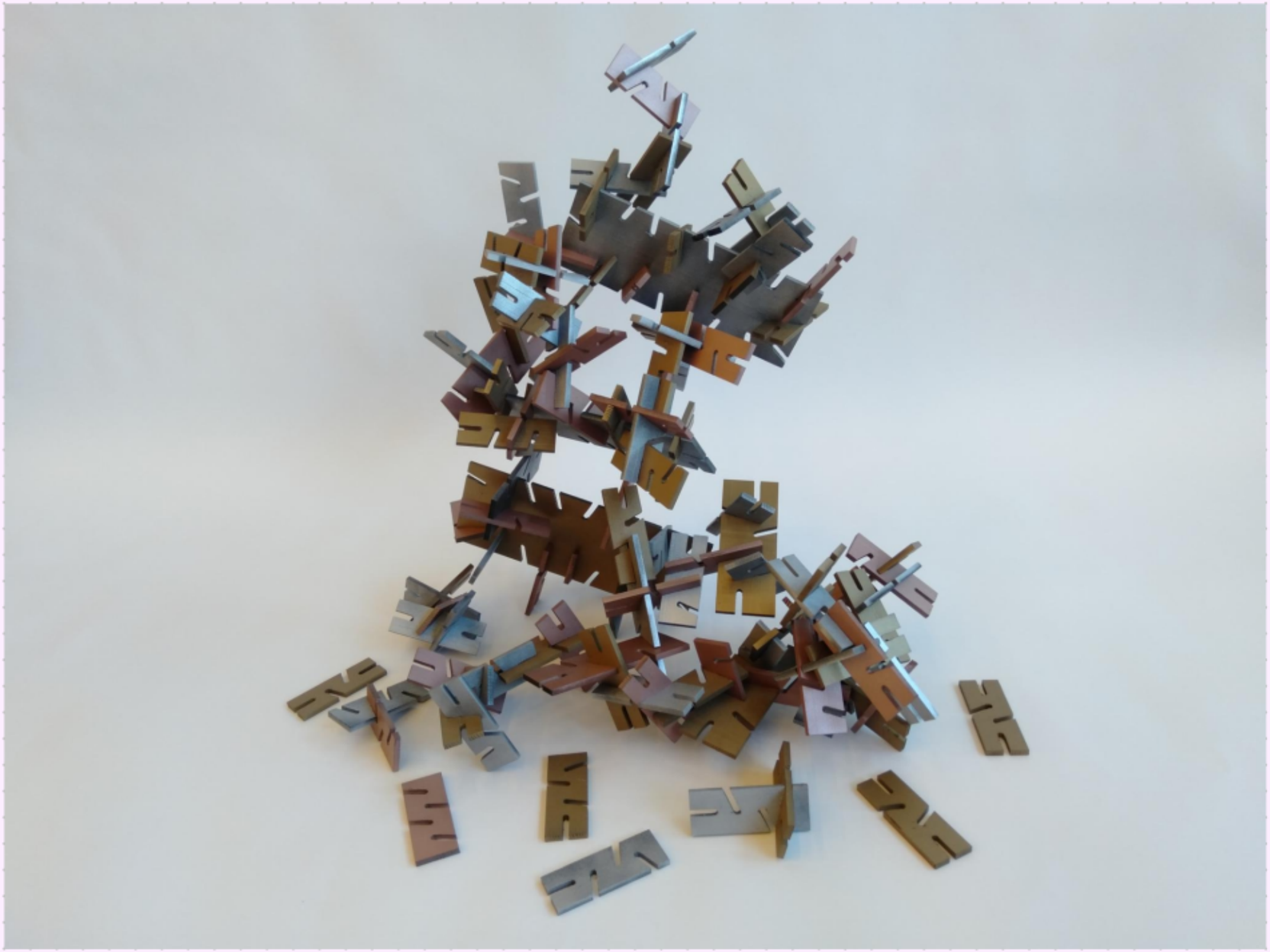
(JAYBIRD QUILTS)

QUILTS

QUESTIONS ?

WOODEN BLOCKS

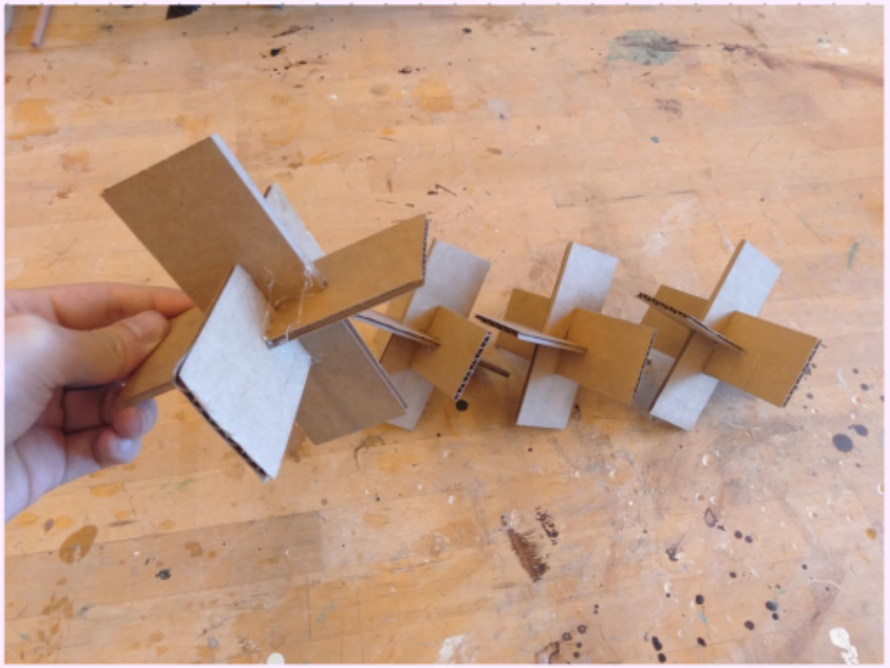
WOODEN BLOCKS



FLOWERMOUNTAIN, 2022

ME!

WOODEN BLOCKS



REGULARITY NOT THAT INTERESTING

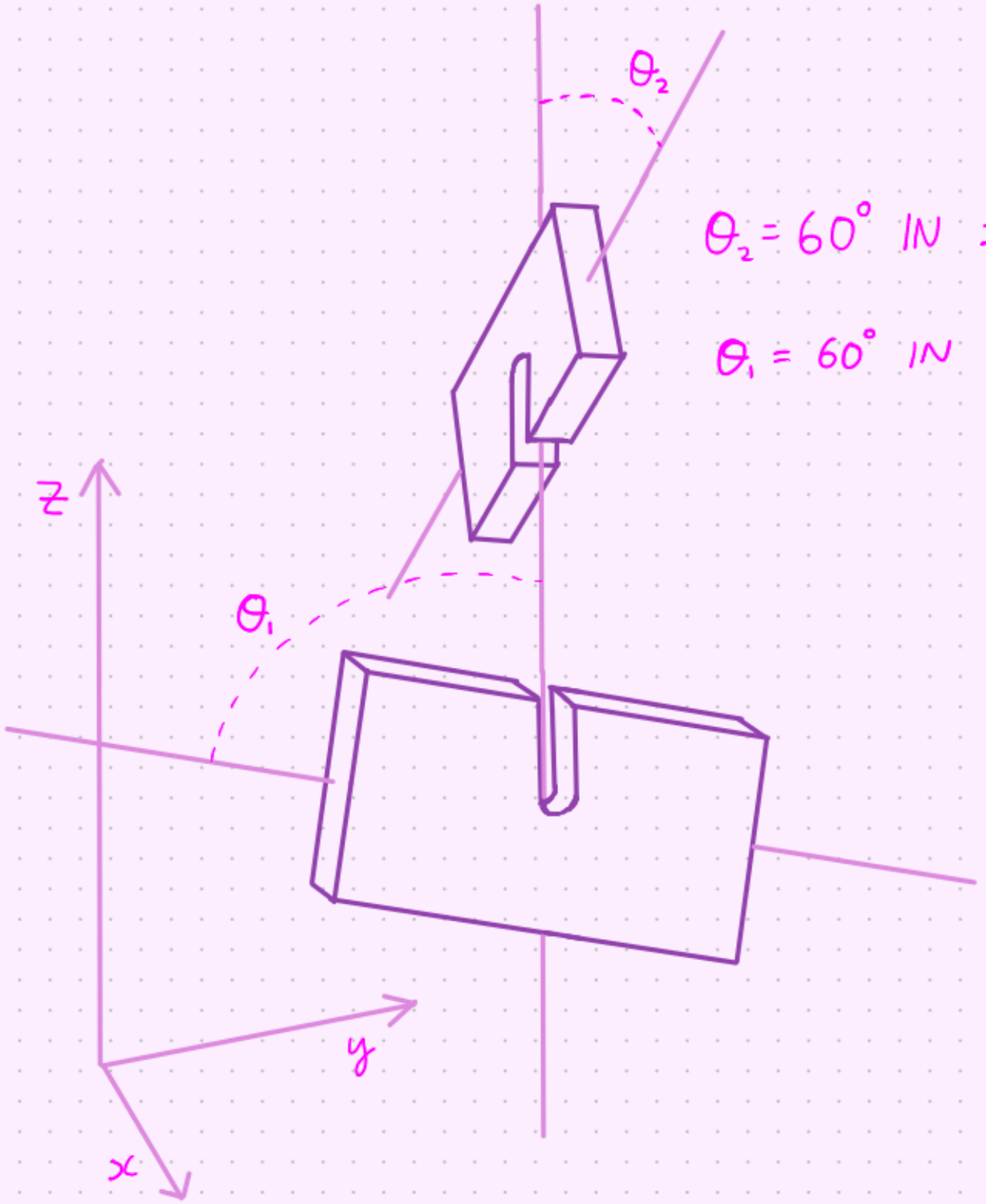
TRIED 60° CUTS...

SURPRISINGLY CHAOTIC!

TESTING PHASE

WOODEN BLOCKS

DOWN TO EARTH EXPLANATION:

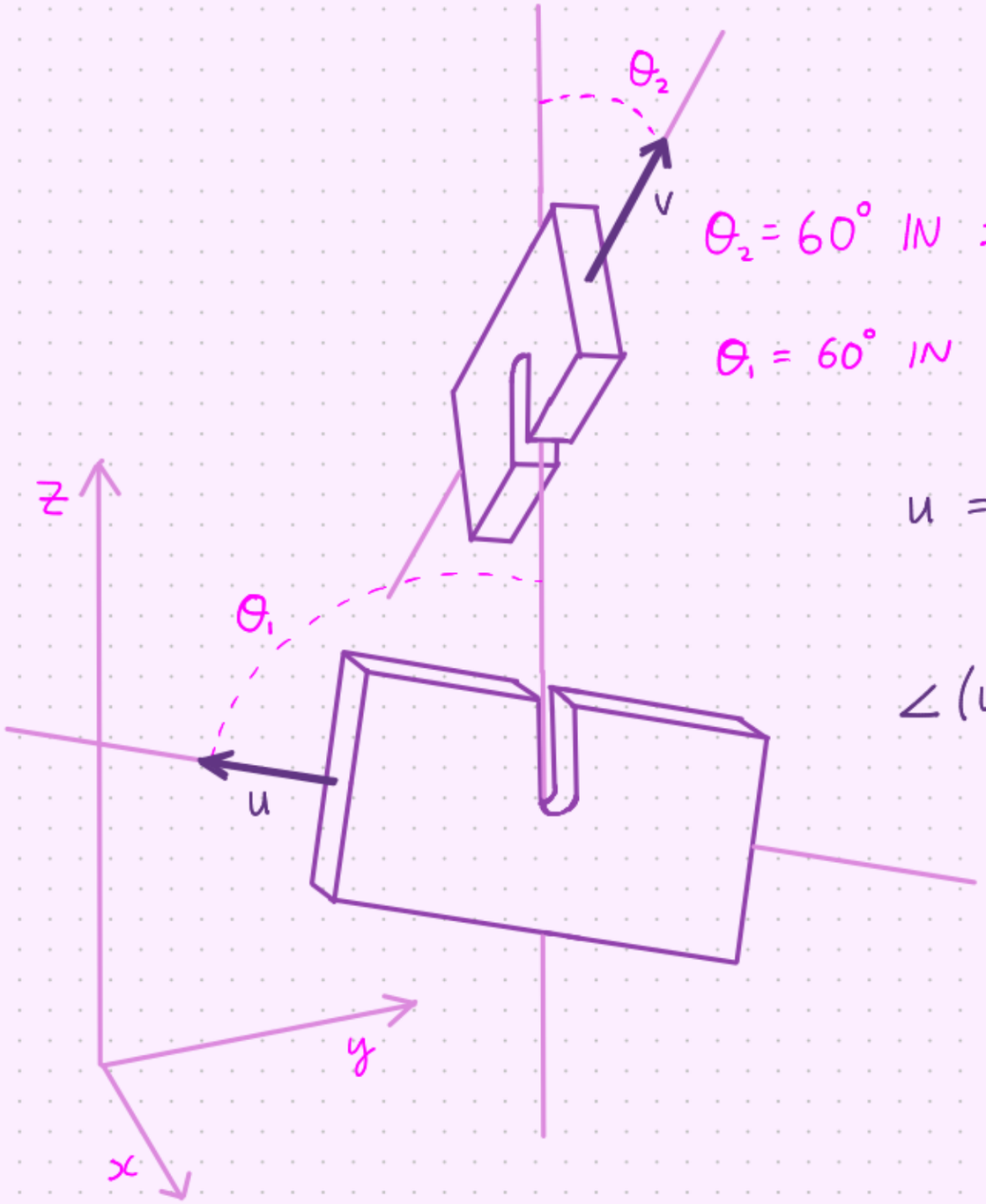


$\theta_2 = 60°$ IN x-z PLANE

$\theta_1 = 60°$ IN y-z PLANE

WOODEN BLOCKS

DOWN TO EARTH EXPLANATION:



$\theta_2 = 60°$ IN x-z PLANE

$\theta_1 = 60°$ IN y-z PLANE

$$u = \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 0 \\ \sqrt{3} \\ 1 \end{pmatrix}, \quad v = \begin{pmatrix} \sqrt{3} \\ 0 \\ 1 \end{pmatrix}$$

$$\angle(u, v) \quad \rightsquigarrow \quad \cos\theta = \frac{u \cdot v}{\|u\| \|v\|}$$

$$= \frac{1}{4}$$

$$\theta = 75.5224\ldots°$$

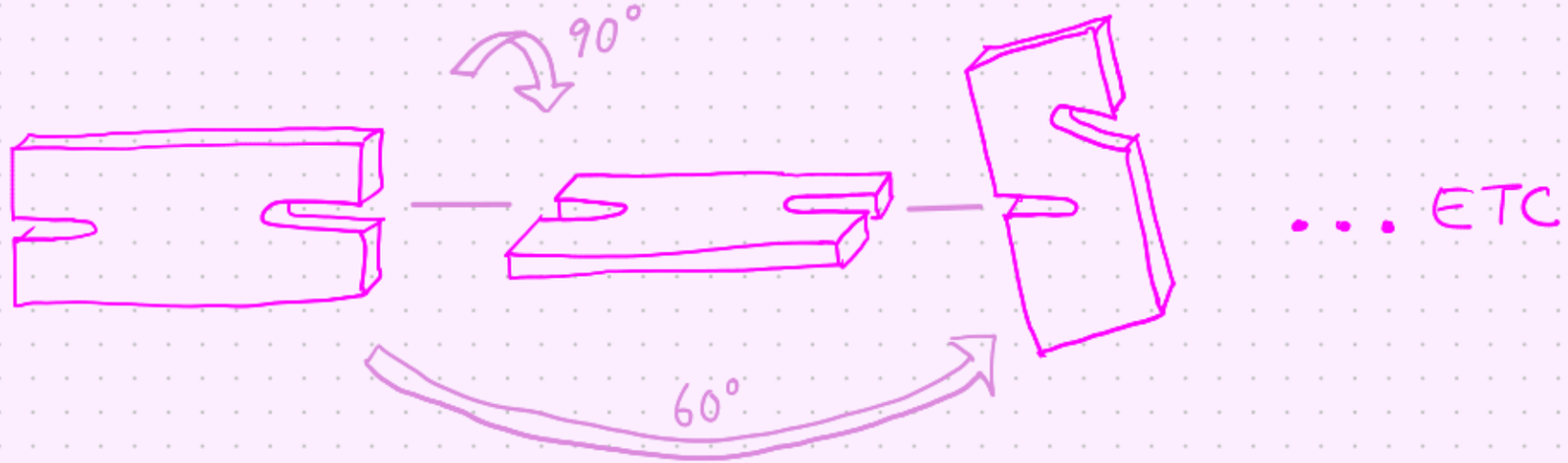
WOODEN BLOCKS

LESS DOWN TO EARTH EXPLANATION

$$SO(3) := \text{THE "GROUP" OF ALL ROTATIONS IN } \mathbb{R}^3$$

$$= \left\{ \begin{array}{l} 3 \times 3 \text{ ORTHOGONAL} \\ \text{MATRICES WITH DET. } 1 \end{array} \right\}$$

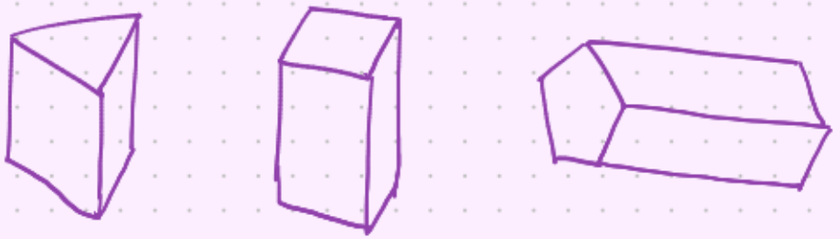
WHICH ROTATIONS ARE INVOLVED IN BUILDING WITH OUR BLOCKS?



WOODEN BLOCKS

CLASSIFICATION OF FINITE SUBGROUPS OF $SO(3)$:

- CYCLIC GROUPS (ROTATIONAL SYMMETRY IN $\mathbb{R}^2$)
- DIHEDRAL GROUPS (ROTATIONS + REFLECTIONS IN $\mathbb{R}^2$)



SYMMETRIES OF PRISMS OF REGULAR POLYGONS

- TETRAHEDRAL GROUP

SYMMETRIES OF A REGULAR TETRAHEDRON

- OCTAHEDRAL GROUP

SYMMETRIES OF A REGULAR CUBE OR OCTAHEDRON

- ICOSAHEDRAL GROUP

SYMMETRIES OF A REGULAR DODECAHEDRON OR ICOSAHEDRON

WOODEN BLOCKS

ROTATIONS OF OUR BLOCKS FALL INTO NONE OF THESE FINITE FAMILIES

$\rightsquigarrow$ AS WE BUILD WITH OUR BLOCKS, INFINITLY MANY DISTINCT ROTATIONS MAY APPEAR.

"CAST CHAIN"
MY FAVOURITE PUZZLE

WOODEN BLOCKS

QUESTIONS ?

CROCHET

EXCEPTIONAL ISOMORPHISMS

(ALSO CALLED ACCIDENTAL ISOMOPHISMS)

ARE WHEN TWO SEEMINGLY UNRELATED OBJECTS BELONGING TO DISTINCT FAMILIES ARE ACTUALLY THE SAME.

FOR THE MOST PART, JAPANESE AND ENGLISH ARE DIFFERENT LANGUAGES.

BUT SOMETIMES...

"NOSE" "MORE" "DEMO" ETC

CROCHET

EXCEPTIONAL ISOMORPHISMS

(ALSO CALLED ACCIDENTAL ISOMOPHISMS)

ARE WHEN TWO SEEMINGLY UNRELATED OBJECTS BELONGING TO DISTINCT FAMILIES ARE ACTUALLY THE SAME.

E.G. ICOSAHEDRAL GROUP

SYMMETRIES OF A REGULAR DODECAHEDRON OR ICOSAHEDRON

ALTERNATING GROUP A_5

THE GROUP OF EVEN PERMUTATIONS OF $\{1, 2, 3, 4, 5\}$.

MAYBE WE CAN USE ART AND CRAFTS TO UNDERSTAND THESE?

CROCHET

CAN I MAKE SOMETHING TO CAPTURE

SYMMETRIES OF THE "KLEIN QUARTIC" ⟷ SYMMETRIES OF THE "FANO PLANE"

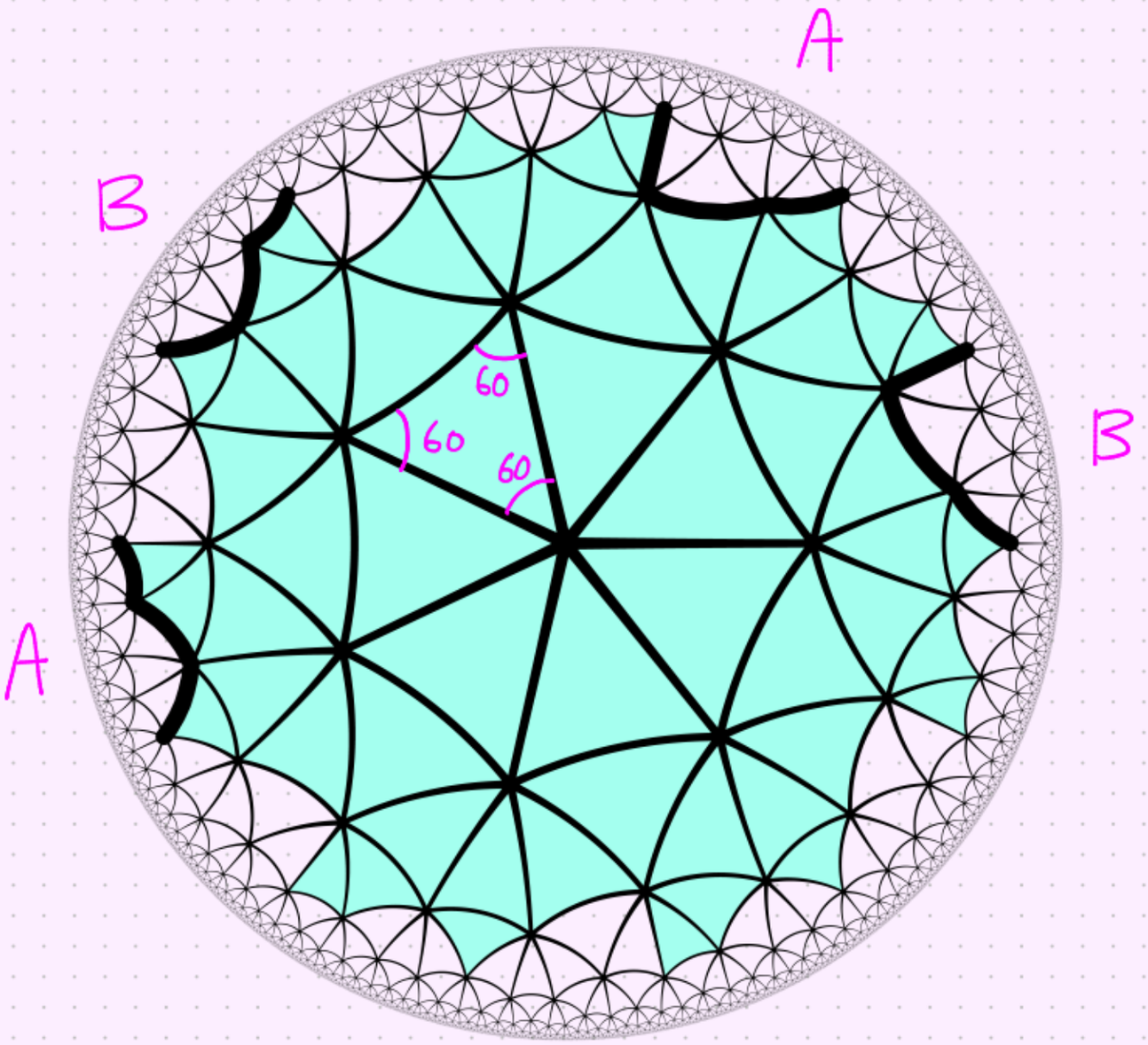
S F-H. CROCHETING AN ISOMORPHISM BETWEEN THE AUTOMORPHISM GROUPS OF THE KLEIN QUARTIC AND FANO PLANE

BRIDGES CONF. PROC. 2021

CROCHET

WHAT IS THE KLEIN QUARTIC?

- A CERTAIN HYPERBOLIC SURFACE!



CROCHET

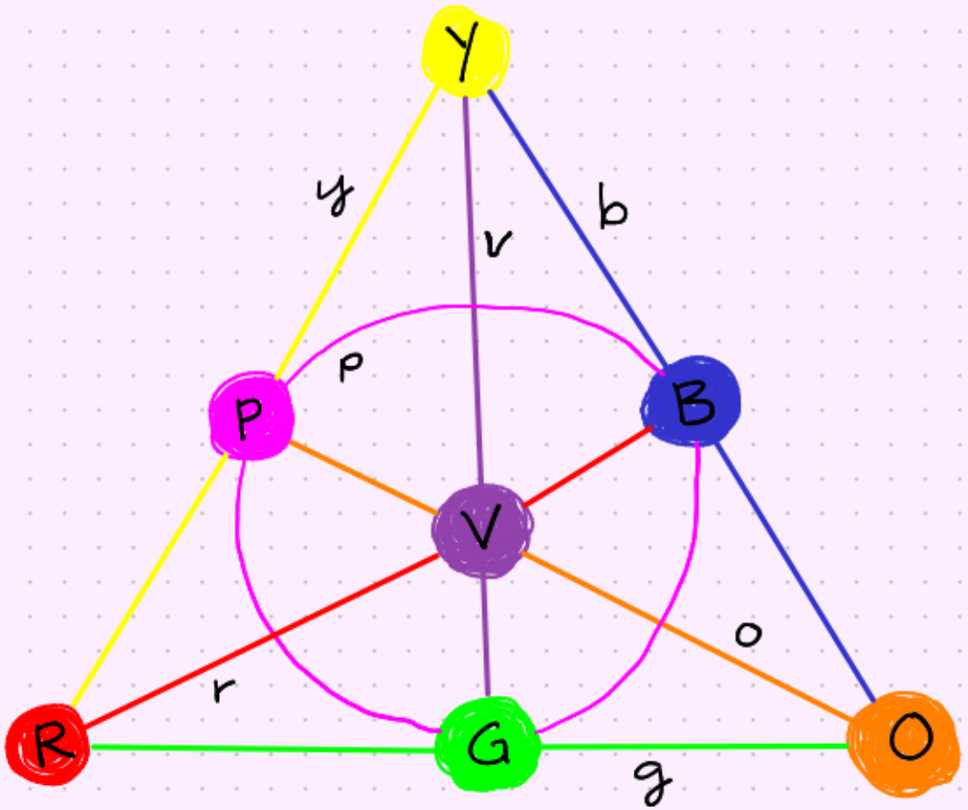
CROCHET AS A MEDIUM:

FANTASTIC BALANCE OF RIGIDITY AND FLEXIBILITY

CROCHET

WHAT IS THE FANO PLANE?

— "THE SPACE OF LINES IN $\mathbb{F}_2^3$"



E.g. Y, B, O are collinear since they all lie on b.

A SYMMETRY IS A PERMUTATION OF VERTICES RESPECTING COLLINEARITY.

CROCHET

THE ISOMORPHISM

GEOMETRICALLY : "SHAPE" PRESERVED ; SYMMETRY OF KLEIN QUARTIC

CHROMATICALLY : ORANGE ↔ YELLOW, GREEN ↔ PINK ; COLLINEARITY PRESERVED

CROCHET

REFLECTION: TOO DENSE!

FROM HERE: OTHER EXCEPTIONAL ISOMORPHISMS?

CROCHET

QUESTIONS ?

CHAINS

MATHS + SCULPTURE

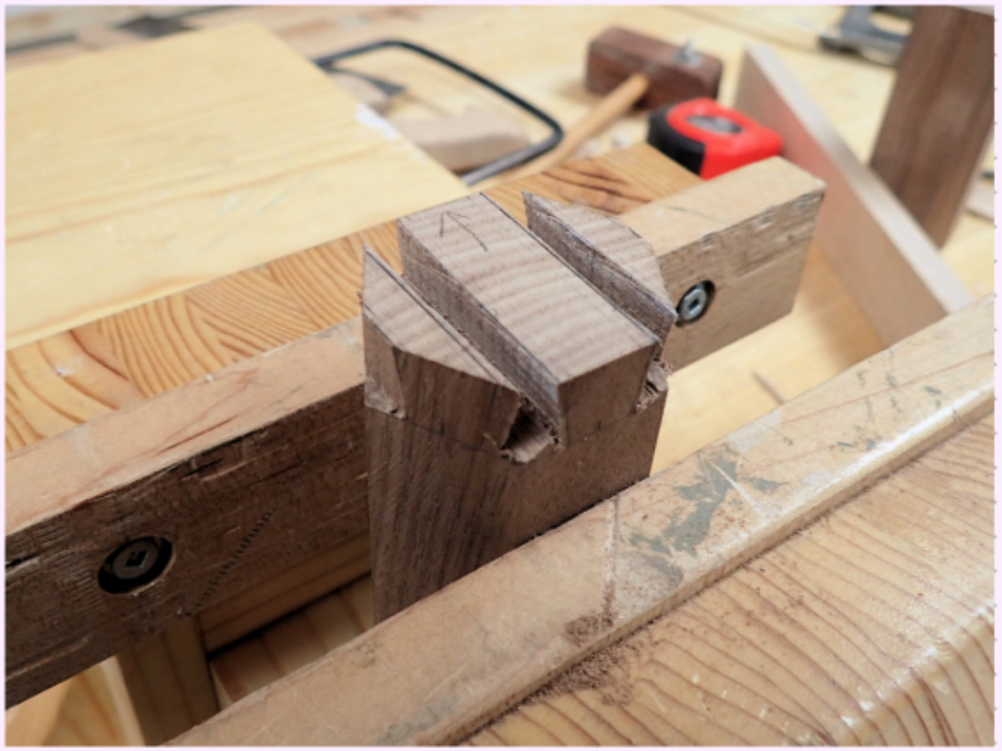
= DESIRE TO CREATE "IMPOSSIBLE" OBJECTS

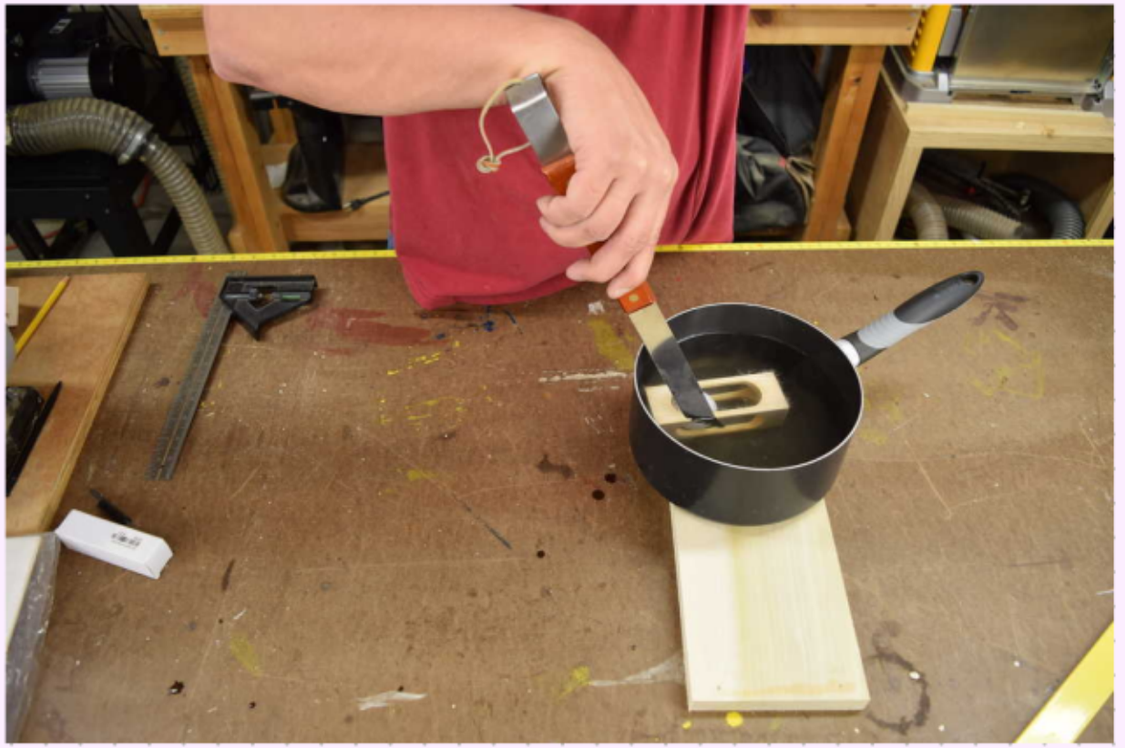
lode_leroy reddit

ibuildit.ca

woodlogger.com

CHAINS





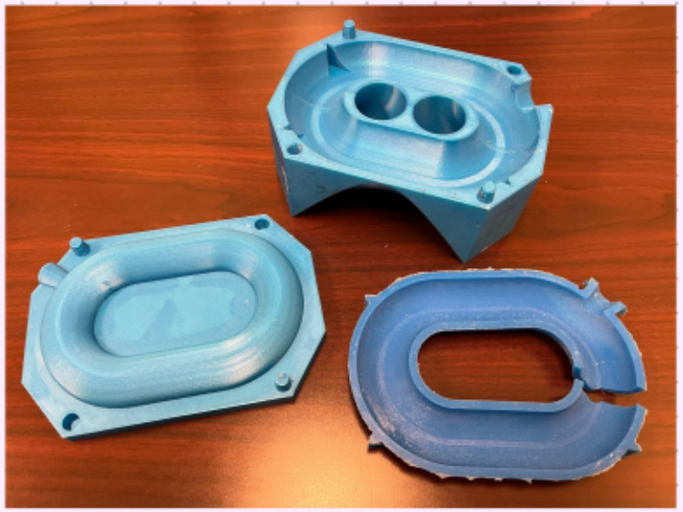
CHAINS

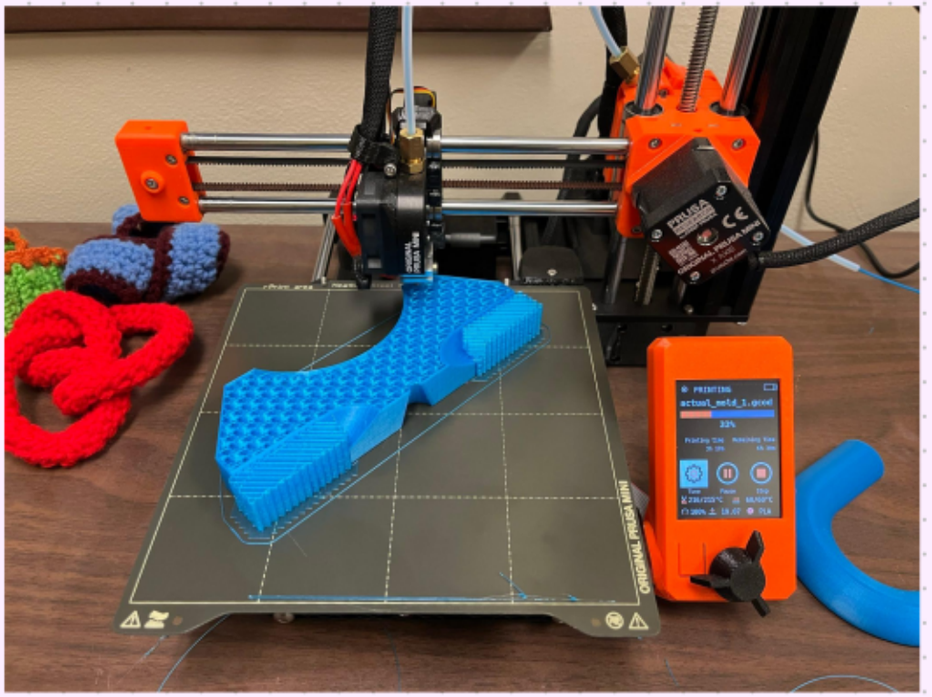
CHAINS

MOLDMAKING & CASTING

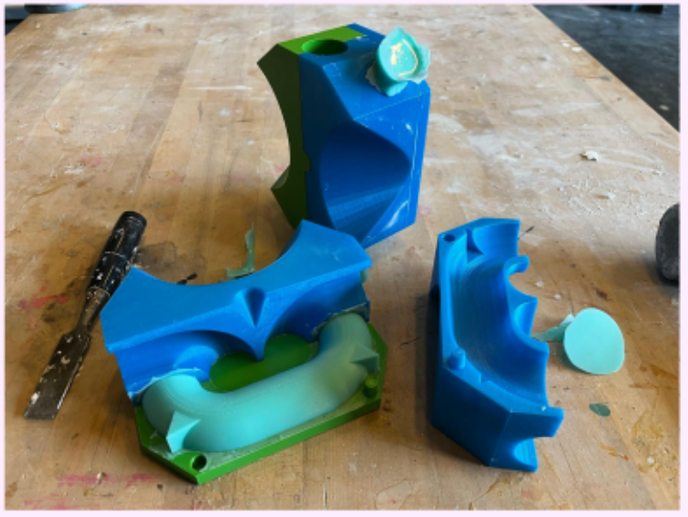
CHAINS

STEP ONE:
MOLD SHELL

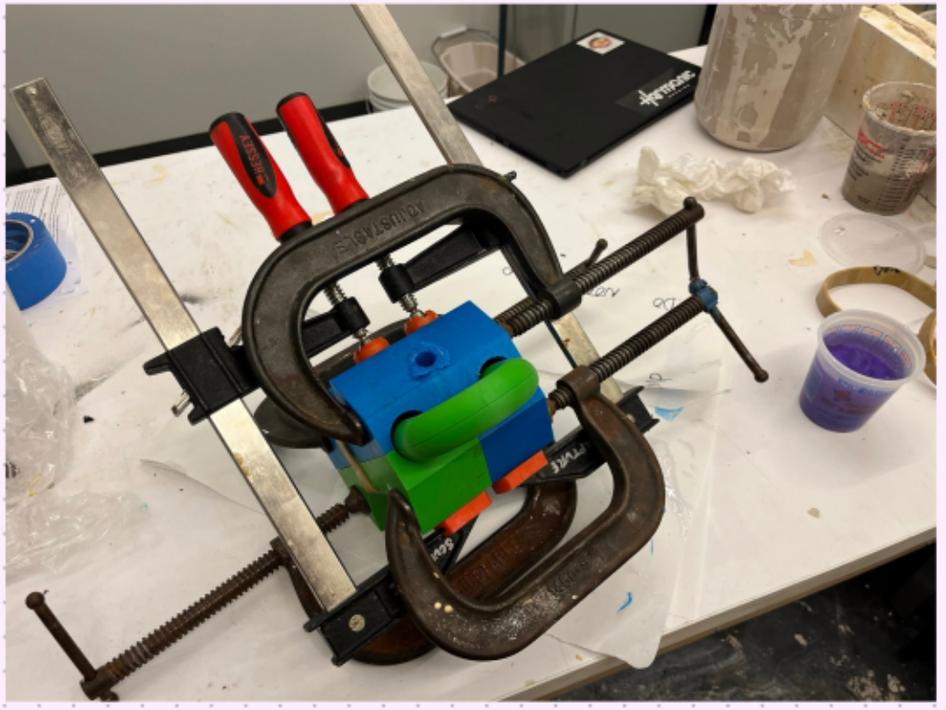




STEP TWO:
POURED
BLANKET
MOLD



STEP THREE:
CASTING



CHAINS

CONJECTURE
→ TRY TO PROVE IT?

FAIL! LEARN SOMETHING.
REFINE CONJECTURE.
TRY SOMETHING ELSE.

IDEA
→ TRY TO BUILD IT?

FAIL! LEARN SOMETHING.
REFINE IDEA
TRY SOMETHING ELSE.

INCREMENTAL IMPROVEMENT!

CHAINS

QUESTIONS ?