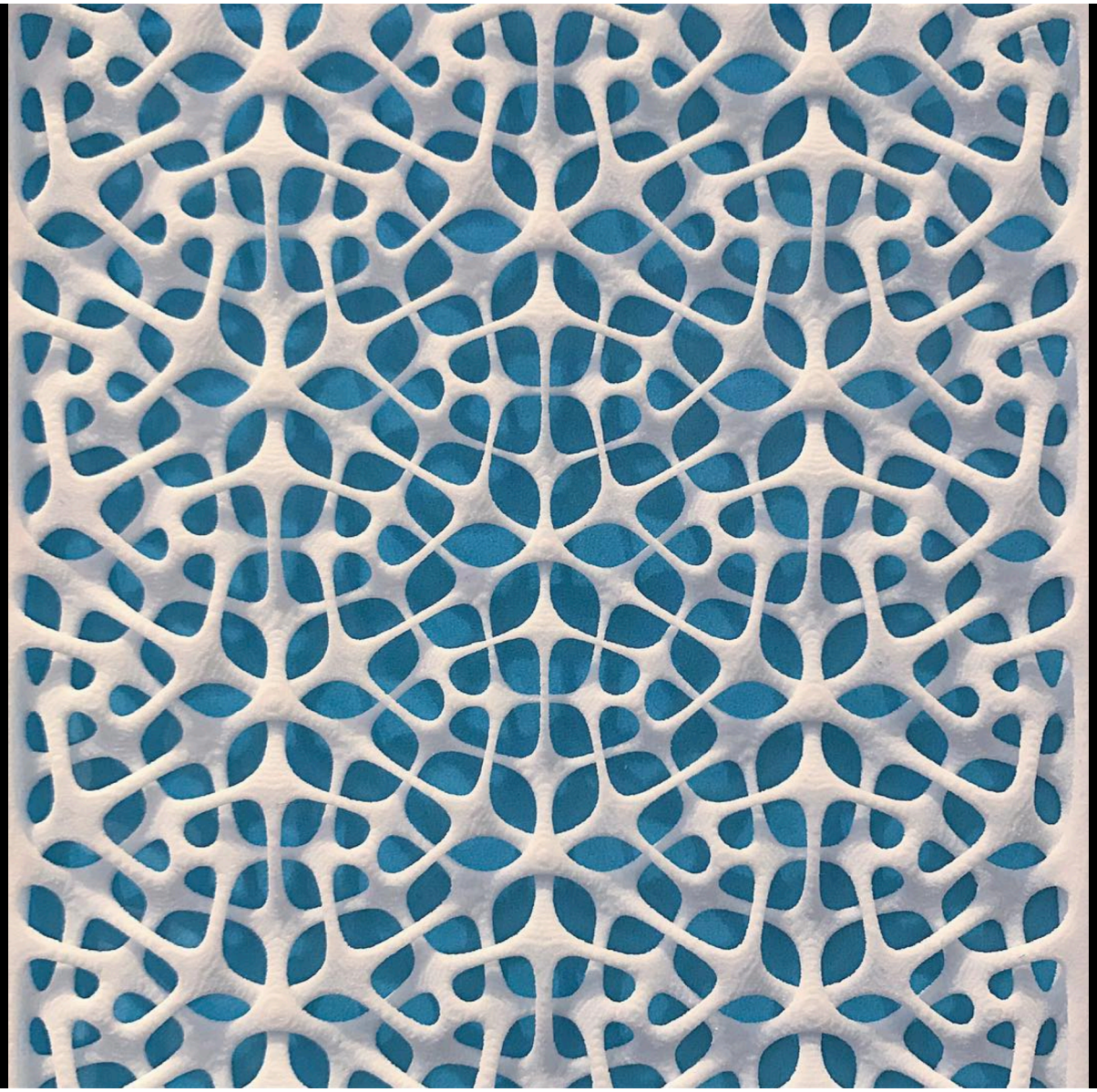
Computational Fabrication

CS 491 and 591
Professor: Leah Buechley
https://handandmachine.cs.unm.edu/classes/Computational_Fabrication_Spring2021/

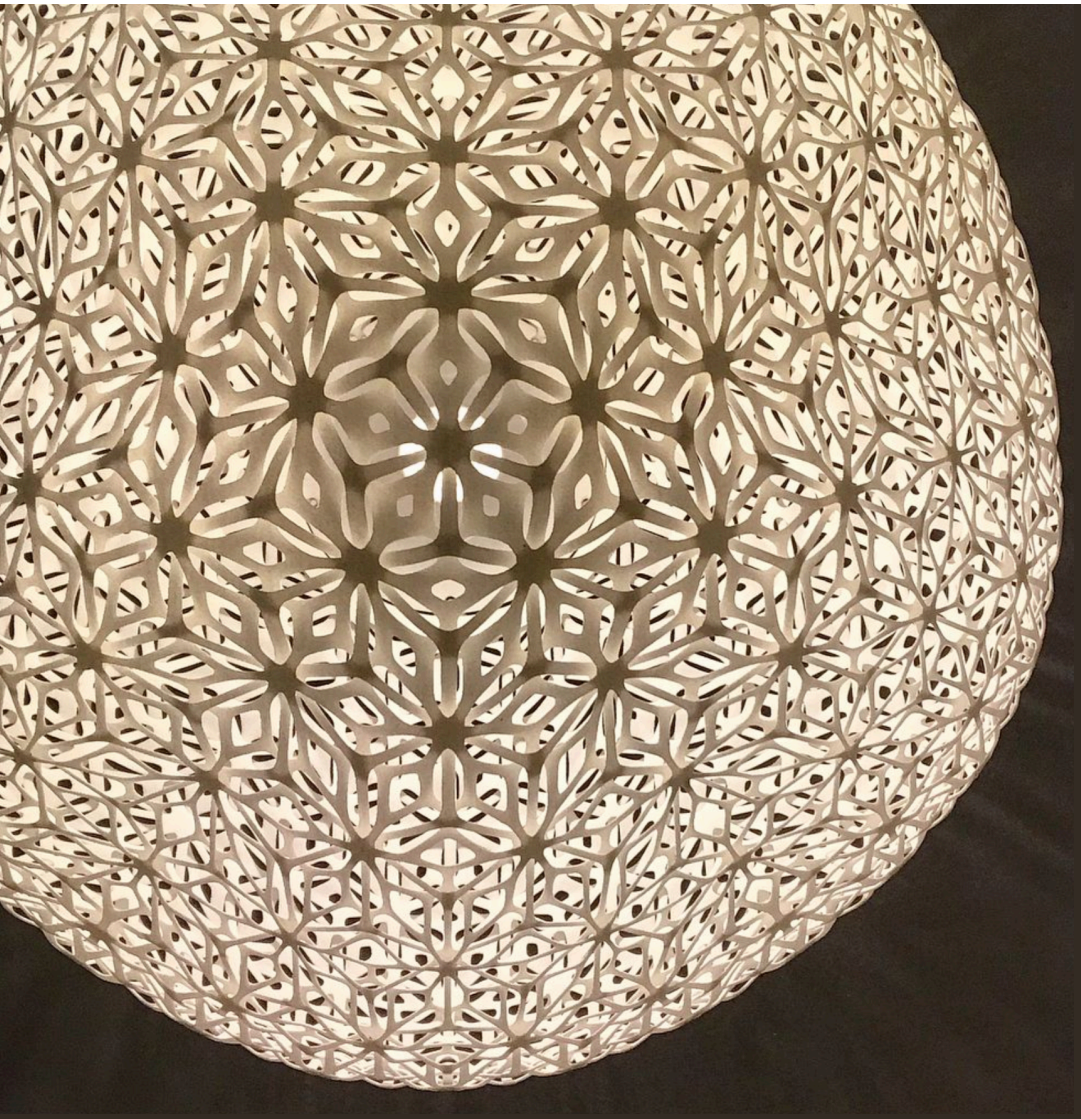
Artist: Travis Fitch

https://fitchwork.com/
https://www.instagram.com/fitchwork/
https://www.futurecurrent.net/travis-fitch


Travis Fitch



Travis Fitch

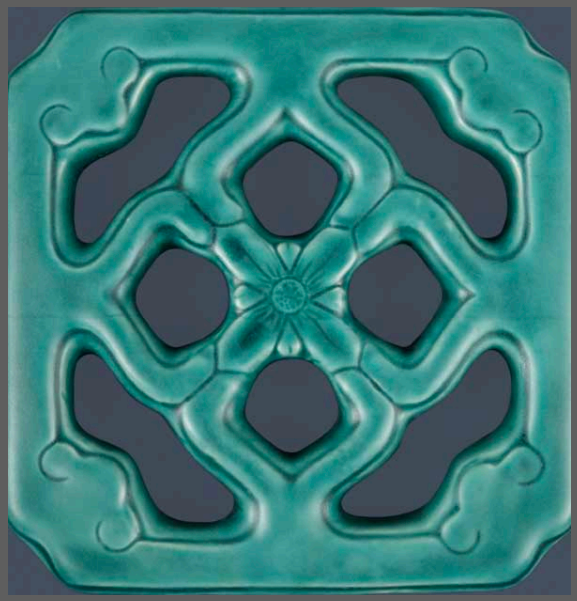


Travis Fitch

Travis Fitch

Tiling

Huge topic! We'll scratch the surface a little.



2D Tiling/Tessellations

What is a Tiling?

A **tiling** (of the plane) is a collection of **tiles** (subsets of the plane), which cover the plane without gaps or overlaps. We also require that each tile consists of a single connected piece without holes or lines.

http://pi.math.cornell.edu/~mec/2008-2009/KathrynLindsey/PROJECT/Page1.htm

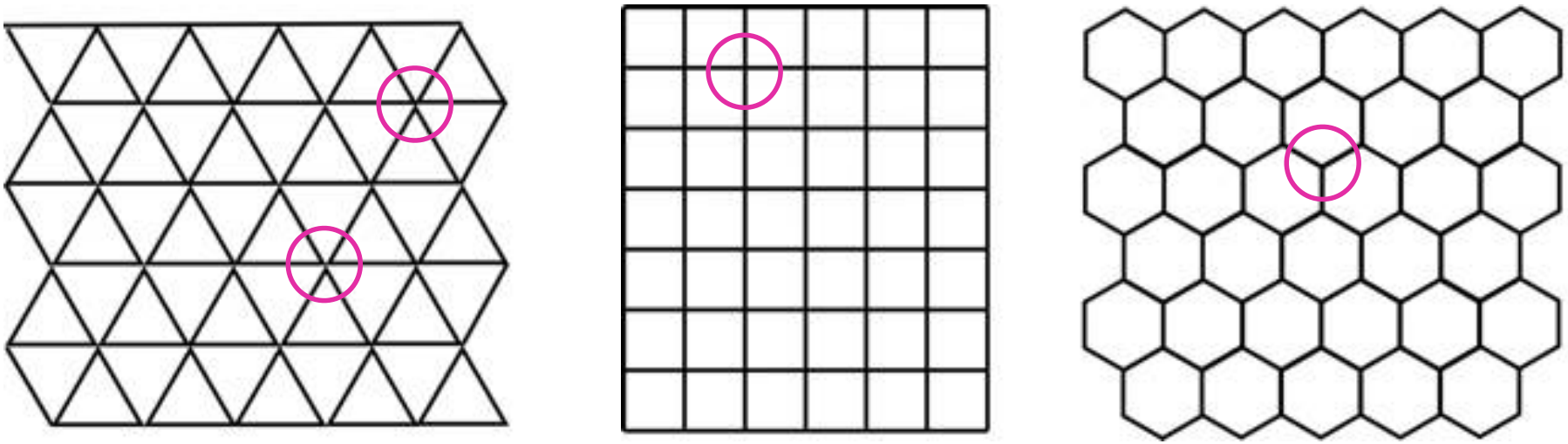
Regular Tilings

Tiling by a single regular polygon

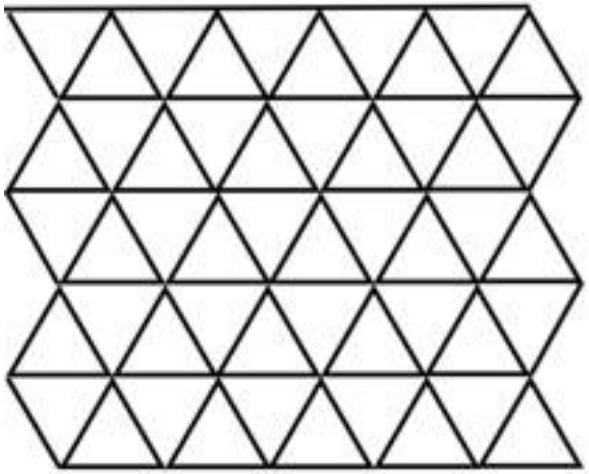
Regular polygon: shapes where all sides and angles are the same

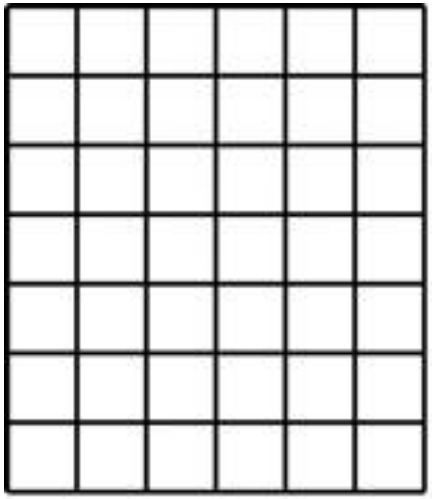
Regular tiling: all vertices are the same

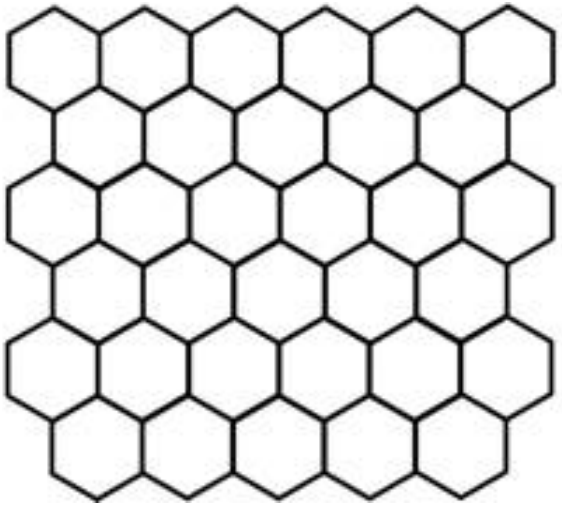
3 Regular Tilings



The Only Regular Tilings!

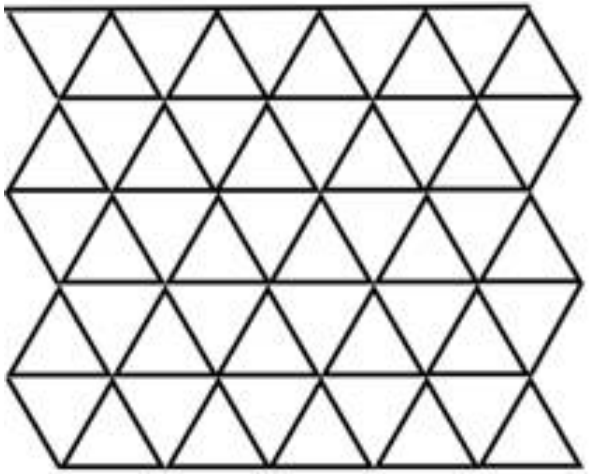




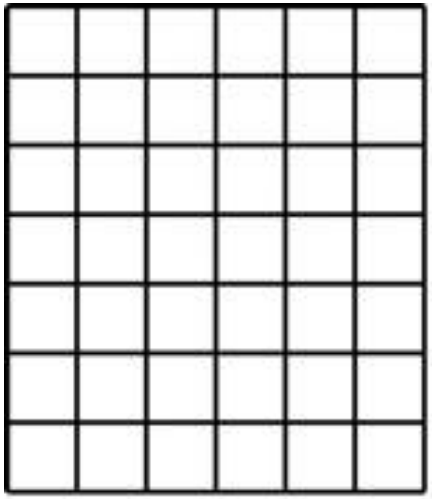


Why?

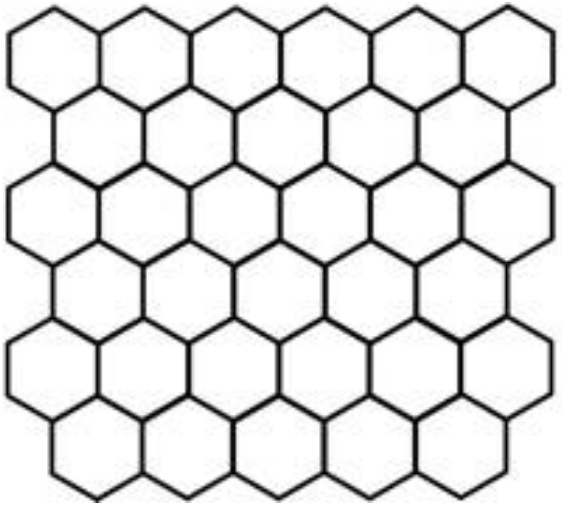
interior angle x integer = 360



angle = 60
60 x 6 = 360



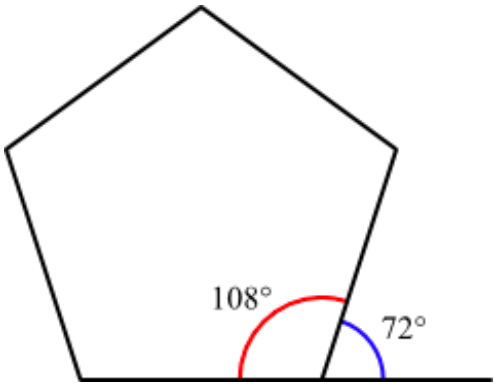
angle = 90
90 x 4 = 360



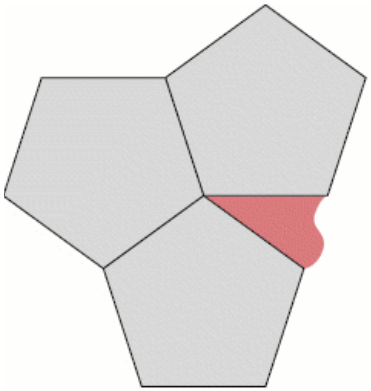
angle = 120
120 x 3 = 360

Why not Pentagons?

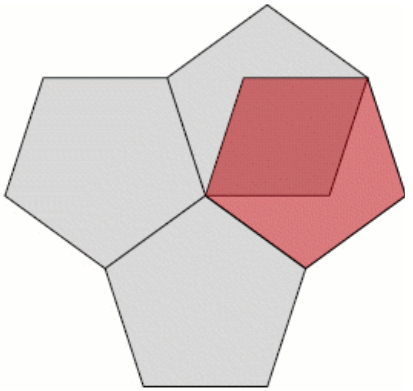
interior angle x integer = 360



pentagon
interior angle = 108

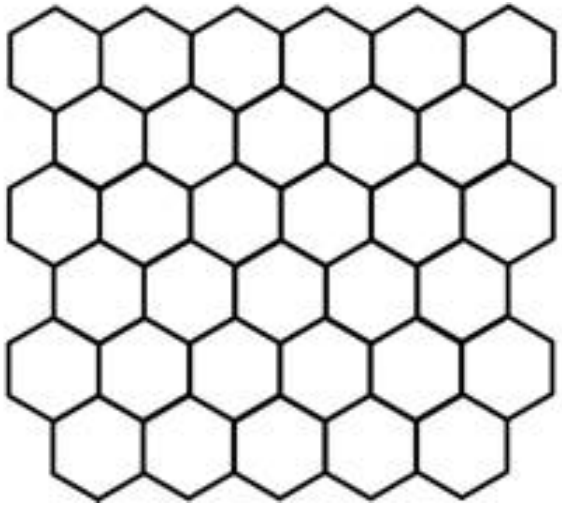


108 x 3 = 324

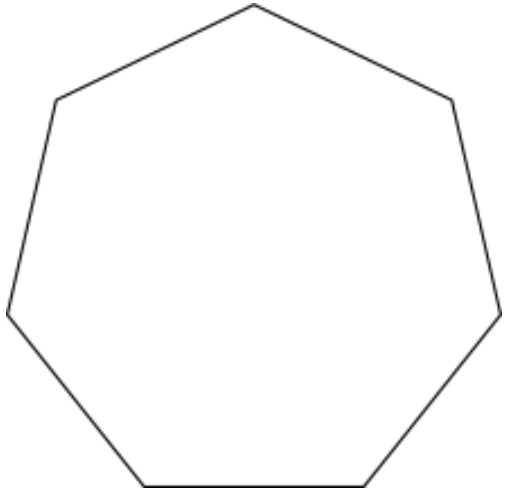


108 x 4 = 432

Why not greater than 6 sides?

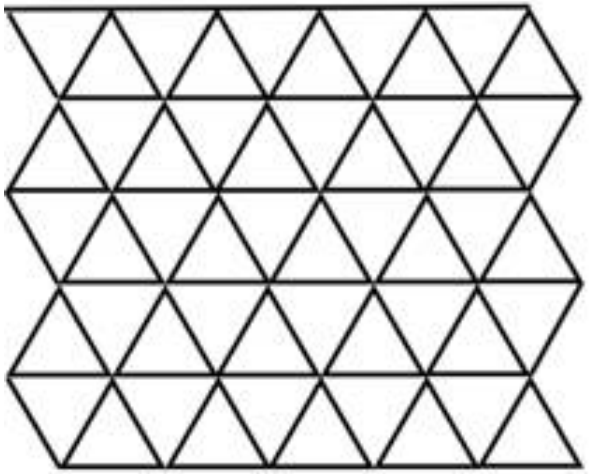


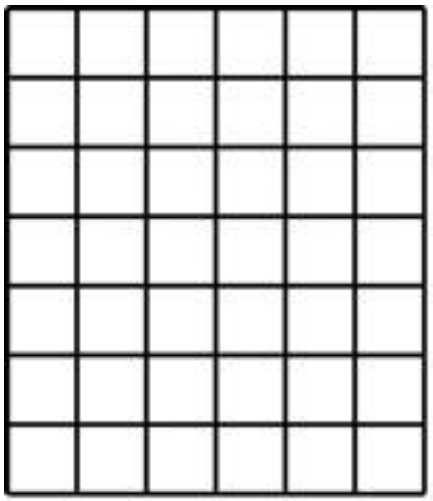
angle = 120
120 x 3 = 360

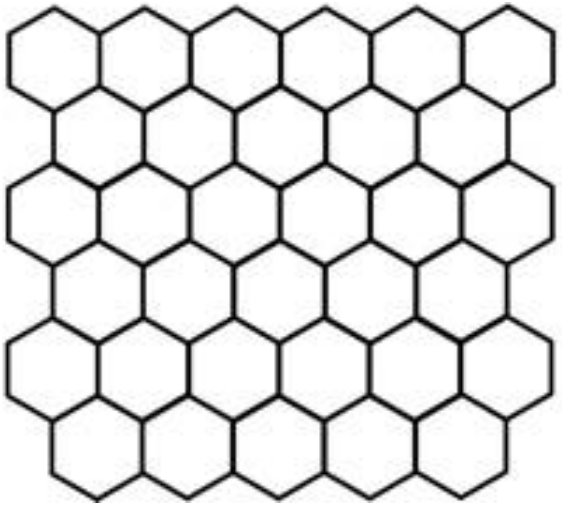


heptagon
angle = 128
128 x 3 = 384

There are Only 3 Regular Tilings





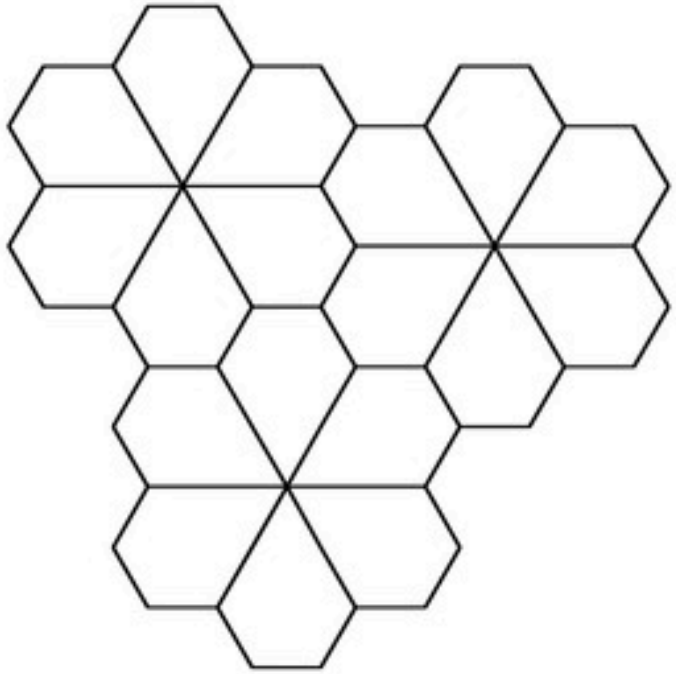


Monohedral Tilings

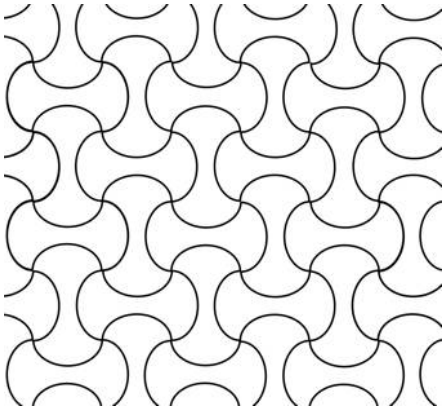
Tiling by a single shape

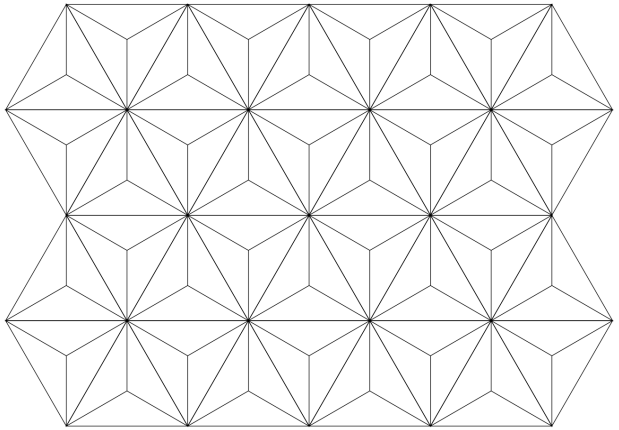
No other constraints

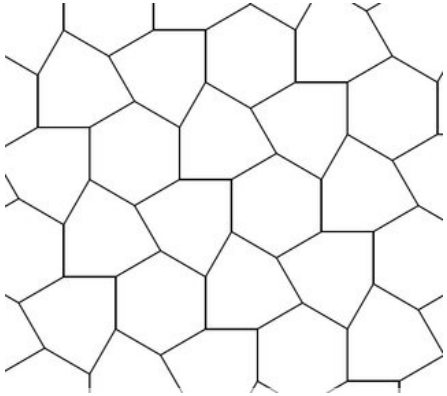
Example: a tiling with non-regular pentagons

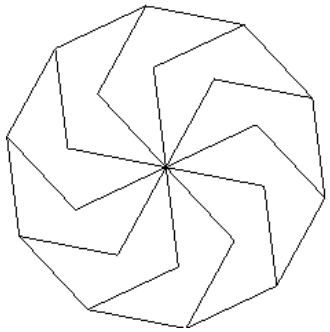


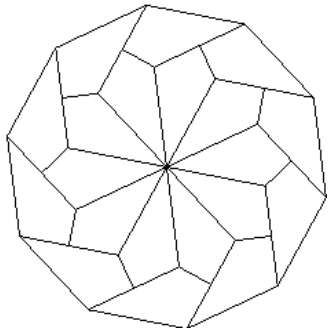
Lots of Monohedral Tilings!

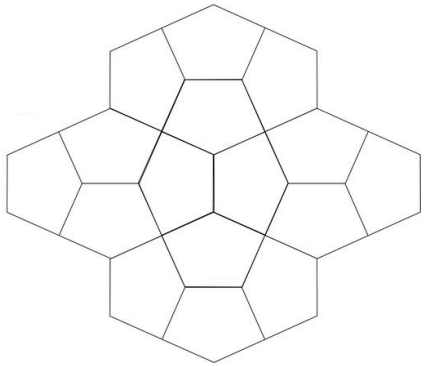


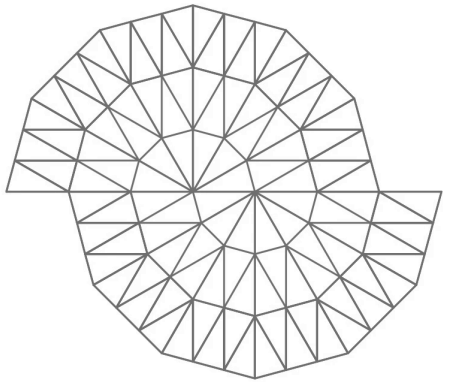






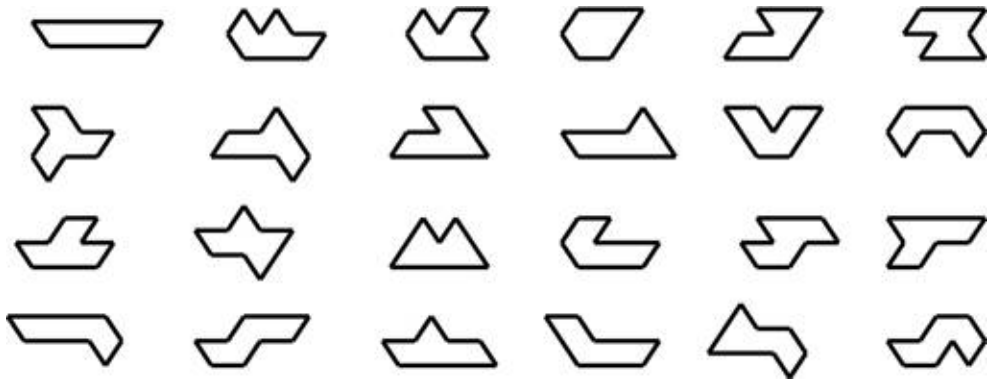






Monohedral Tilings: a Question

If you are given a tile, can you determine if it tiles the plane?

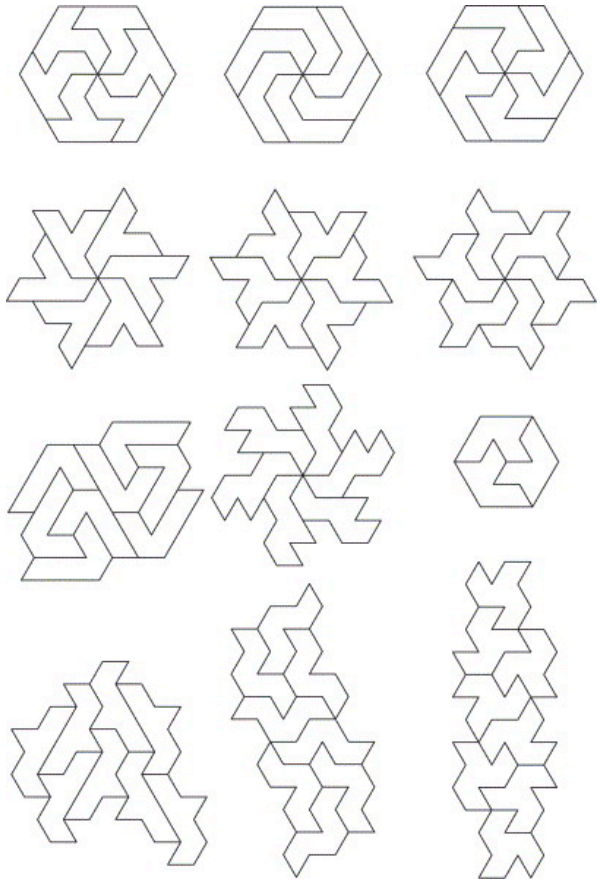


Monohedral Tilings

If you are given a tile, can you determine if it tiles the plane?

An open question!

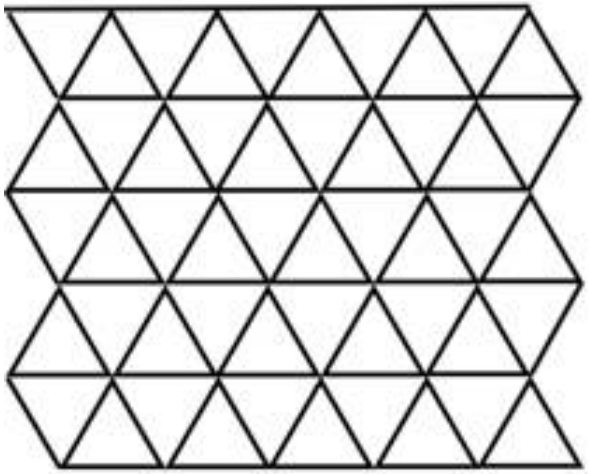
May be undecidable. We don't know!

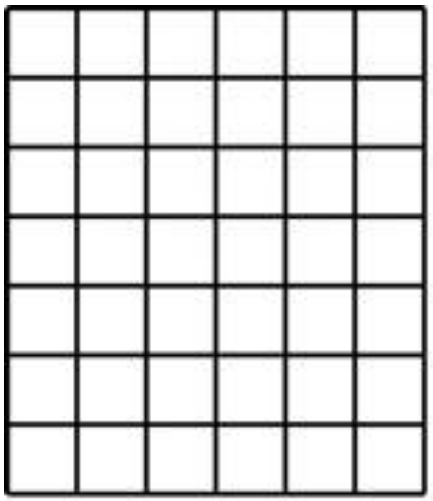


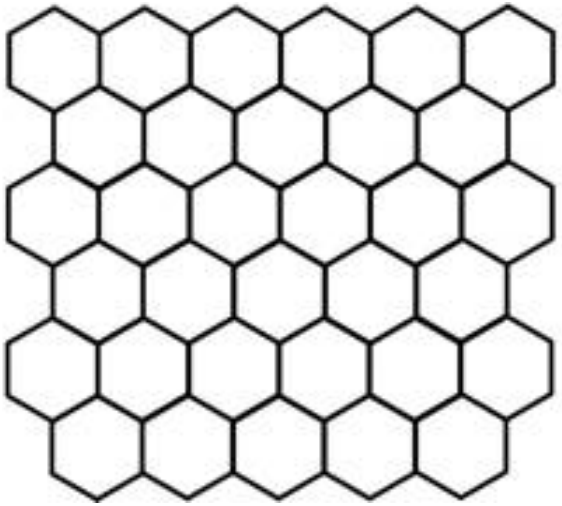
http://www.ams.org/notices/201003/rtx100300343p.pdf
http://math.tsukuba.ac.jp/ant/Sympo/GS_kyoto1.pdf
http://www.cs.bc.edu/~straubin/cs385-07/tiling

Lots of interesting open tiling questions in CS theory!

Back to Regular Tilings





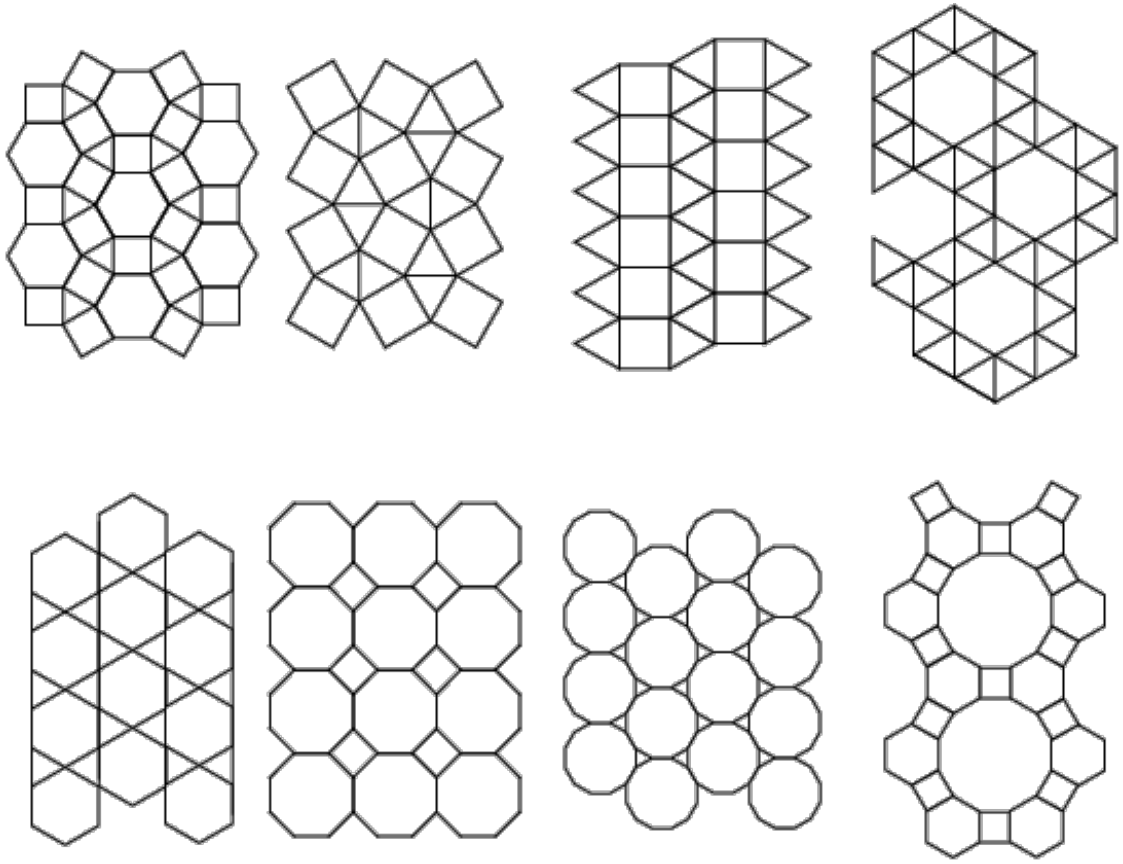


Semi-Regular Tilings

Tilings by one or more regular polygons

All vertices are the same

Eight Semi-Regular Tilings

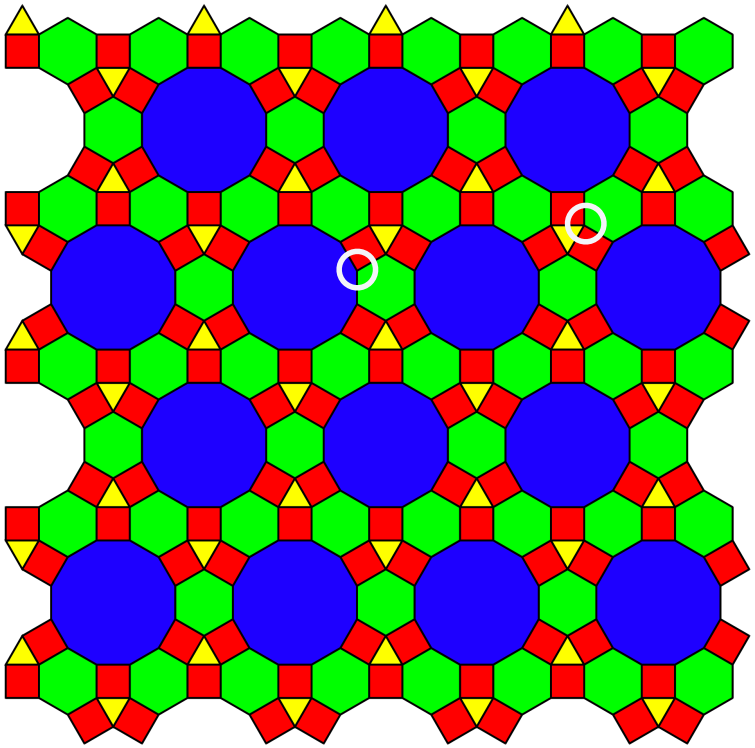


Demi-Regular Tilings

Also known as 2-Uniform Tilings

Tilings by one or more regular polygons

Two types of vertices

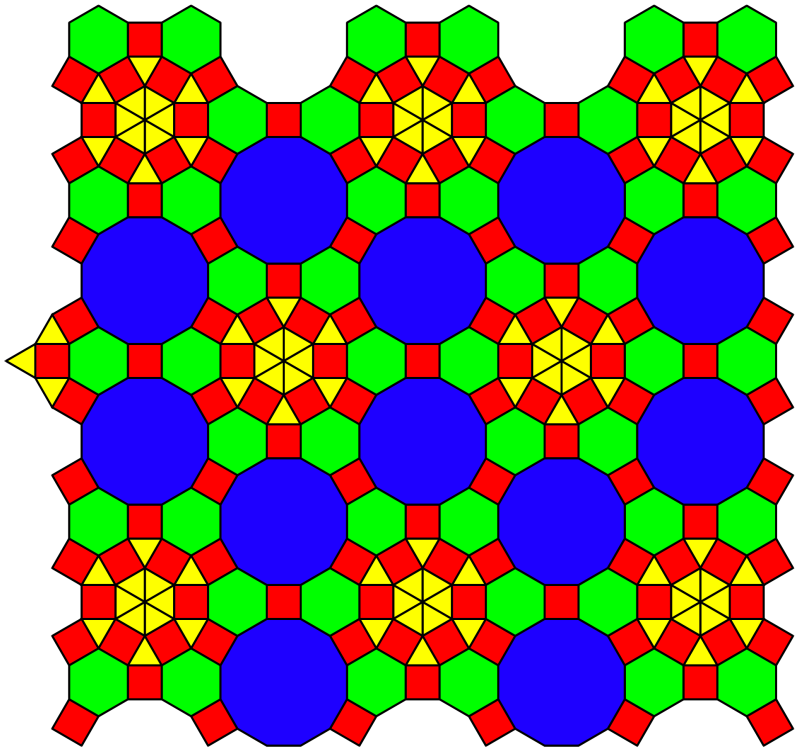


k-Uniform Tilings

Tilings by one or more regular polygons

k types of vertices

Example: 5-uniform tiling



https://en.wikipedia.org/wiki/List_of_k-uniform_tilings

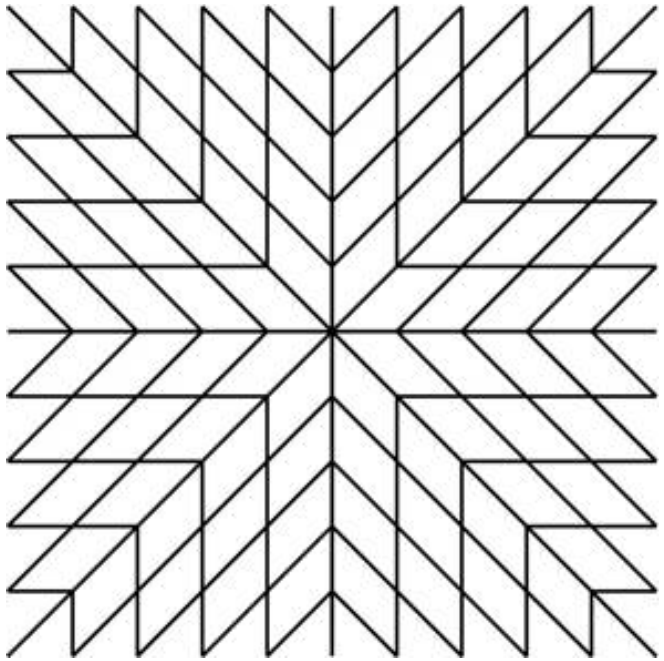
Different Kinds of Tilings

Nonperiodic Tilings

A tiling that you cannot replicate **by translation**

Think about wallpaper. A tiling you cannot create a wallpaper from.

Note: does not rule out radial symmetry

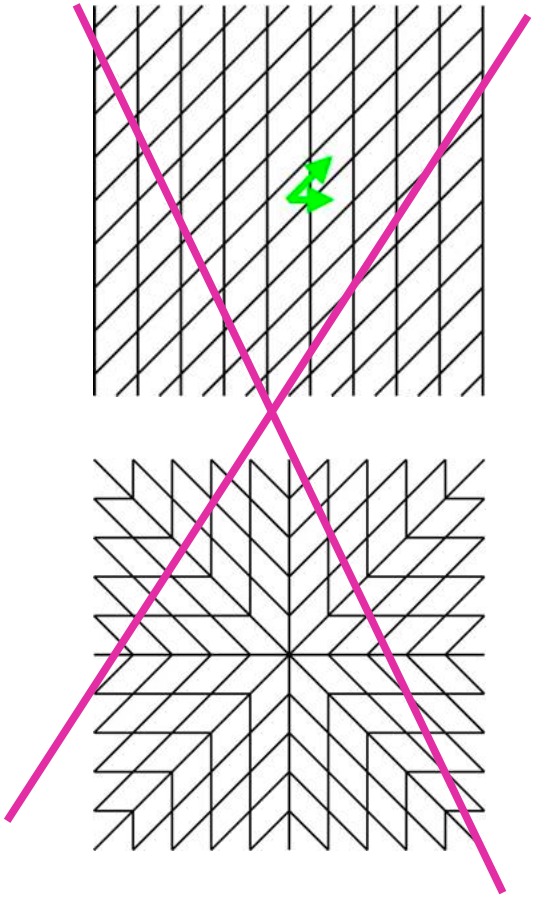


http://pi.math.cornell.edu/~mec/2008-2009/KathrynLindsey/PROJECT/Page4.htm

Aperiodic Tilings

A set of tiles that can **only** create Non-periodic tilings.

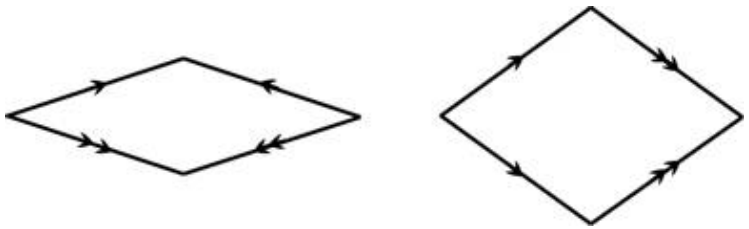
Negative example on the right.

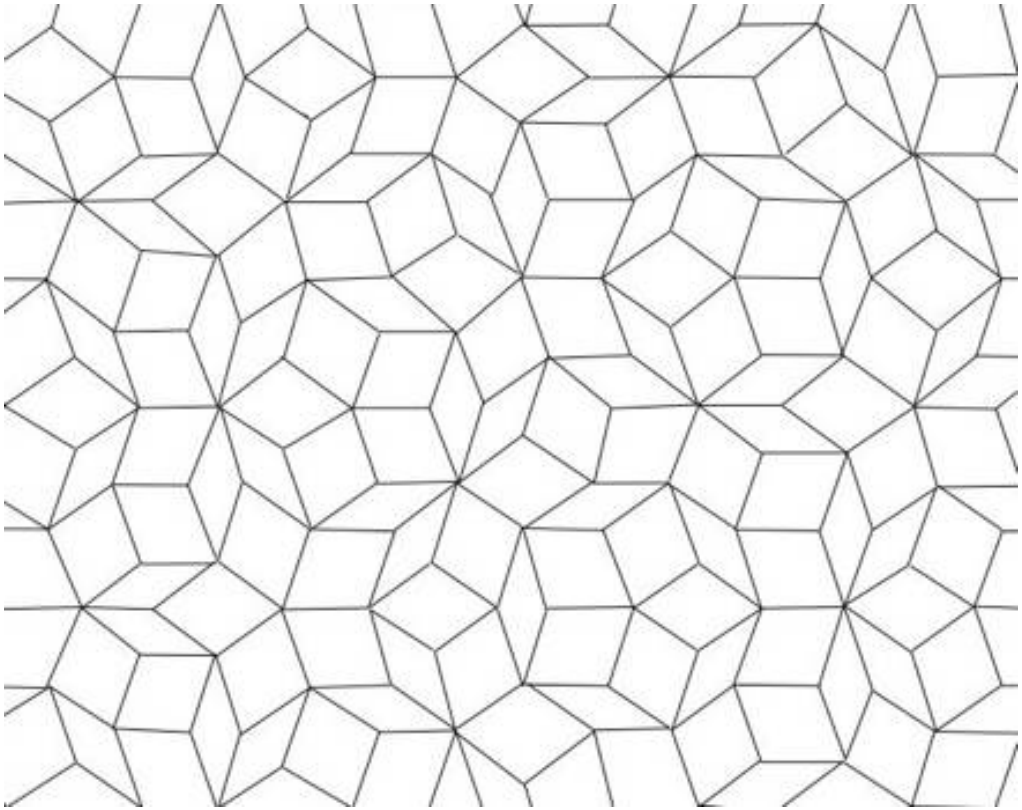


http://pi.math.cornell.edu/~mec/2008-2009/KathrynLindsey/PROJECT/Page5.htm

Aperiodic Tiling: Penrose Tiling

Tiles

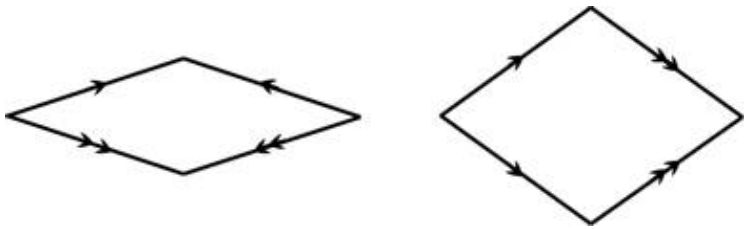


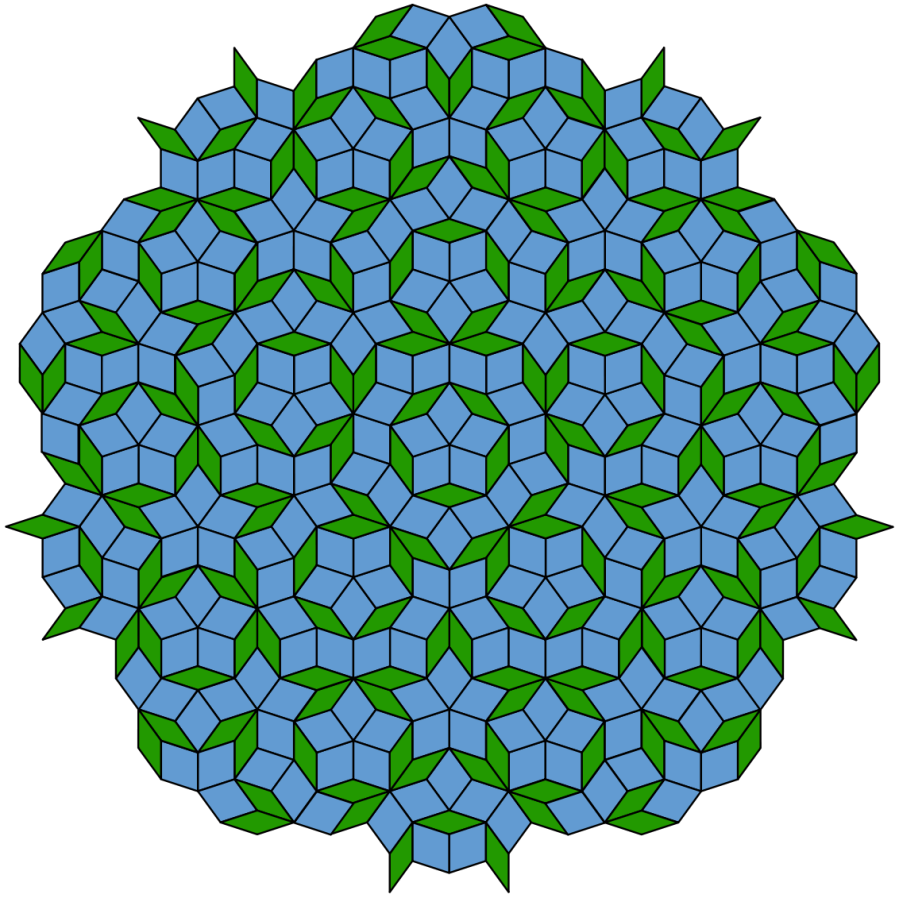


http://pi.math.cornell.edu/~mec/2008-2009/KathrynLindsey/PROJECT/Page5.htm

Aperiodic Tiling: Penrose Tiling

Tiles





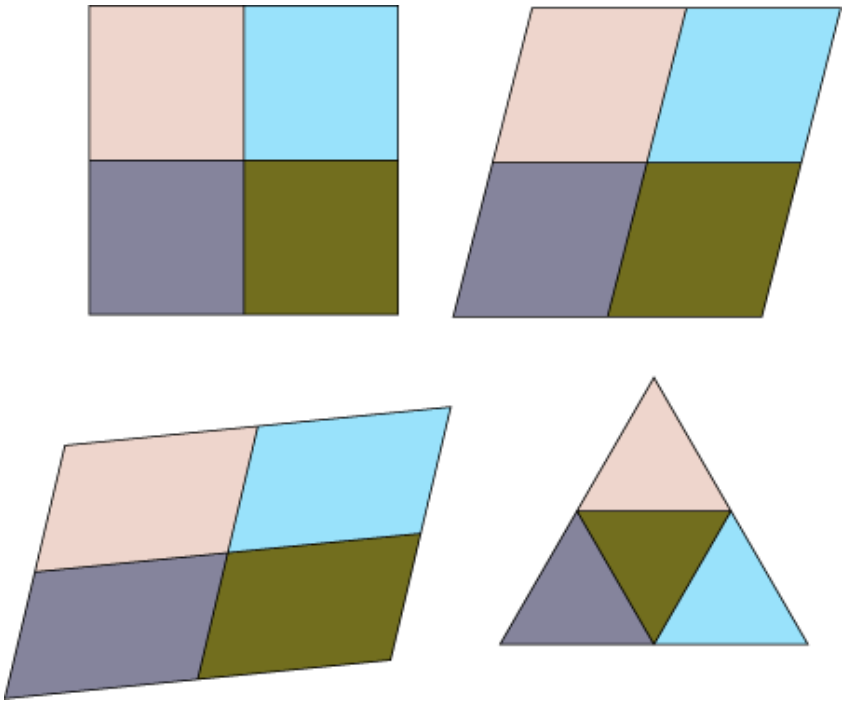
Note: does not rule out radial symmetry

http://pi.math.cornell.edu/~mec/2008-2009/KathrynLindsey/PROJECT/Page5.htm

Rep Tiles

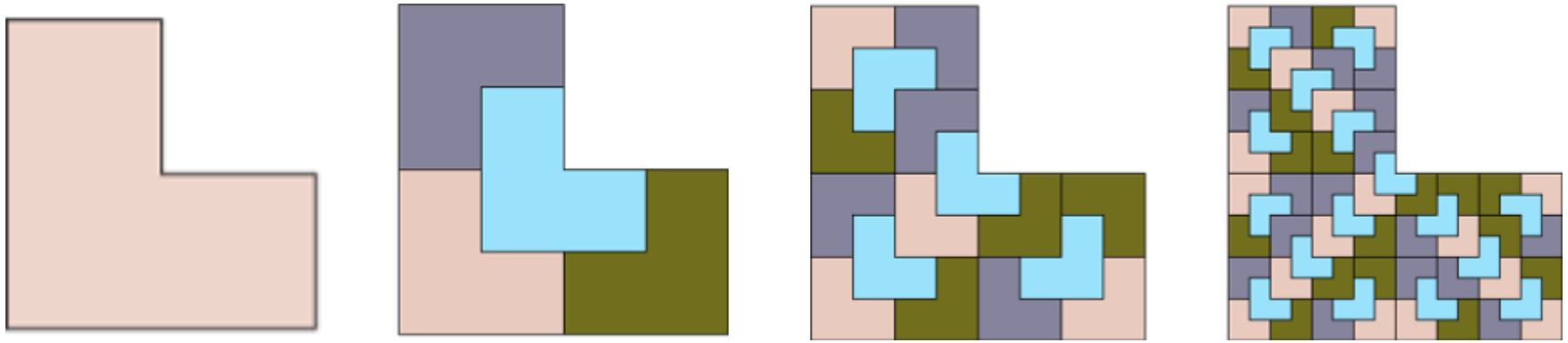
Self-Similar/Fractal Tiles

Rep-Tiles



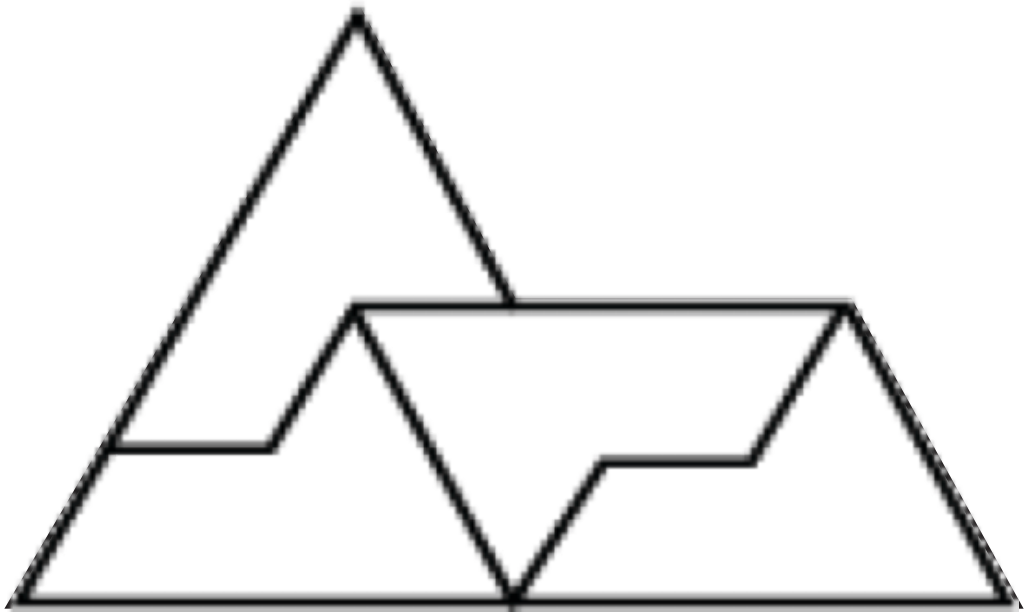
Rep-Tiles

Can you break the shape into 4 copies of itself?



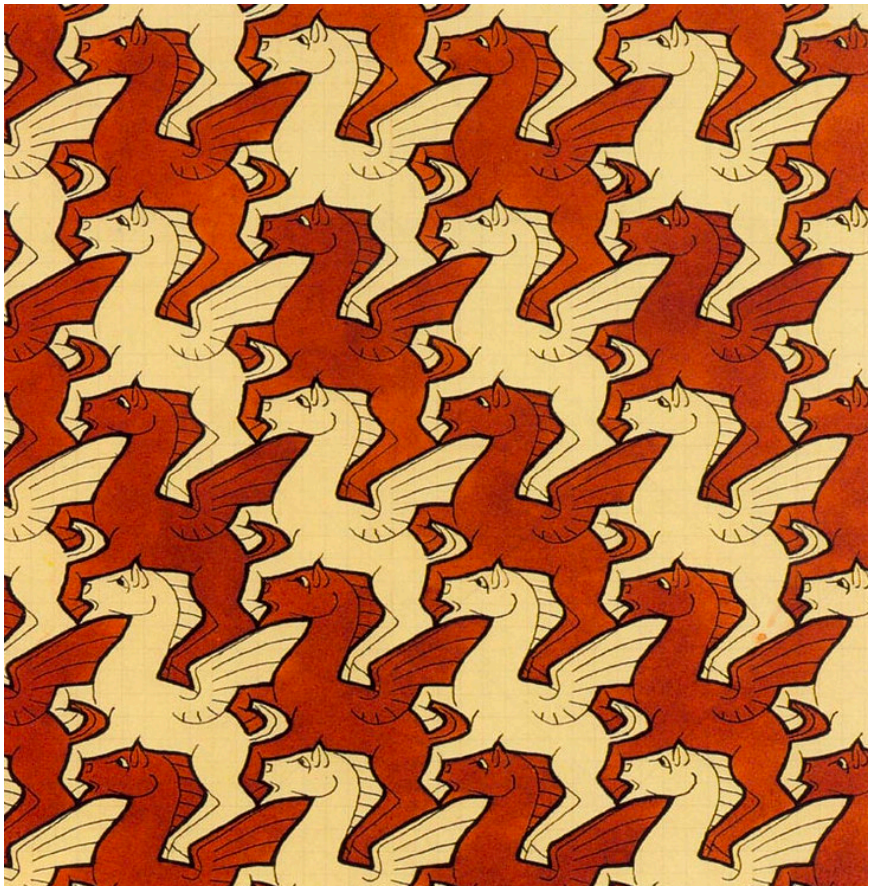
This one?

This one?



Escher Tiles

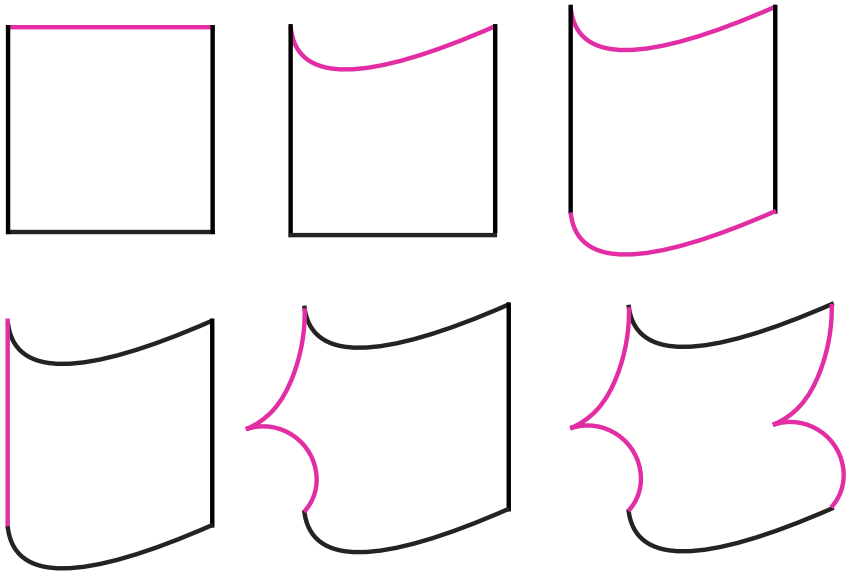
M.C. Escher



Creating Interesting Tiles

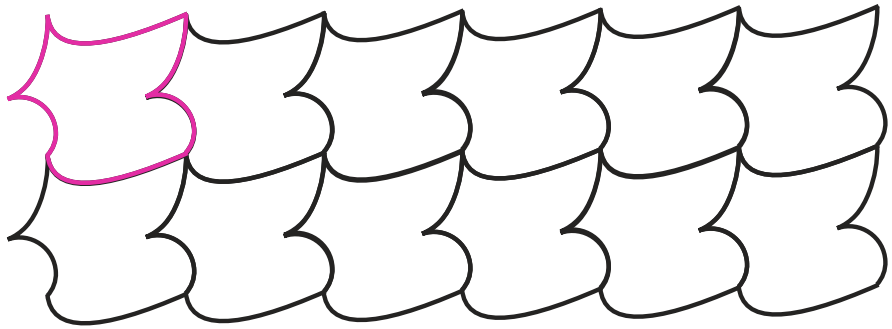
How to create your own tiles using existing tilings as a starting point.

Modify two matching edges or vertices in the same way



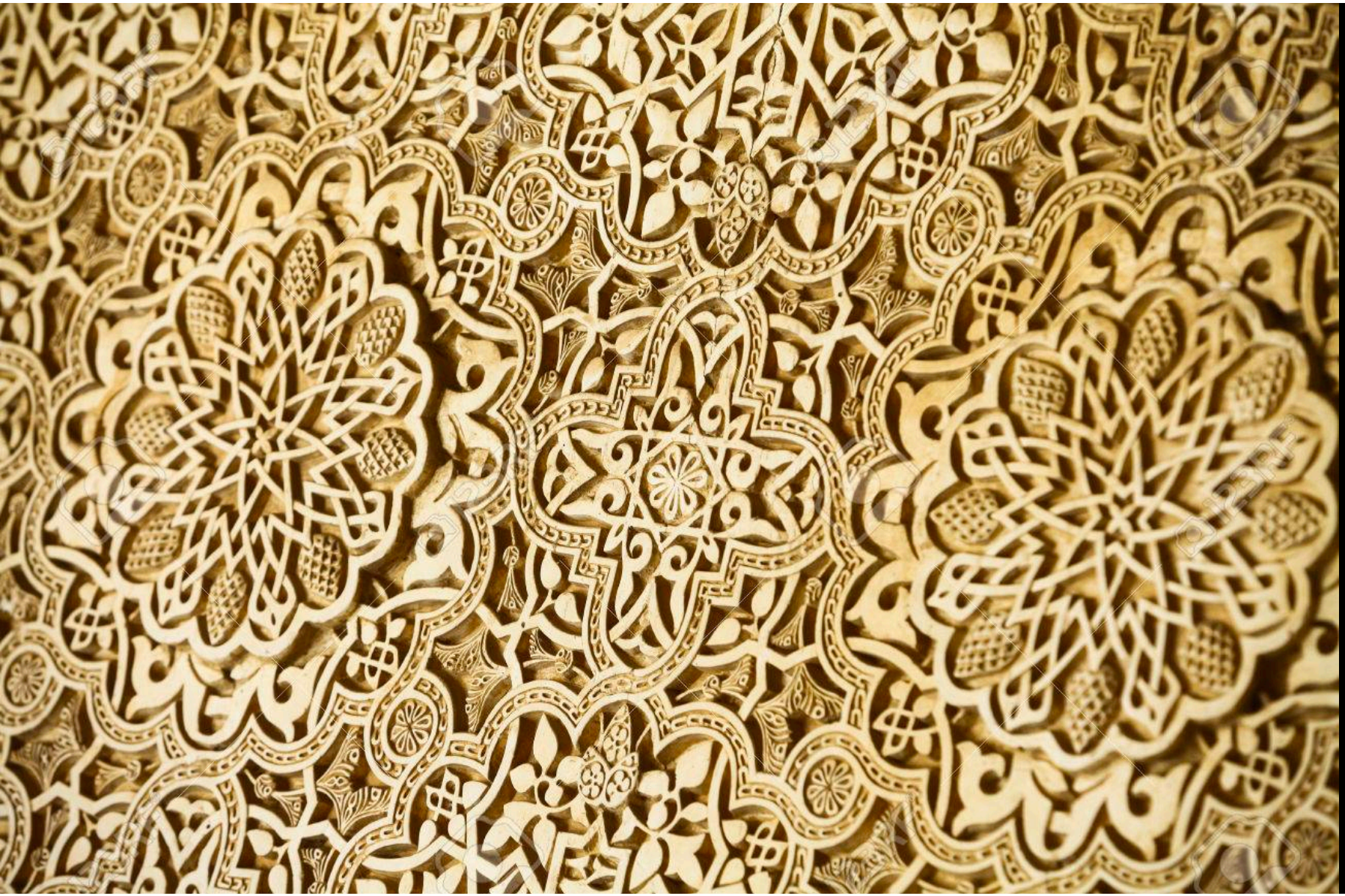
https://www.rochester.edu/pr/Review/V79N3/0603_schattschneider_side.html

Creating Interesting Tiles



http://www.shodor.org/interactivate/activities/Tessellate/

2.5 D Tiling/Tessellations



Alhambra Mosque

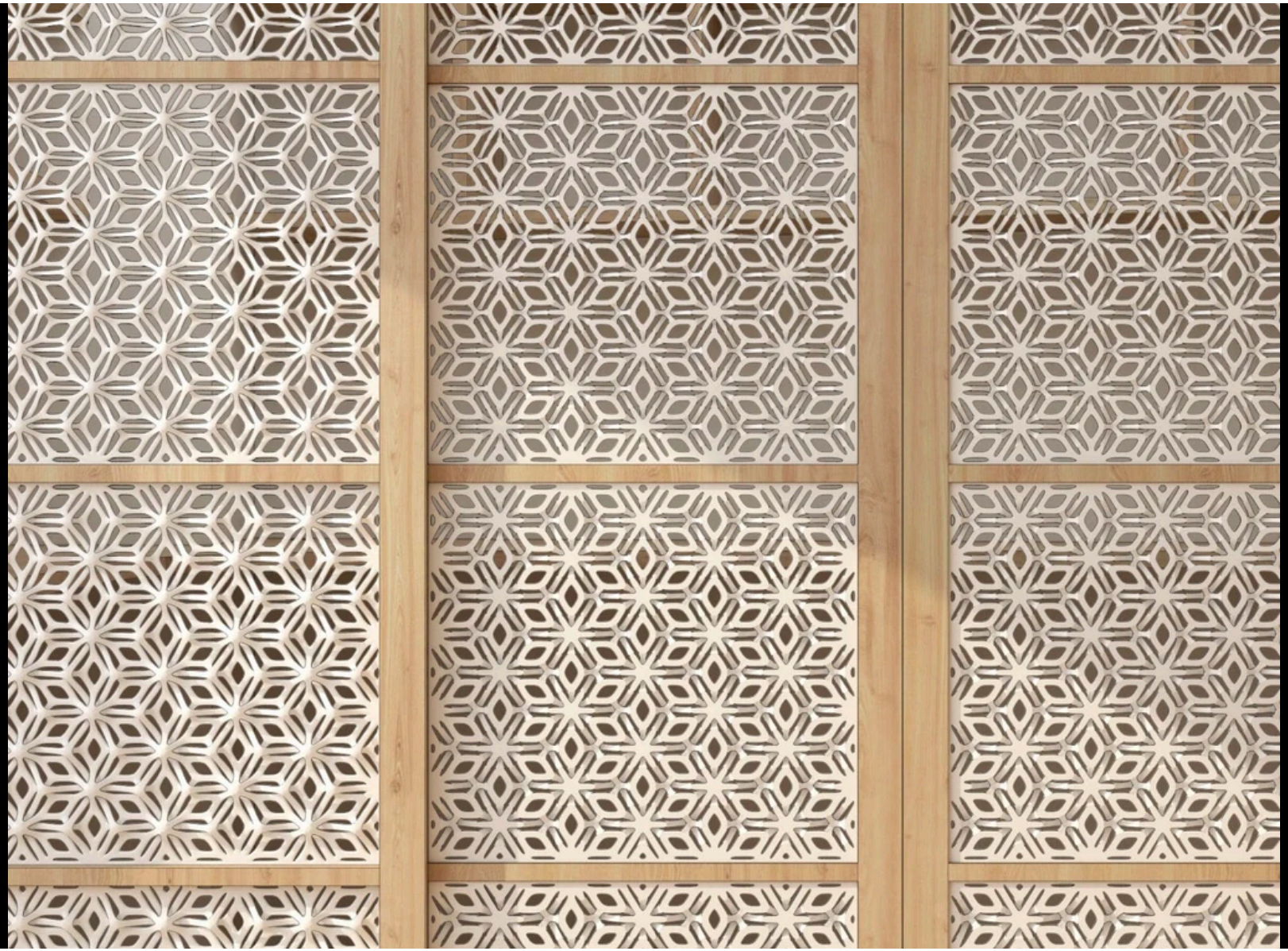
Alhambra Mosque

Alhambra Mosque

Alhambra Mosque

Raffello Galiotto for Lithos Design
https://www.lithosdesign.com/


Travis Fitch



Creating Interesting Tiles

Use one of the foundational tilings as a starting point.

Add complexity (in 2D or 3D). Constraint: maintain edge relationships

Tile through repetition, consider fractalization

Morph across surface

questions?

Thank you!

CS 491 and 591
Professor: Leah Buechley
https://handandmachine.cs.unm.edu/classes/Computational_Fabrication_Spring2021/