

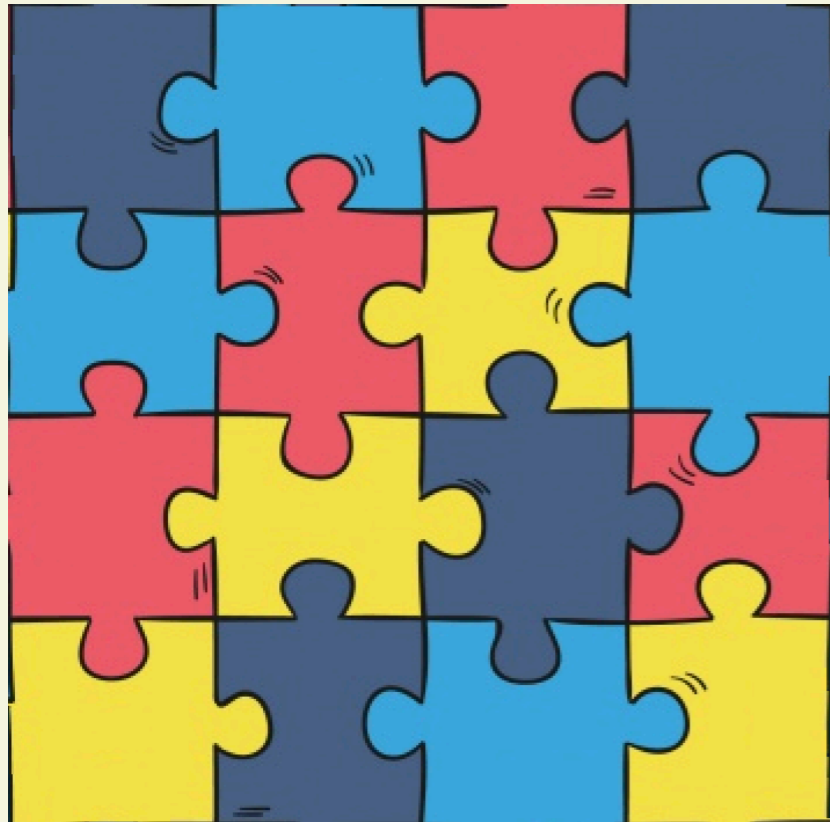


# **CREATING ART FROM MATH**

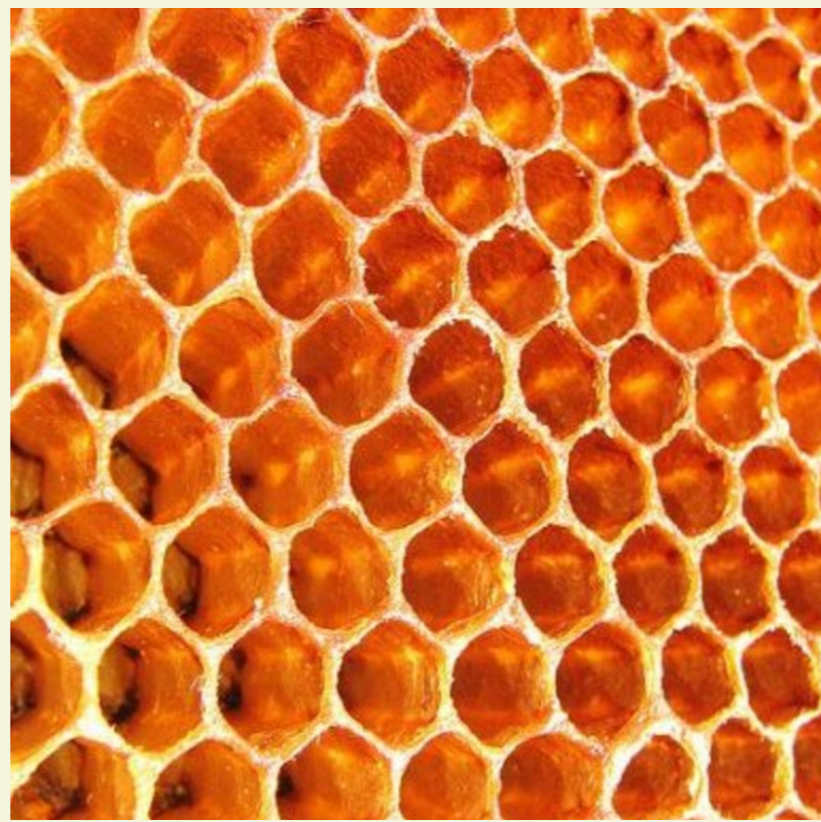
**KAVITA RAMANAN AND ANNA GRIM**

# WHAT DO THESE HAVE IN COMMON?

---



1



2

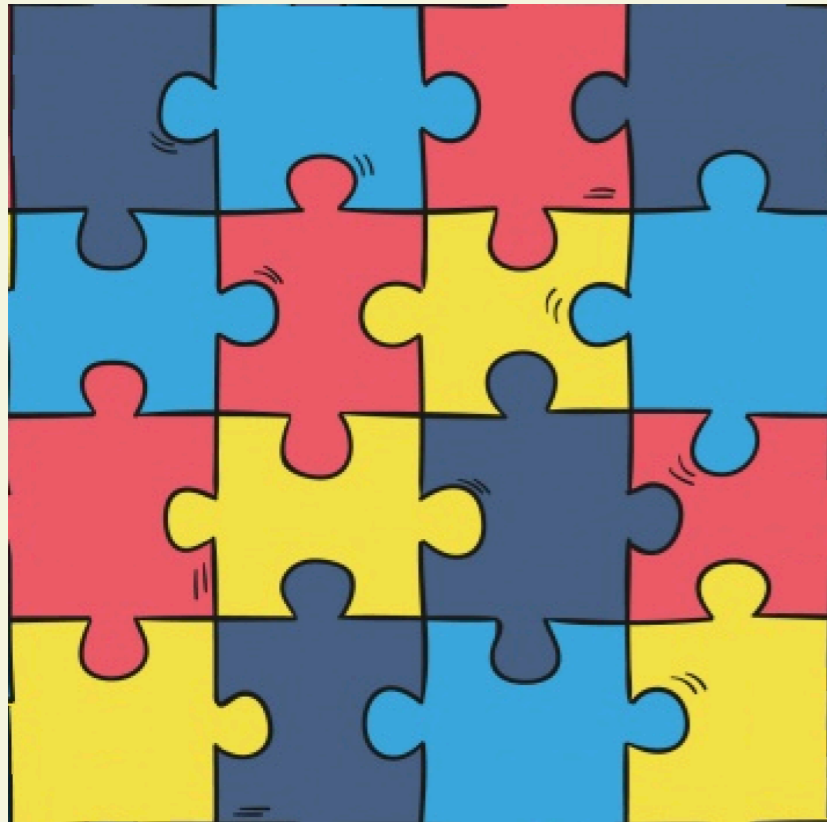


3

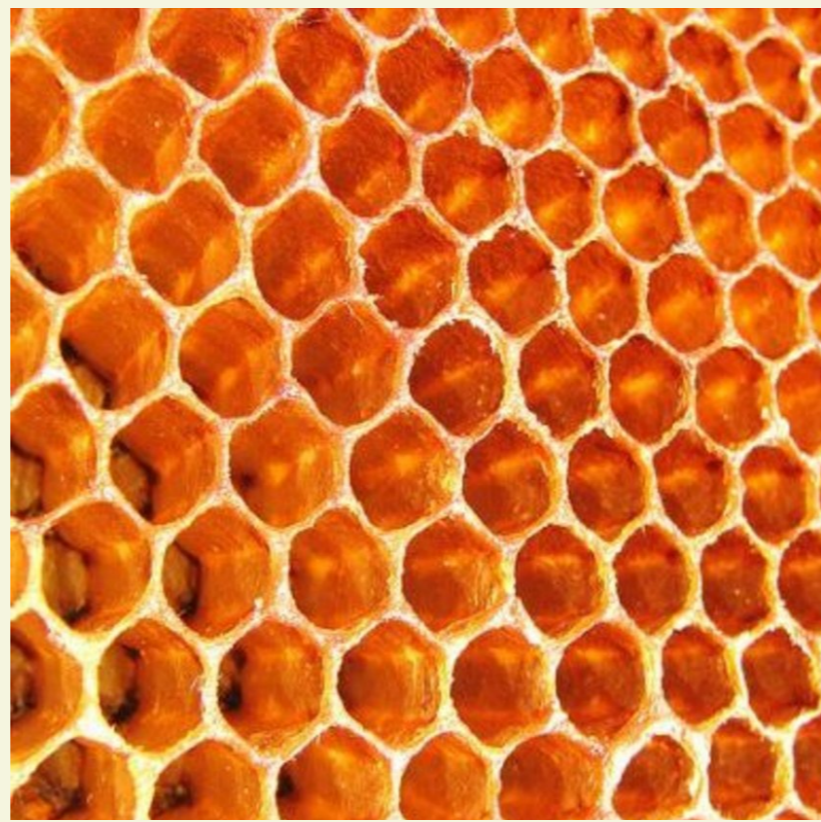
# WHAT DO THESE HAVE IN COMMON?

---

THESE ARE ALL TILINGS!



1



2

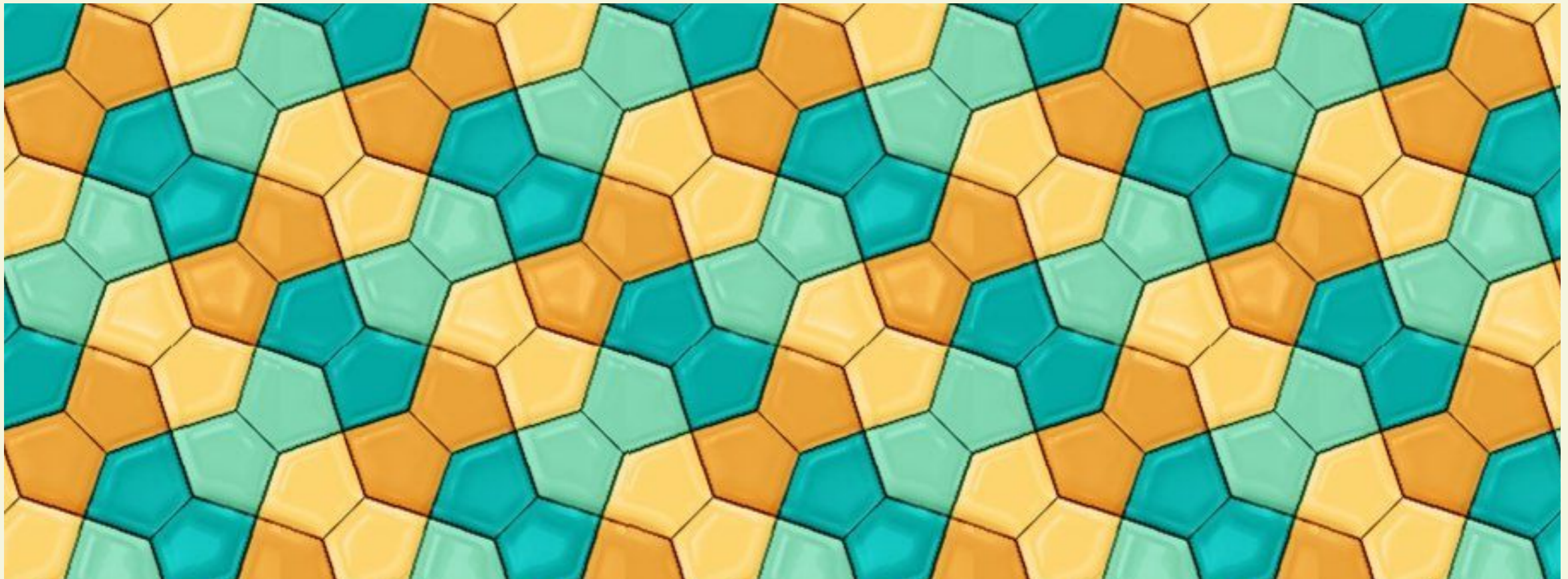


3

# WHAT IS A TILING?

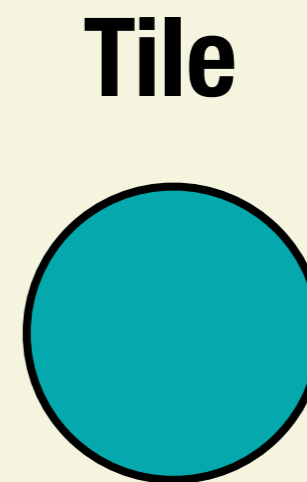
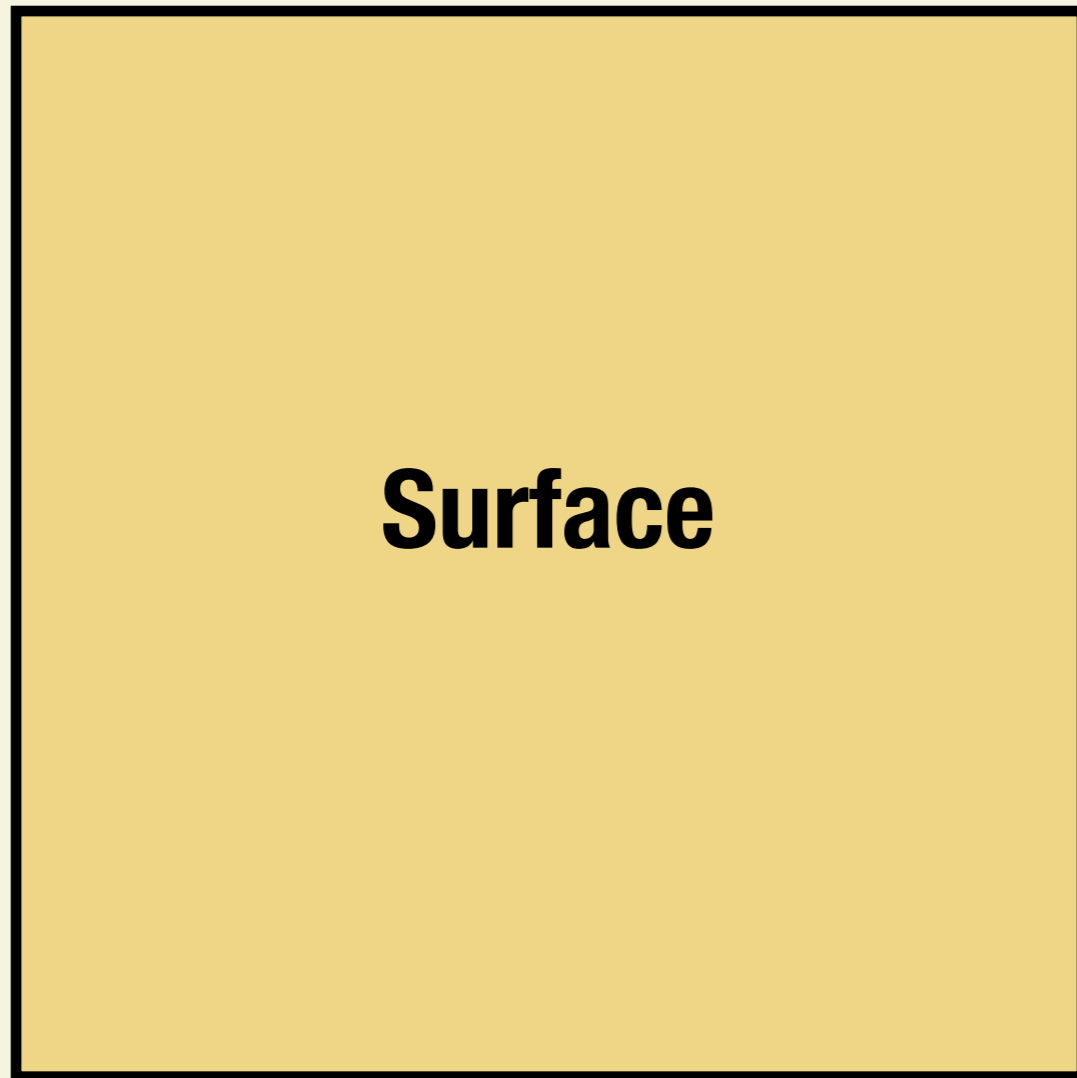
---

**A TILING IS A SET OF SHAPES THAT COVER A FLAT SURFACE WITHOUT ANY GAPS OR OVERLAPS**



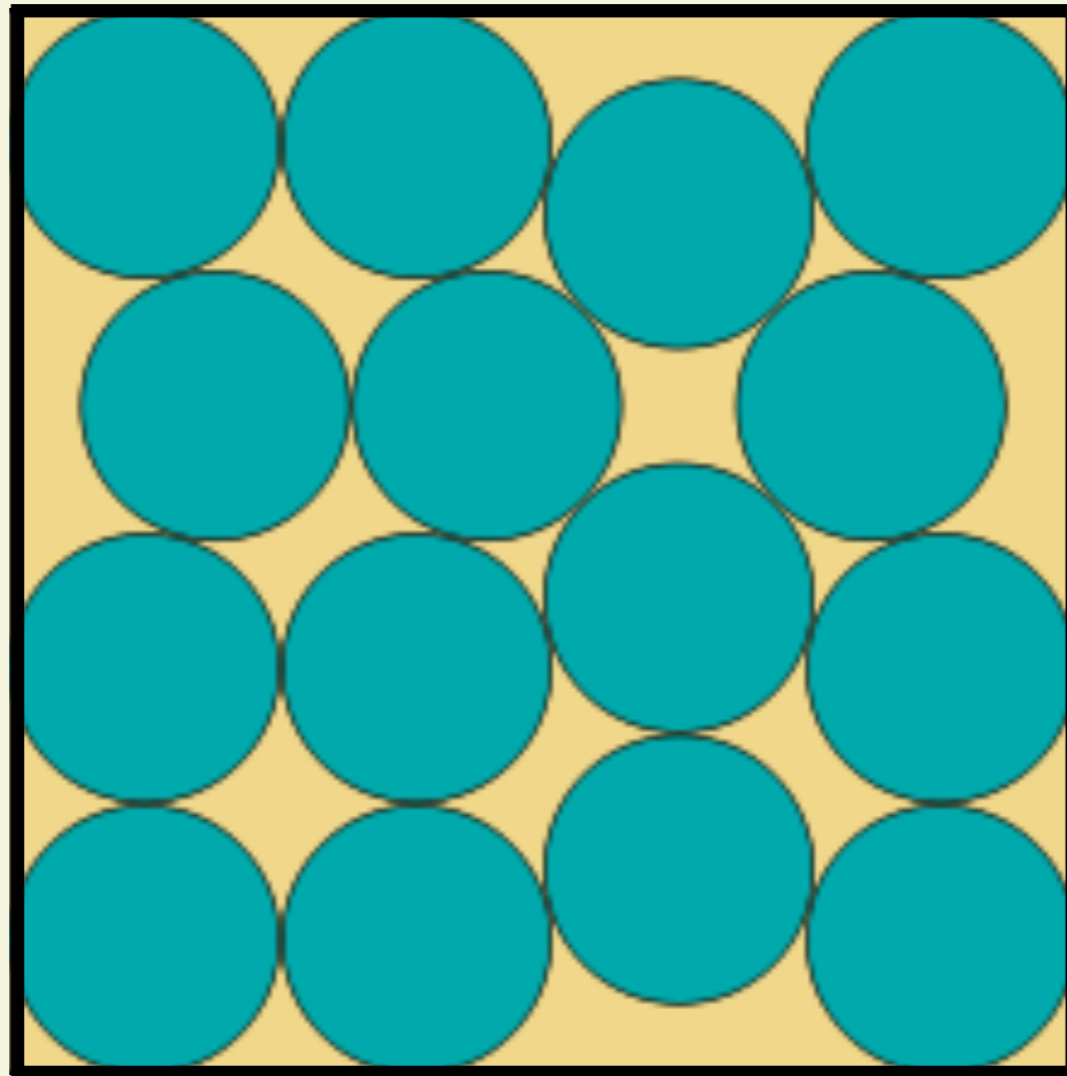
# IS THIS A TILING?

---



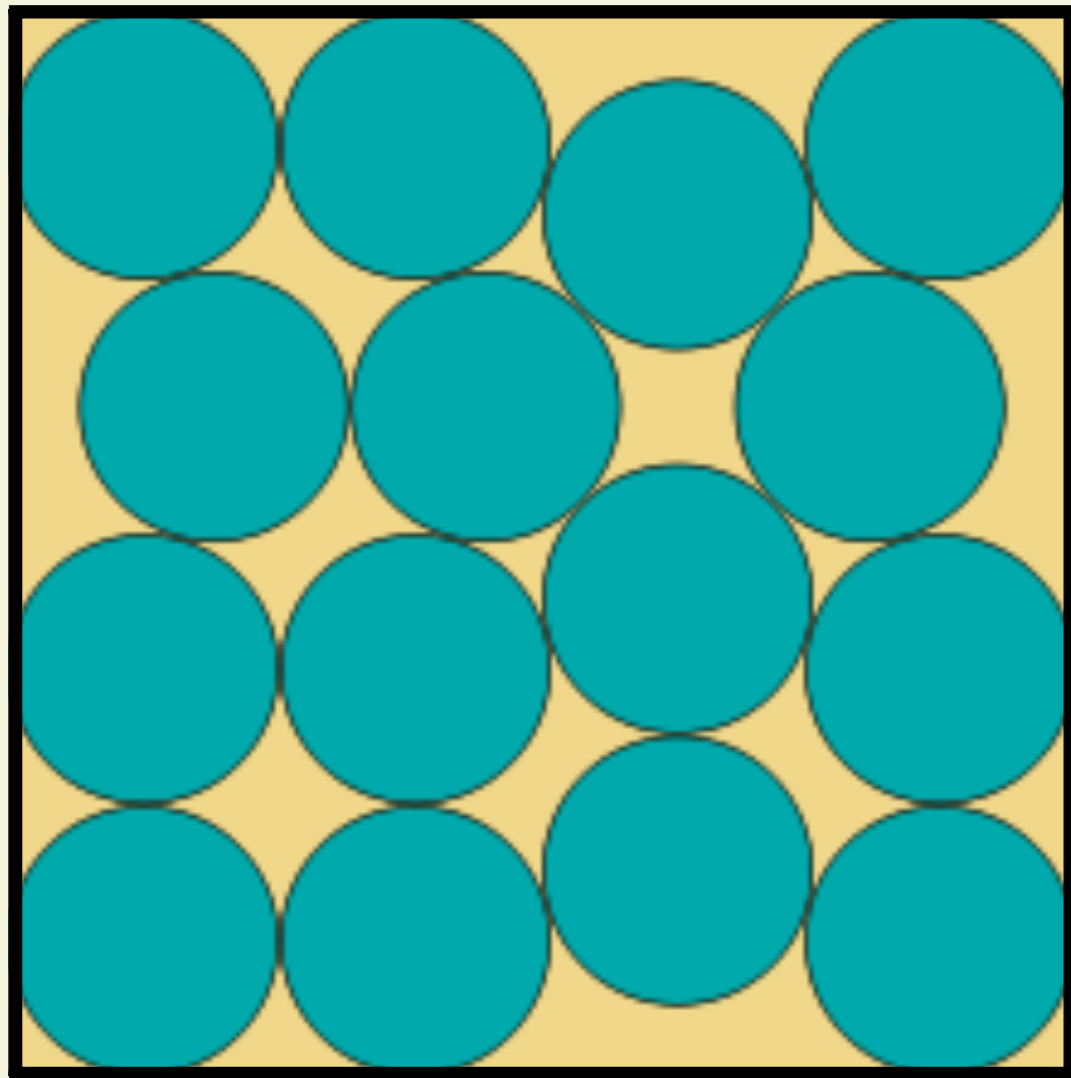
# IS THIS A TILING?

---



# IS THIS A TILING?

---

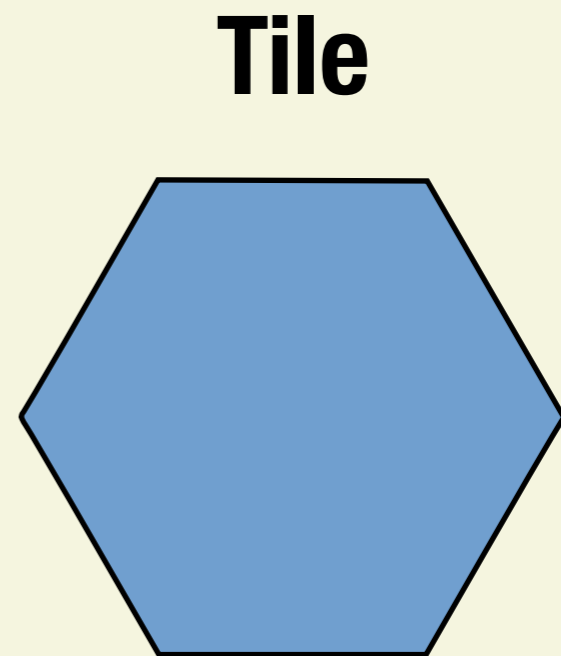
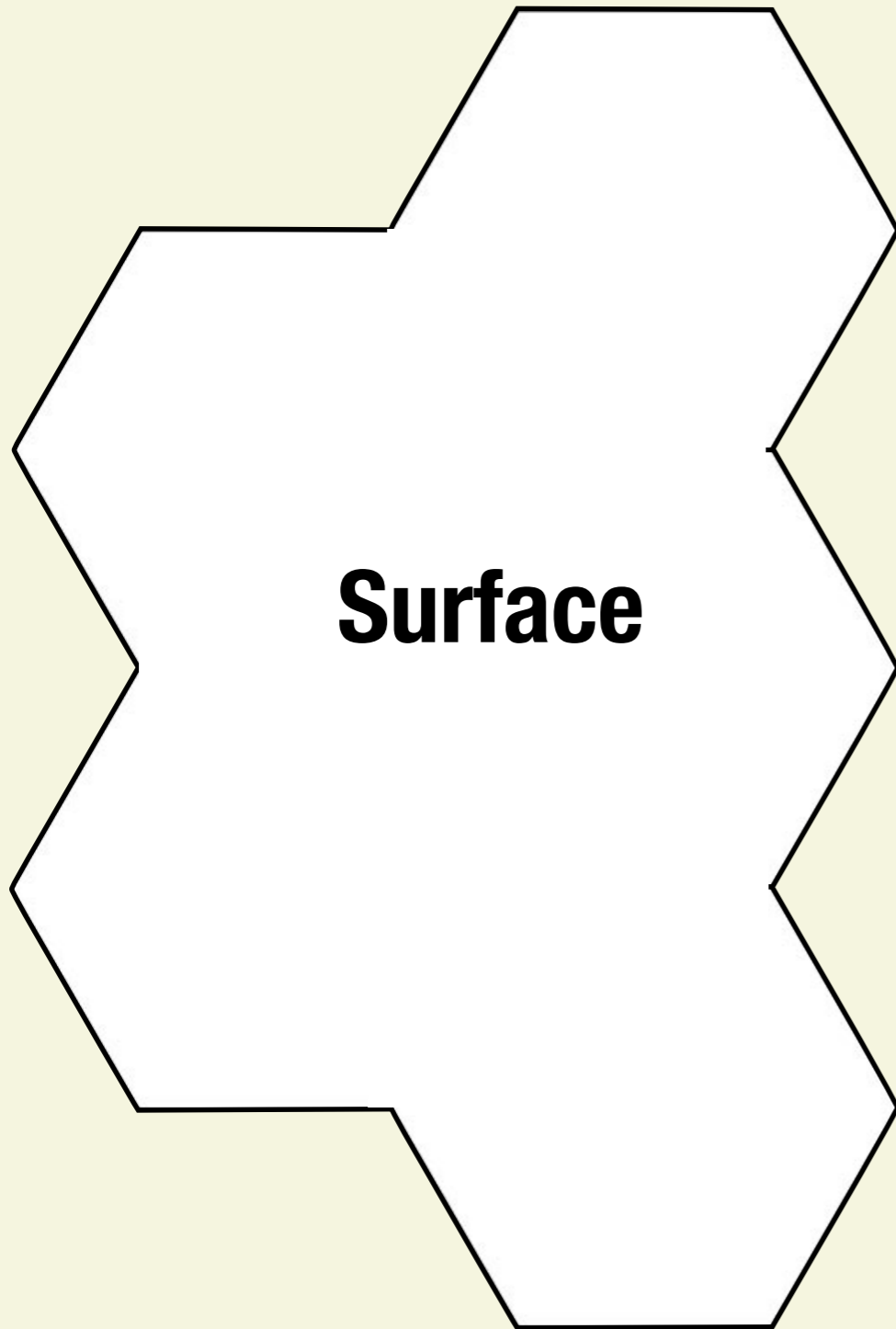


**NO!**

**BECAUSE THE TILES  
DON'T COMPLETELY  
COVER THE SURFACE**

# IS THIS A TILING?

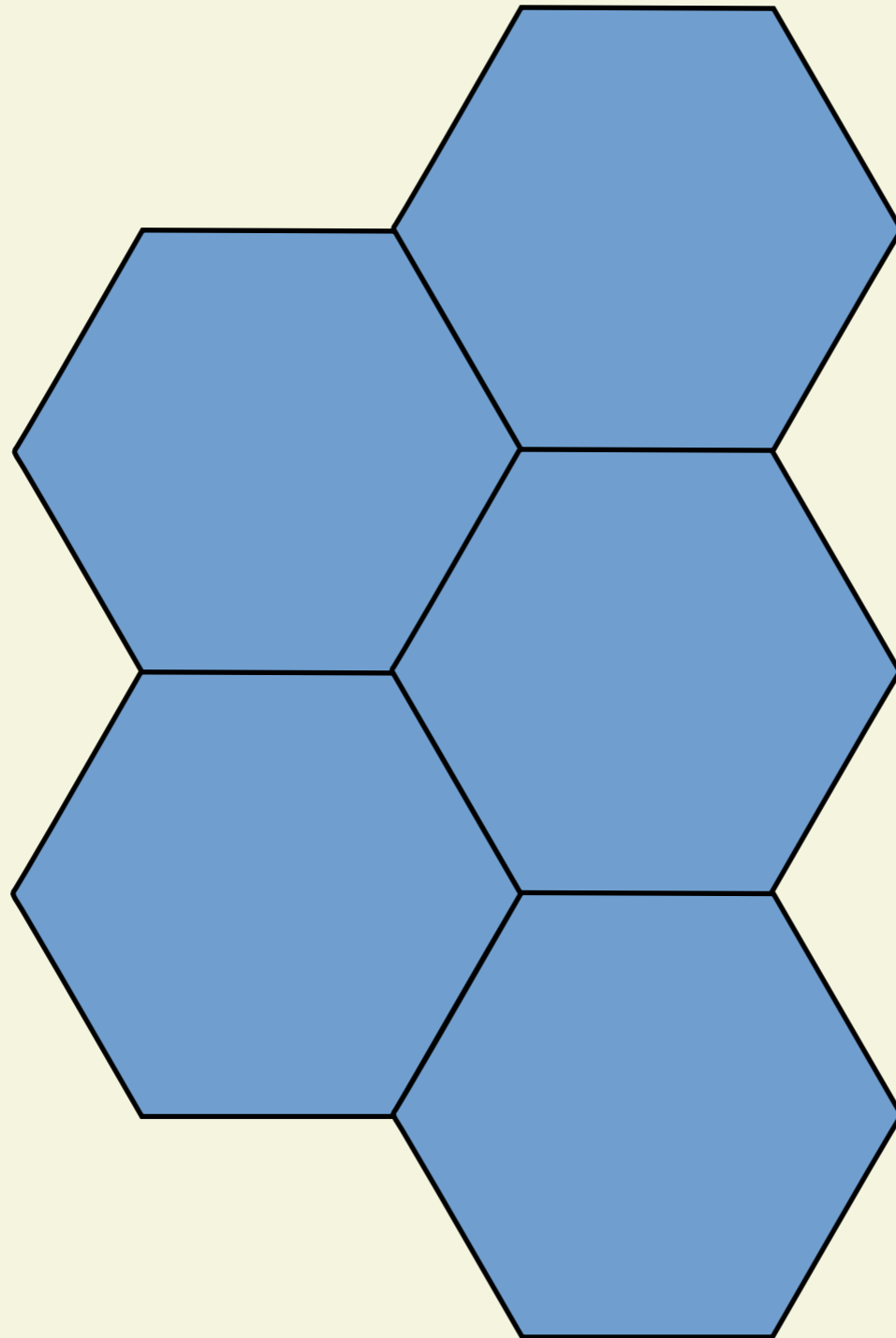
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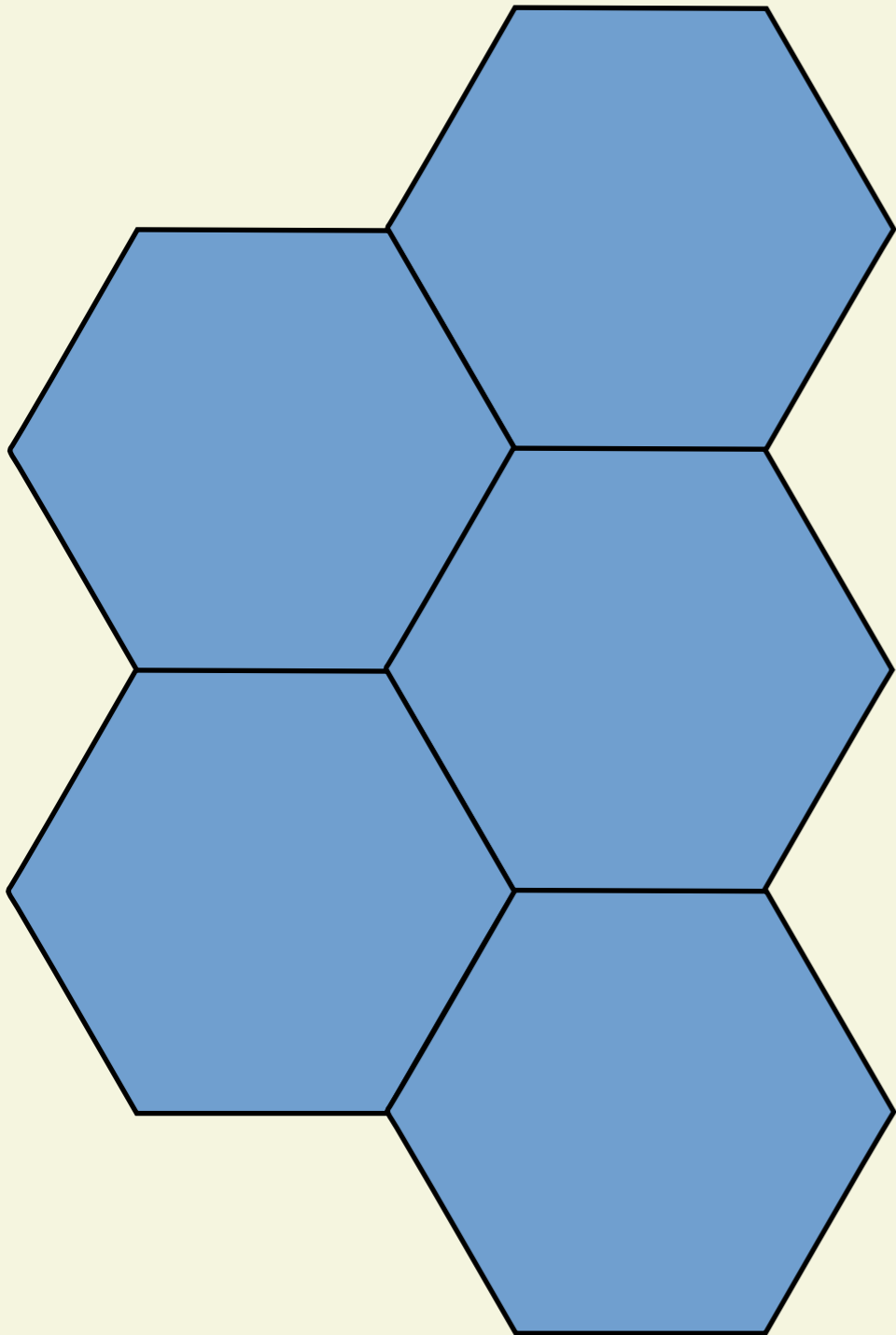
# IS THIS A TILING?

---



# IS THIS A TILING?

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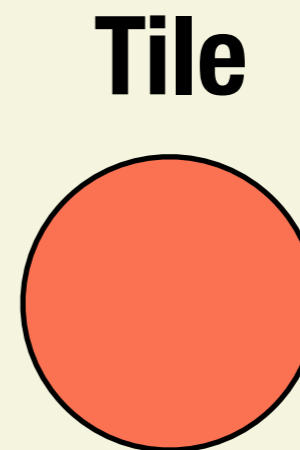
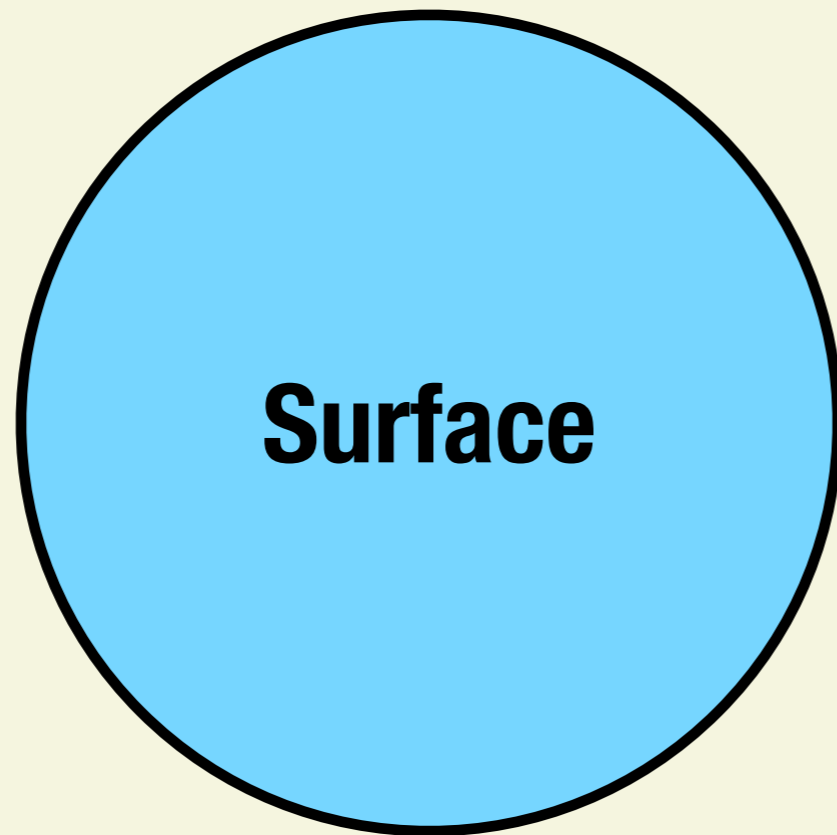


**YES!**

- 1. COMPLETELY COVERS THE SURFACE**
- 2. TILES DO NOT OVERLAP**

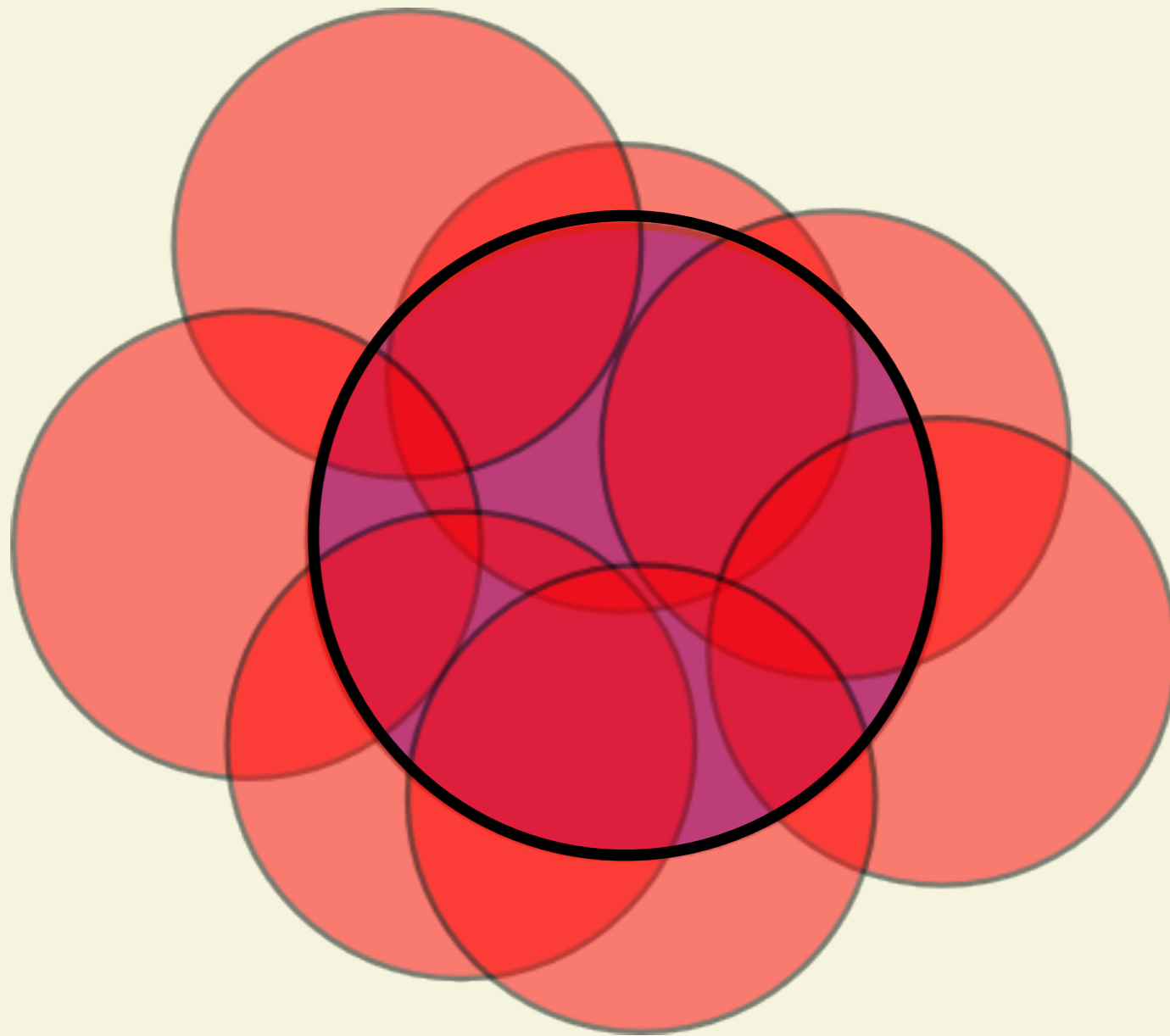
# IS THIS A TILING?

---



# IS THIS A TILING?

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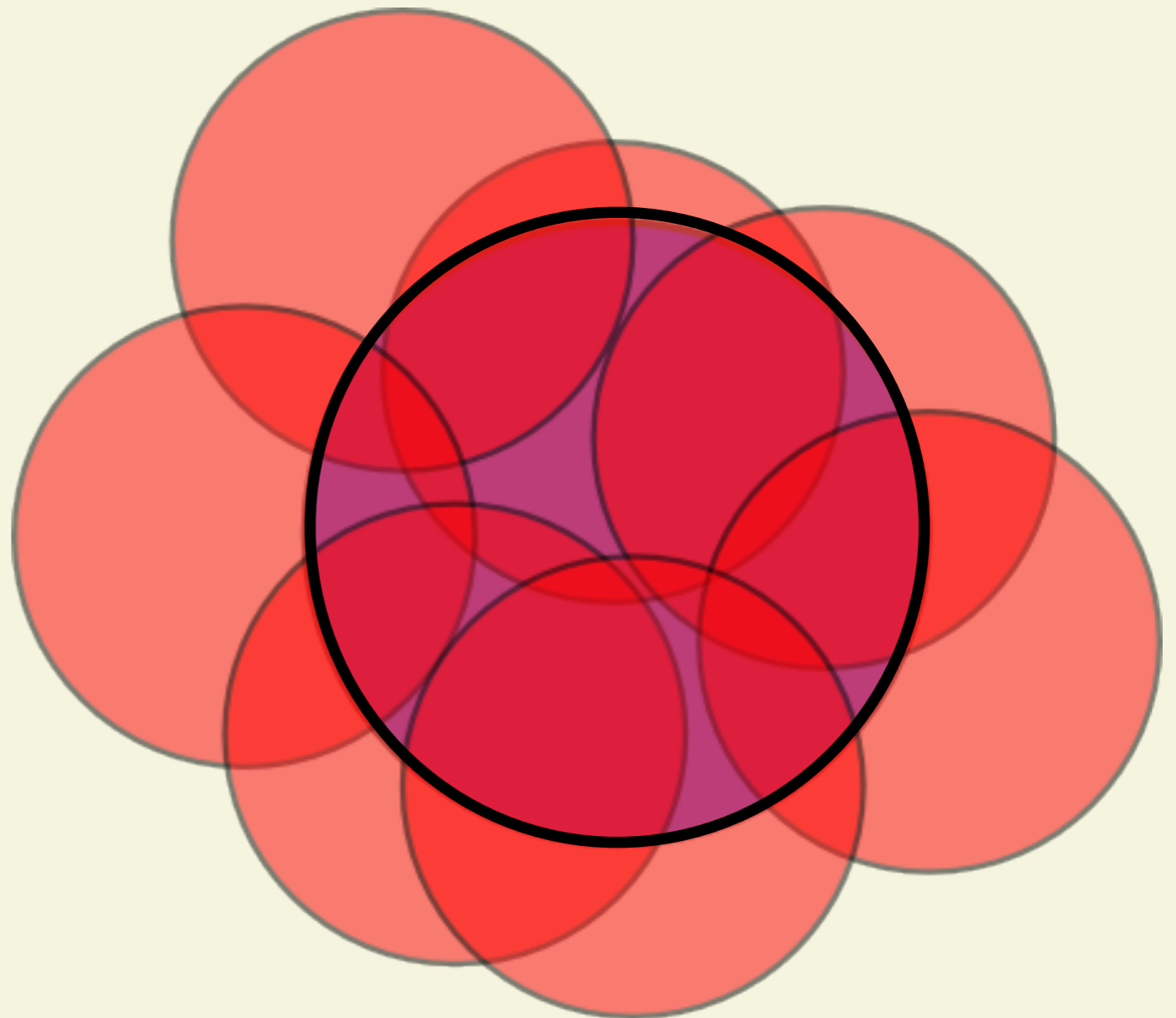


# IS THIS A TILING?

---

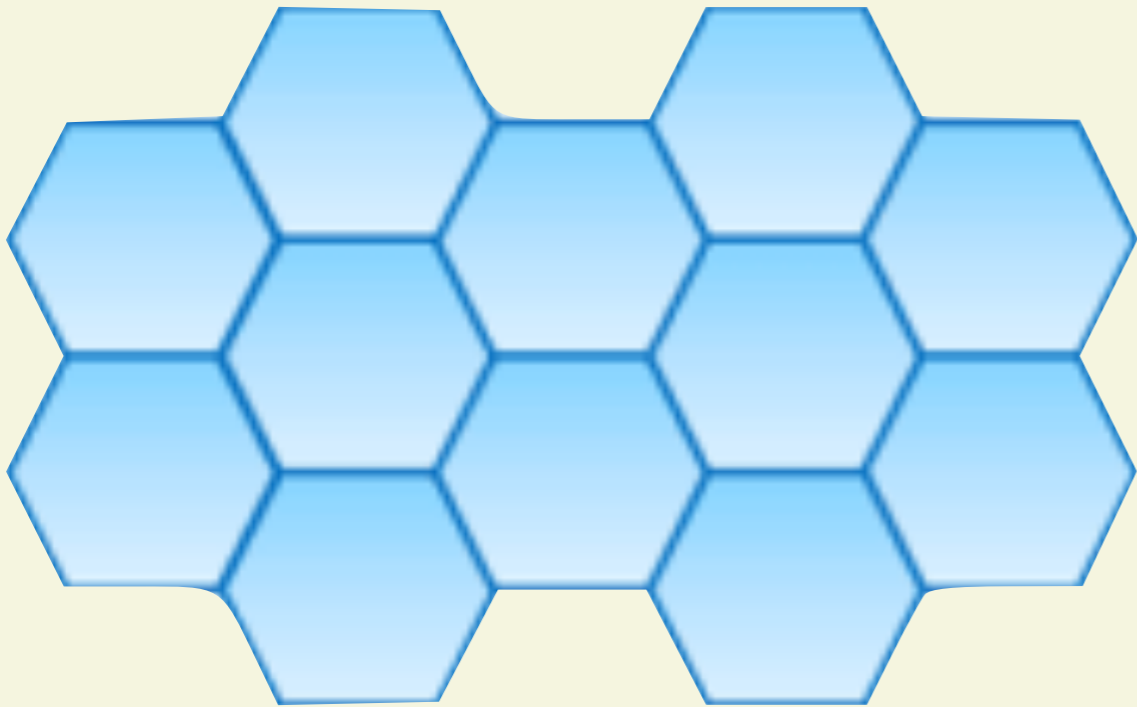
**NO!**

**BECAUSE THE TILES  
OVERLAP**

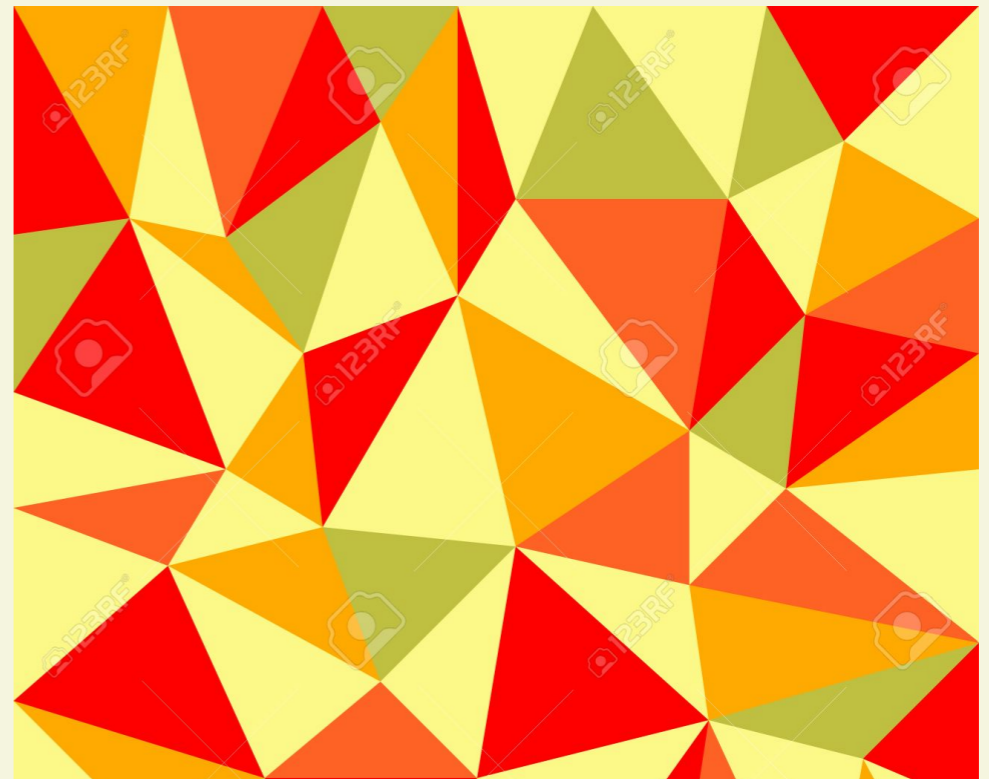


# REGULAR VS. IRREGULAR TILINGS?

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**REGULAR**

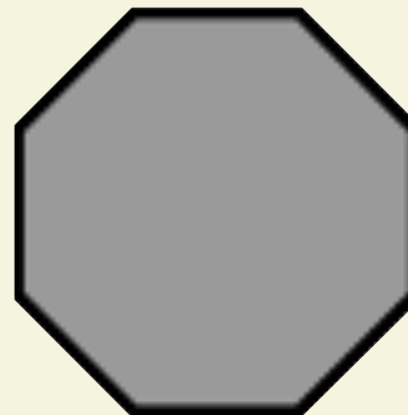
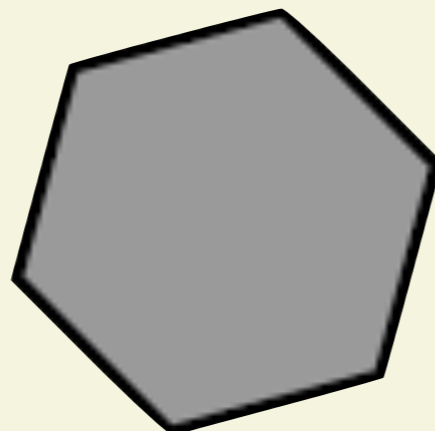
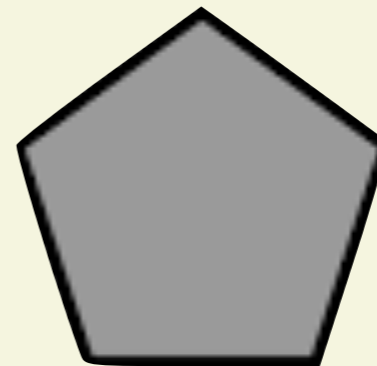
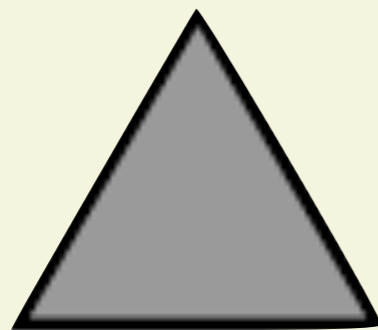


**IRREGULAR**

# PROBLEM 1

---

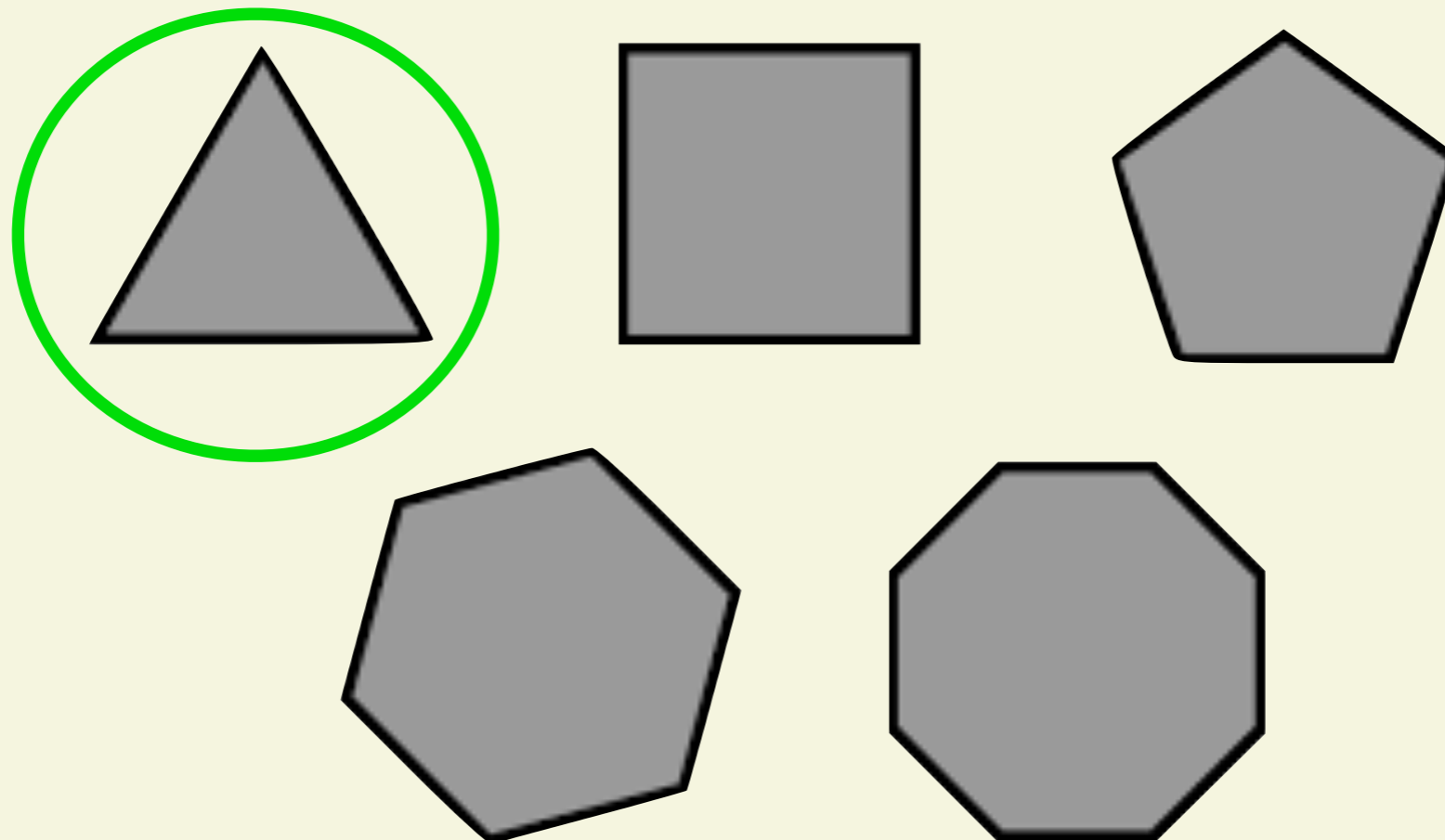
**CAN WE MAKE A TILING WITH ANY  
REGULAR SHAPE?**



# PROBLEM 1

---

**CAN WE MAKE A TILING WITH ANY  
REGULAR SHAPE?**

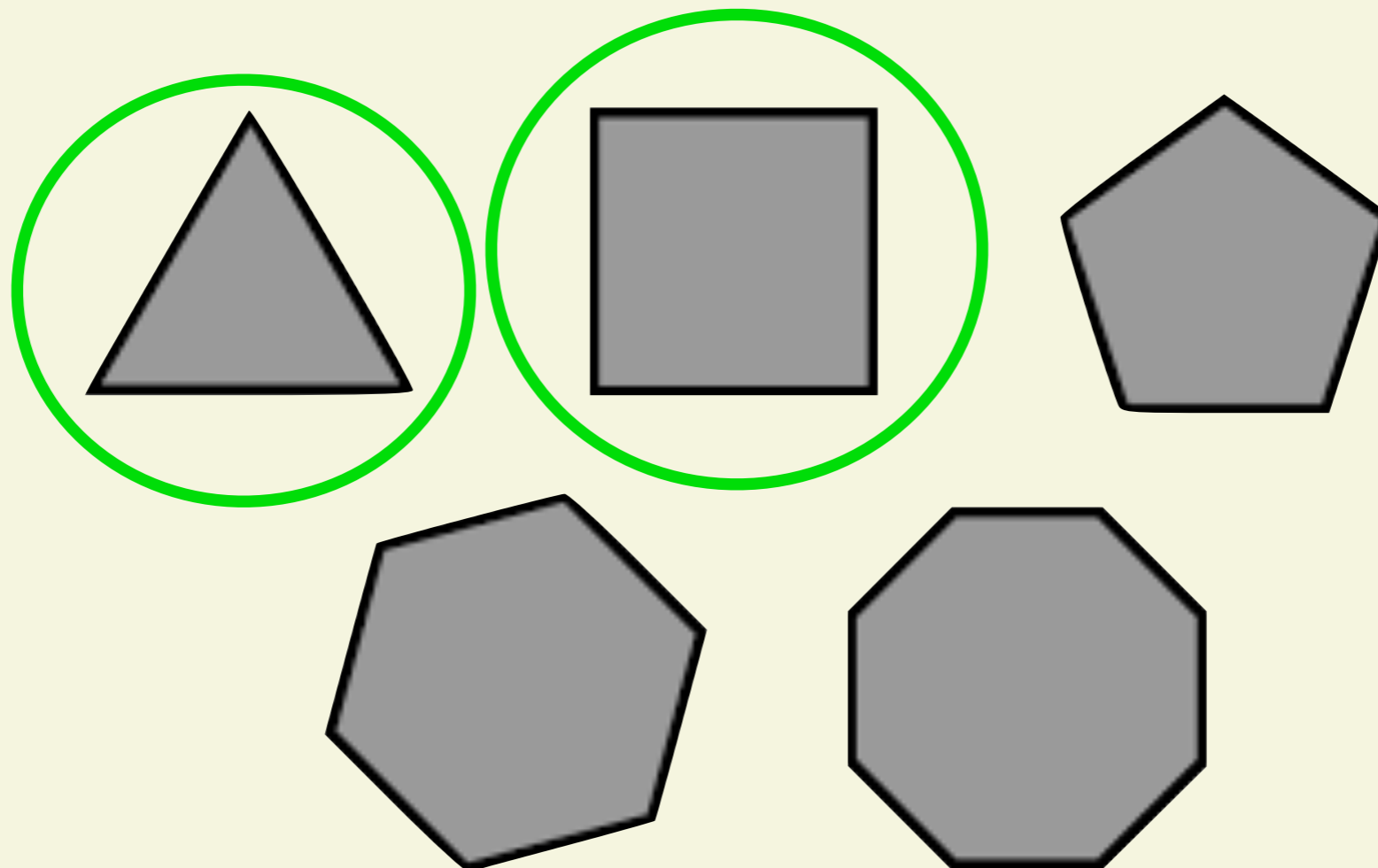




# PROBLEM 1

---

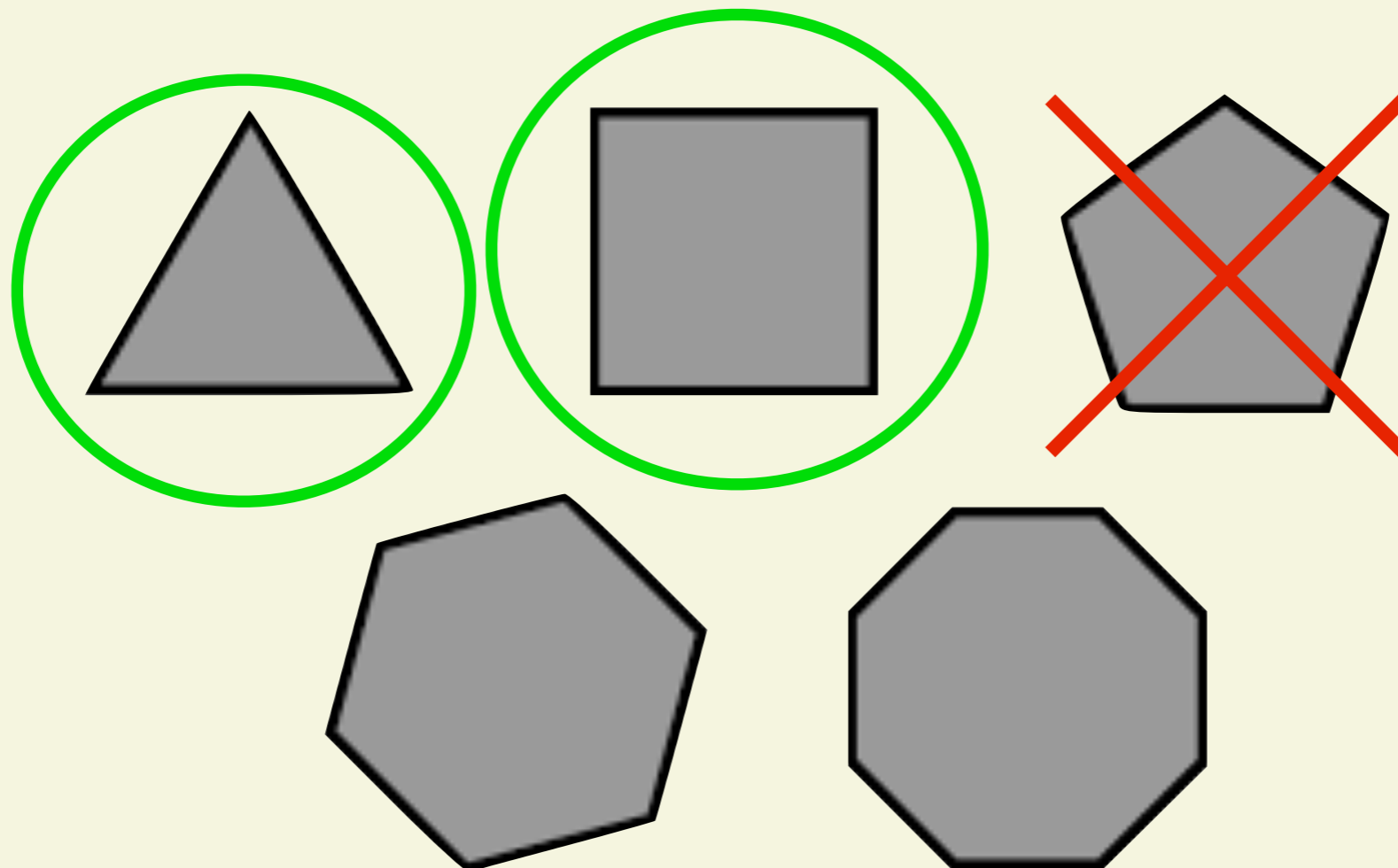
**CAN WE MAKE A TILING WITH ANY  
REGULAR SHAPE?**



# PROBLEM 1

---

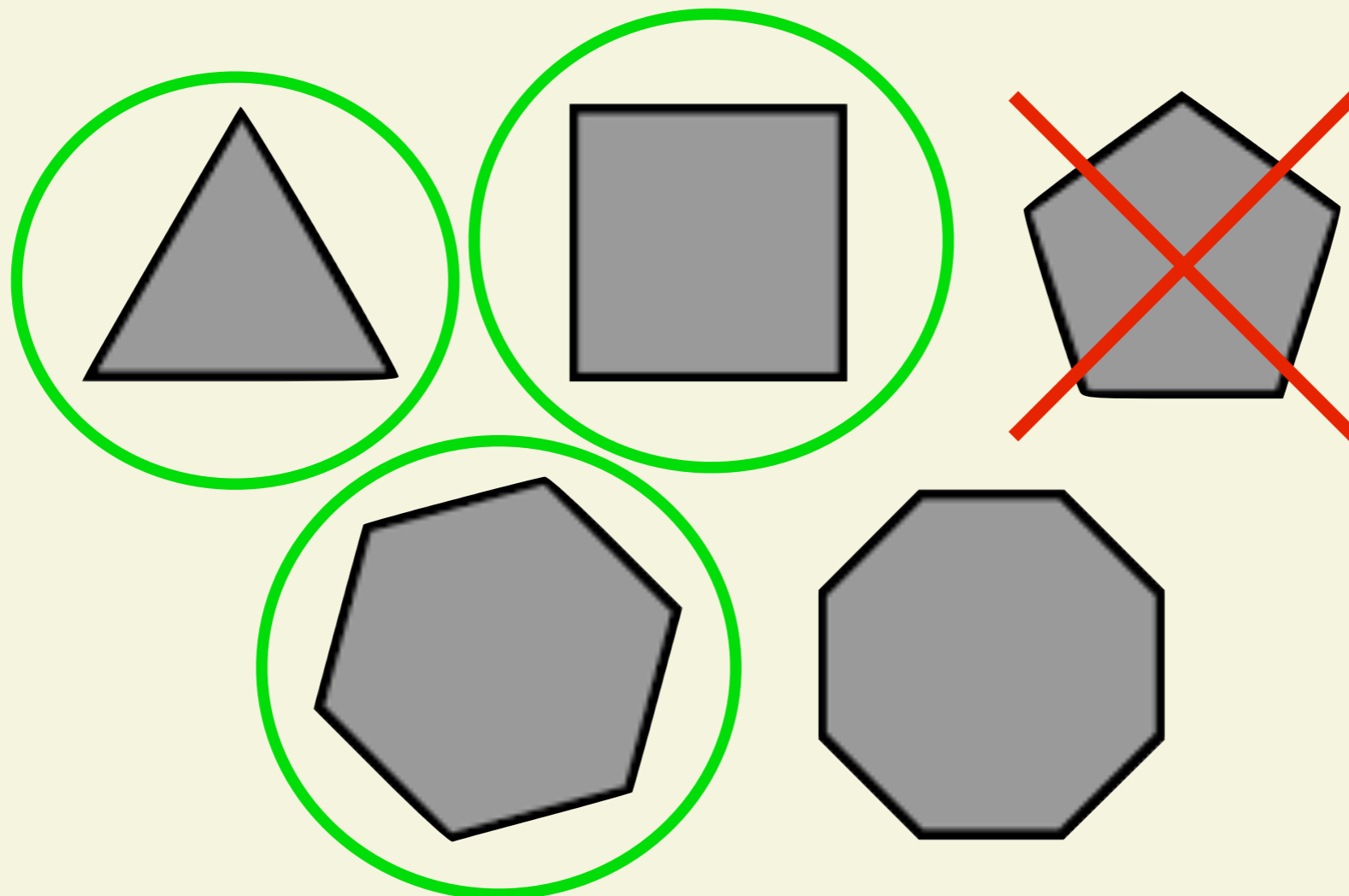
**CAN WE MAKE A TILING WITH ANY  
REGULAR SHAPE?**



# PROBLEM 1

---

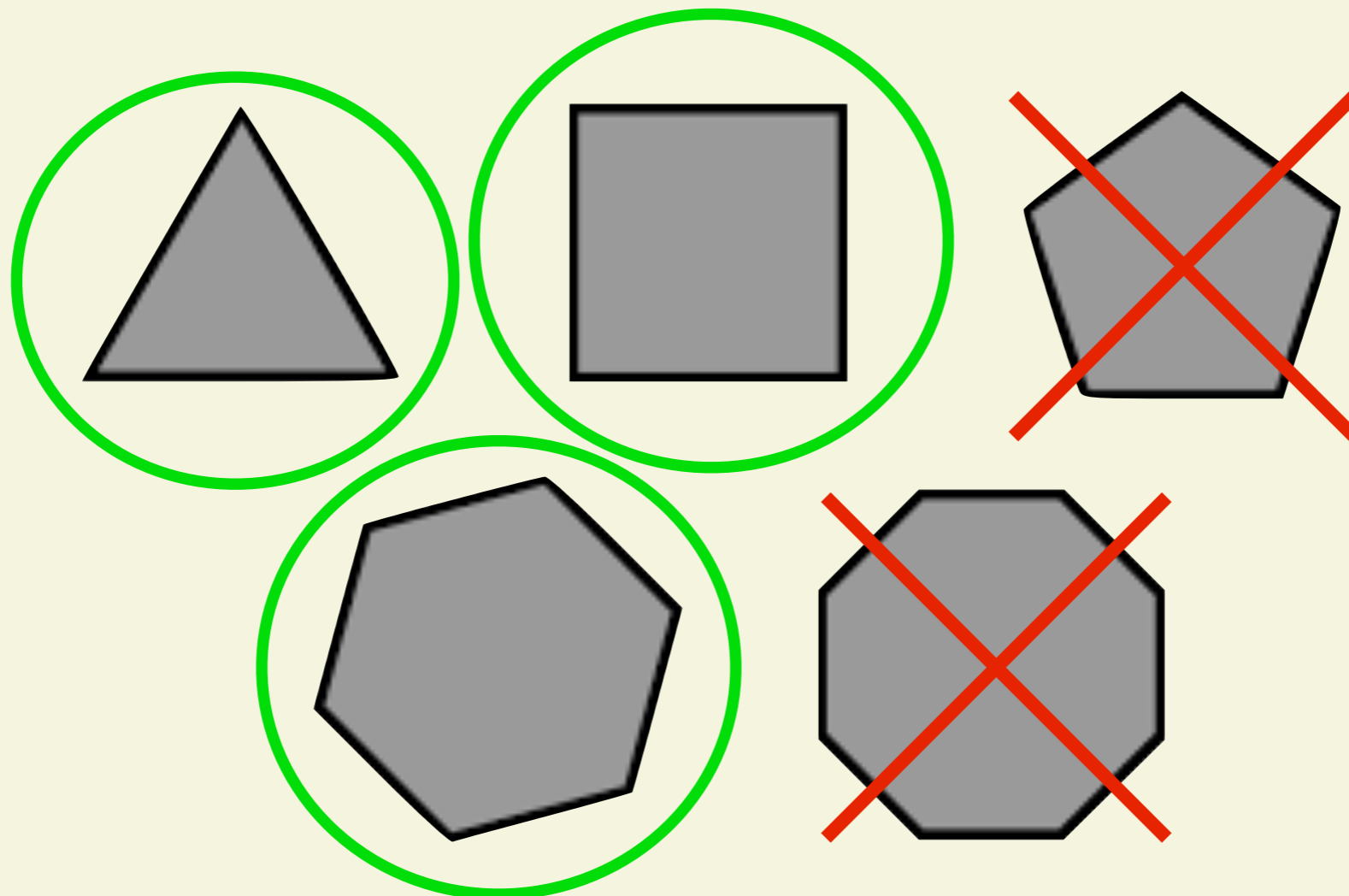
**CAN WE MAKE A TILING WITH ANY  
REGULAR SHAPE?**



# PROBLEM 1

---

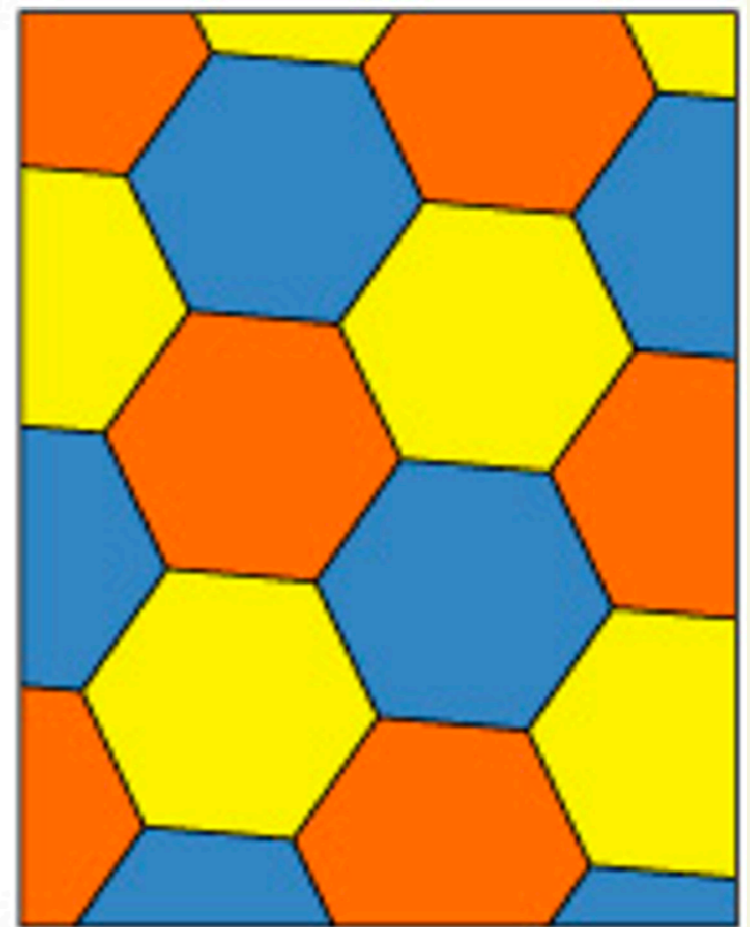
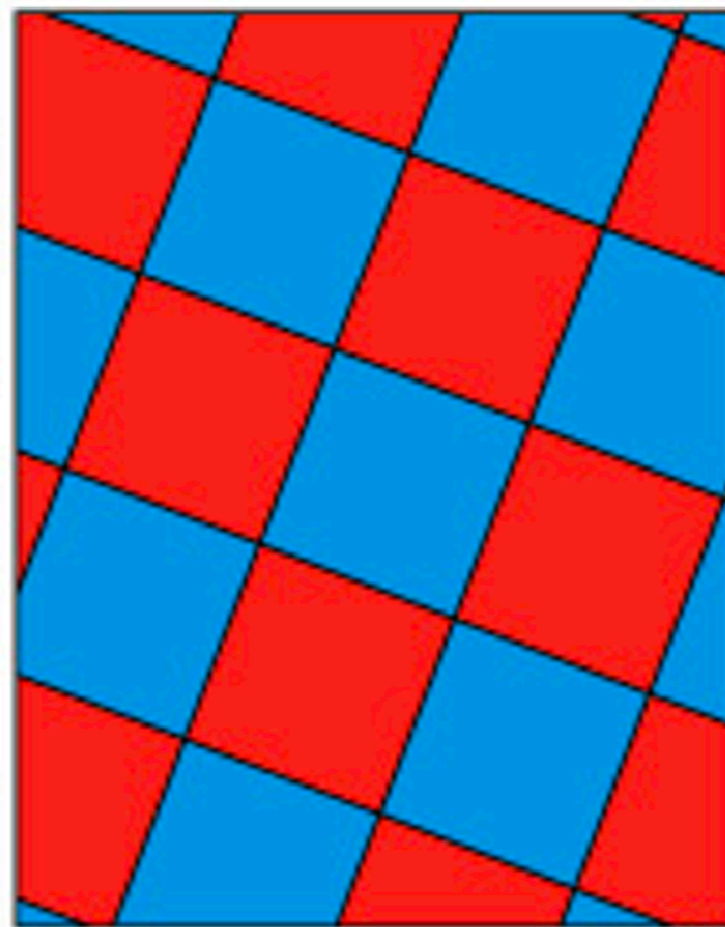
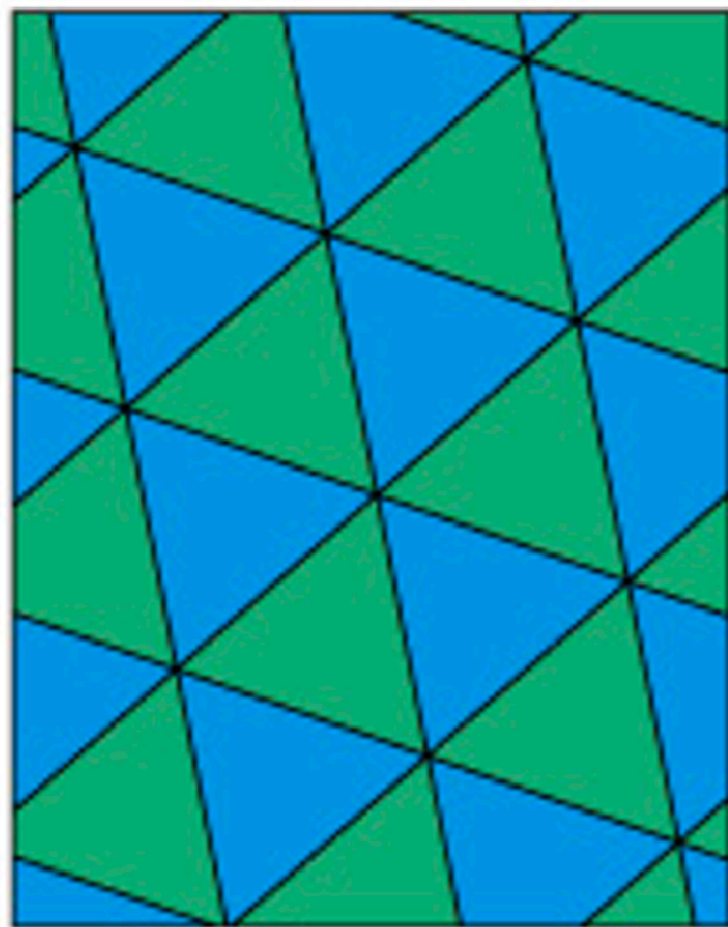
**CAN WE MAKE A TILING WITH ANY  
REGULAR SHAPE?**



# SOLUTION 1

---

**WE CAN ONLY MAKE A TILING OUT OF TRIANGLES, SQUARES, AND HEXAGONS**



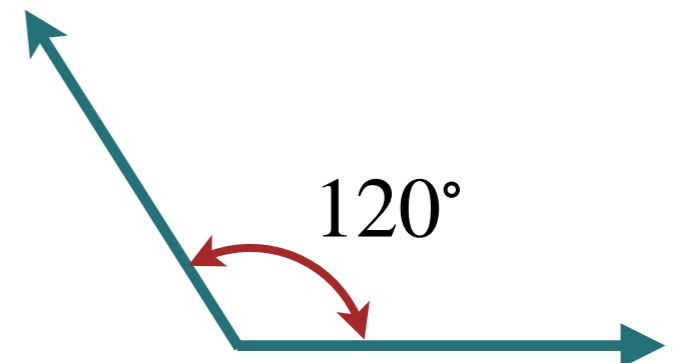
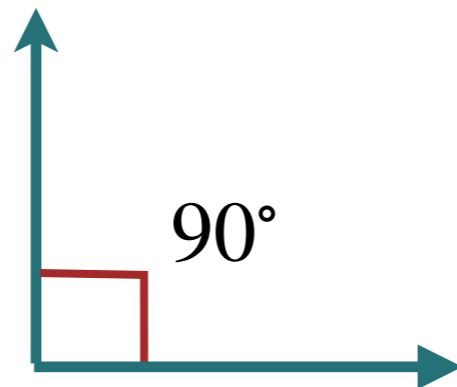
# WHY?

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**IT DEPENDS ON THE ANGLE OF  
THE SHAPE**



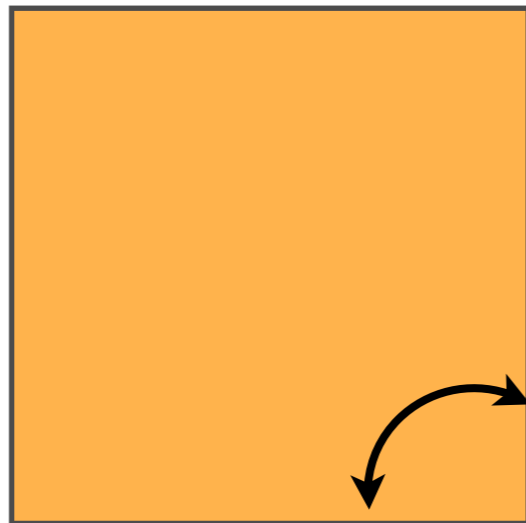
**SMALL ANGLE =  
POINTY CORNER**



**BIG ANGLE =  
WIDE CORNER**

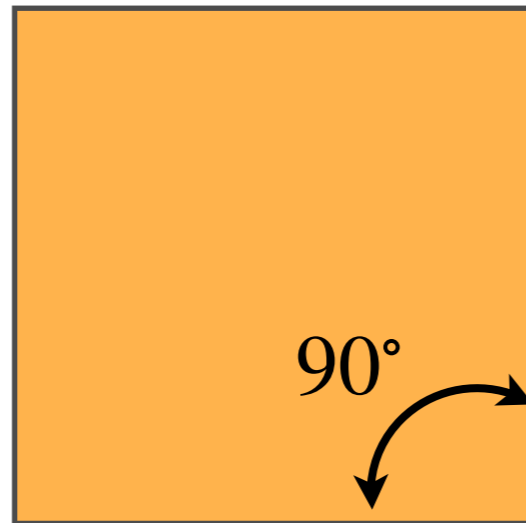
# LET'S TILE WITH SQUARES

---



# LET'S TILE WITH SQUARES

---

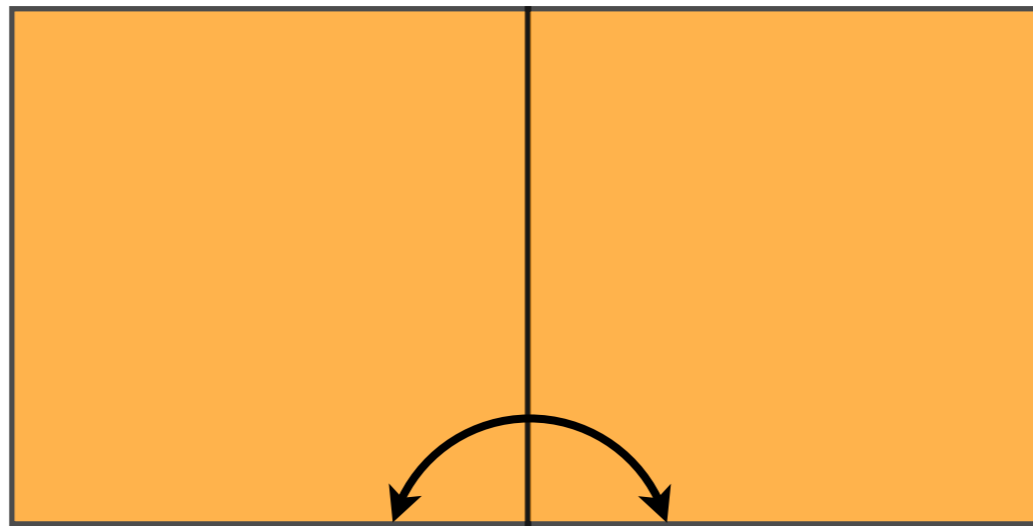


**90**



# LET'S TILE WITH SQUARES

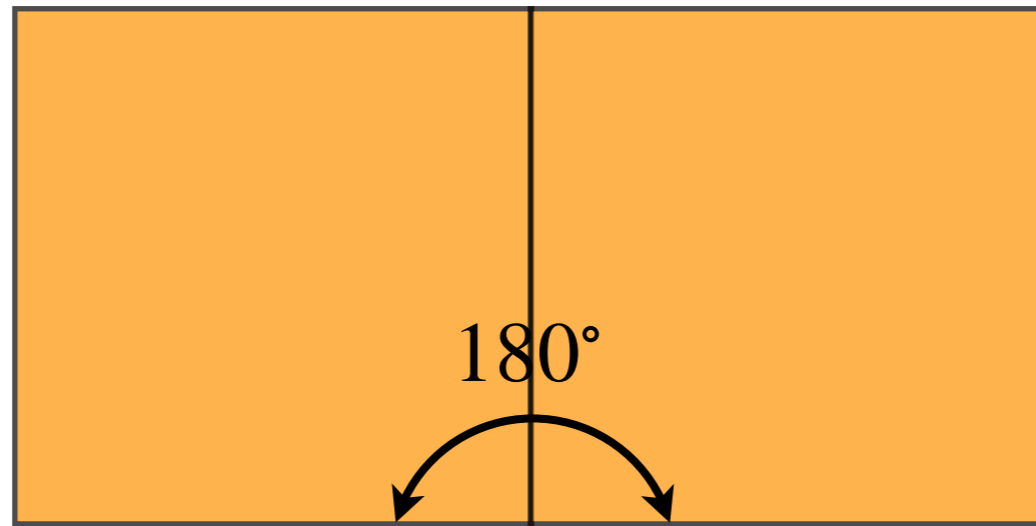
---



$$\begin{array}{r} 90 \\ + 90 \\ \hline \end{array}$$

# LET'S TILE WITH SQUARES

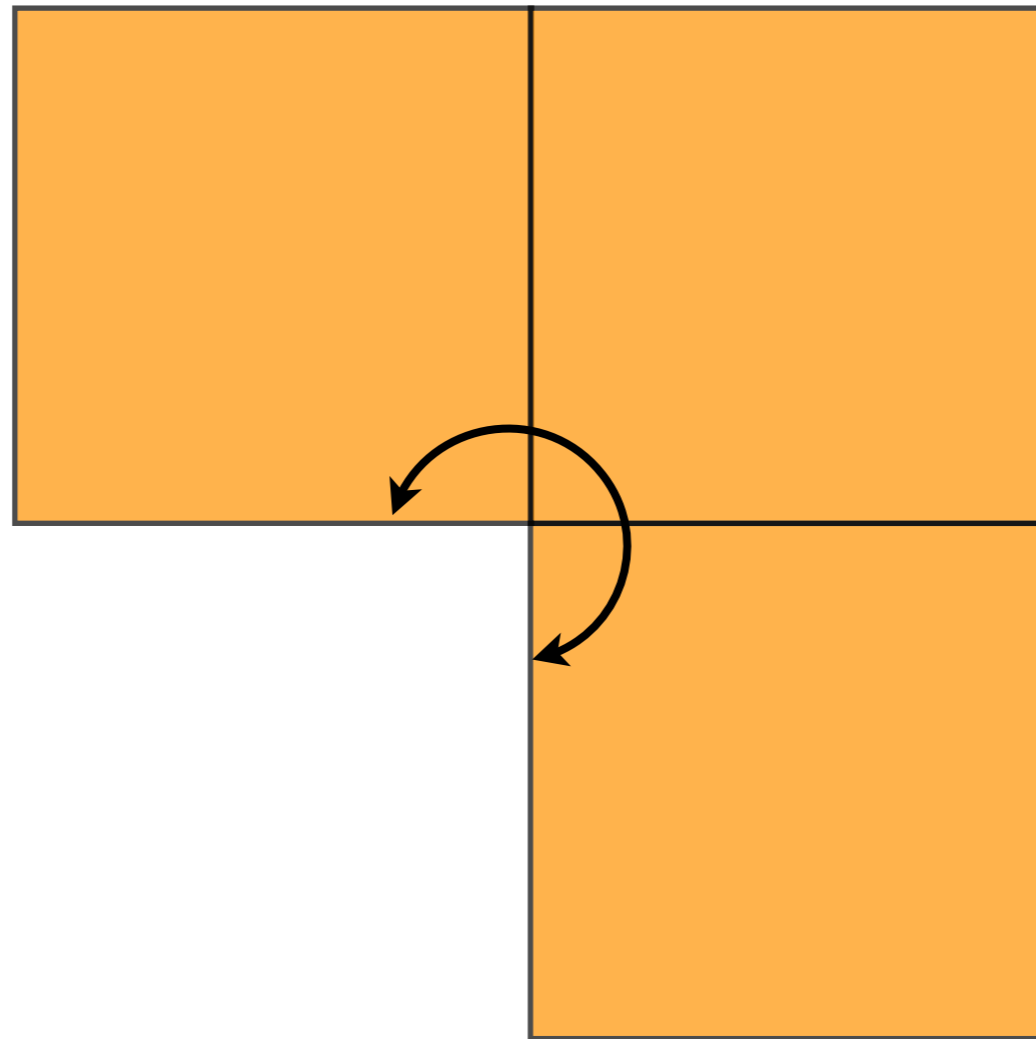
---



$$\begin{array}{r} 90 \\ + 90 \\ \hline 180 \end{array}$$

# LET'S TILE WITH SQUARES

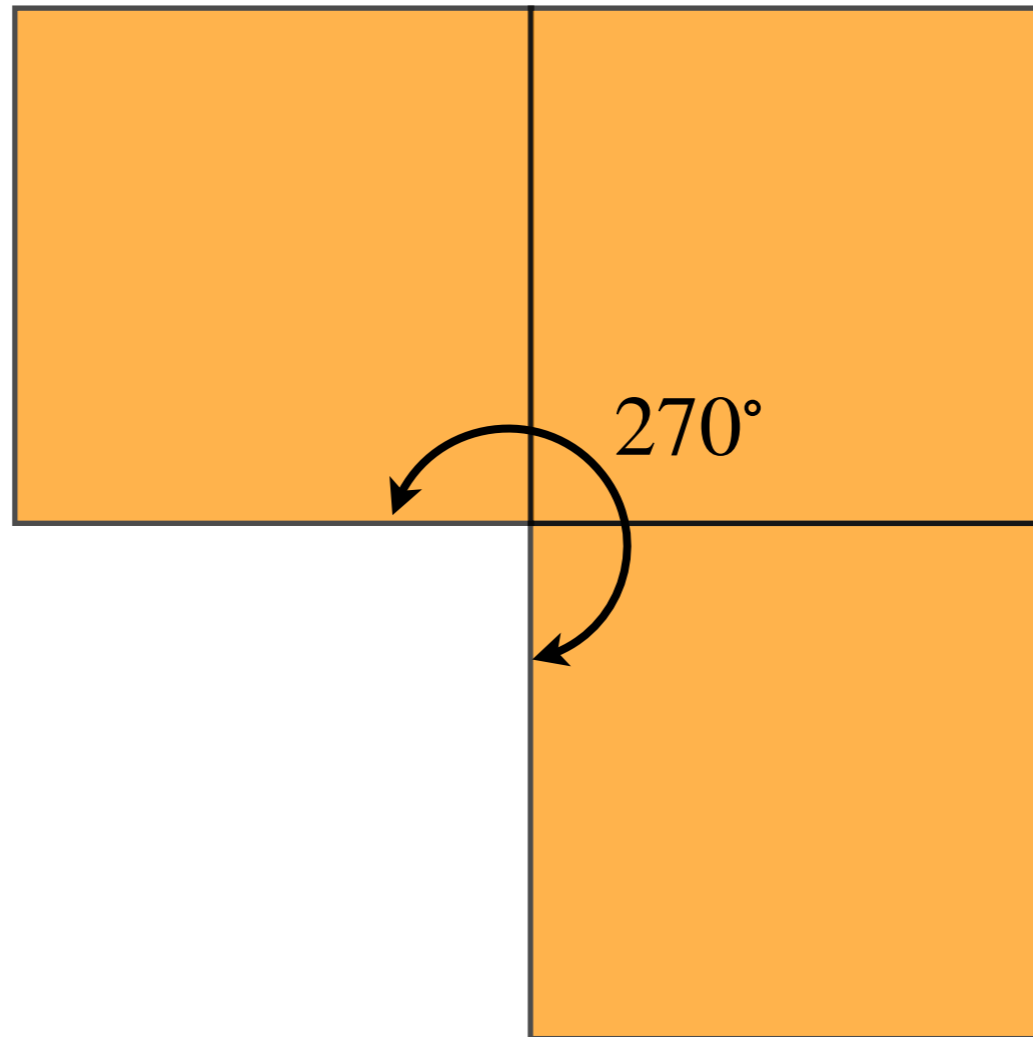
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$$\begin{array}{r} 90 \\ + 90 \\ \hline 180 \\ + 90 \\ \hline \end{array}$$

# LET'S TILE WITH SQUARES

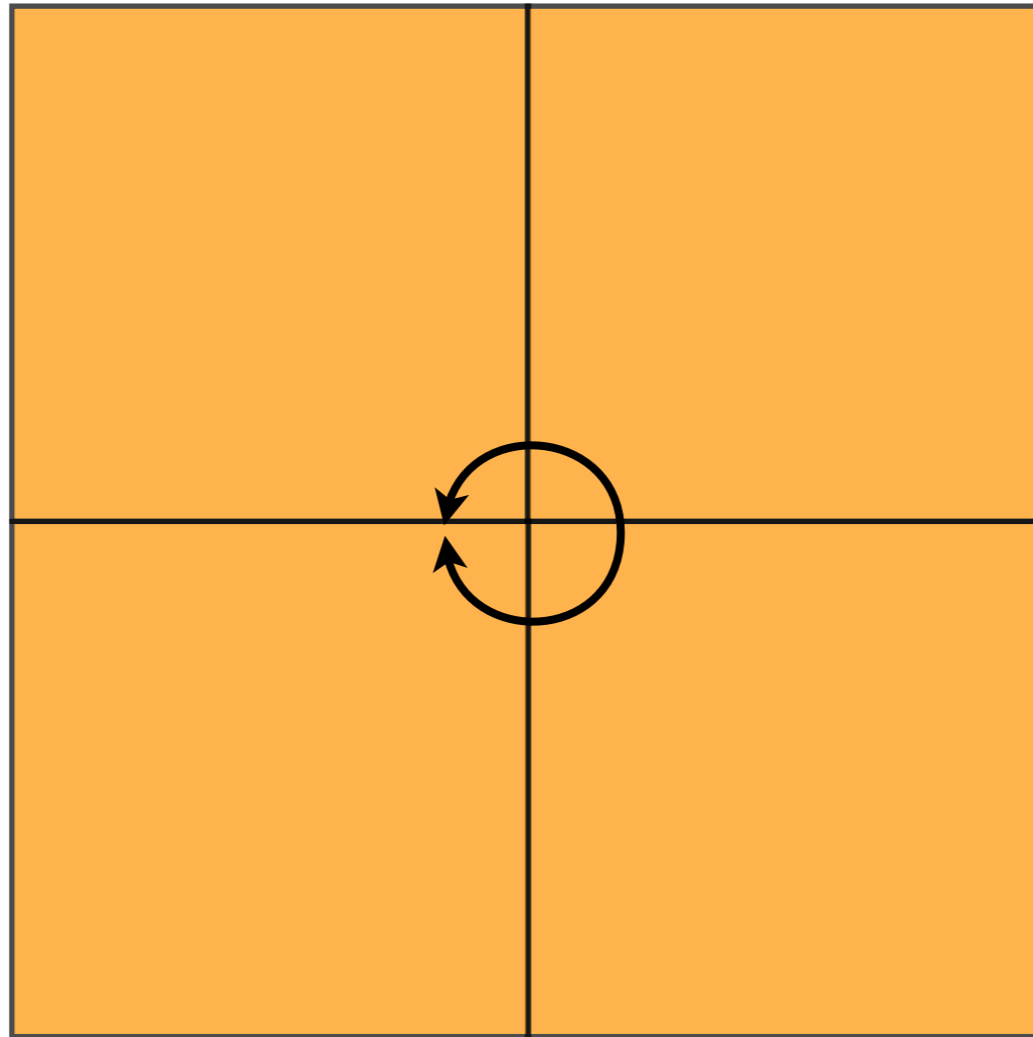
---



$$\begin{array}{r} 90 \\ + 90 \\ \hline 180 \\ + 90 \\ \hline 270 \end{array}$$

# LET'S TILE WITH SQUARES

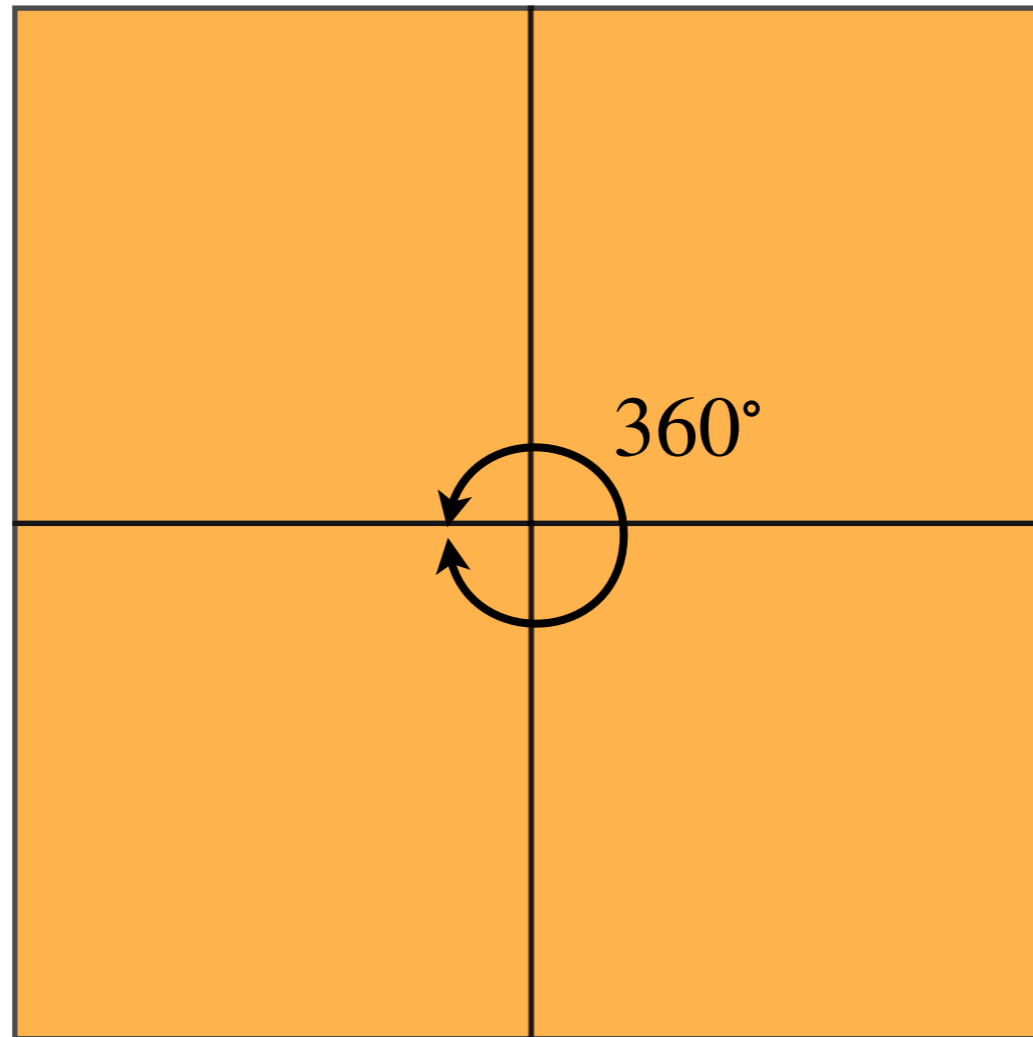
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$$\begin{array}{r} 90 \\ + 90 \\ \hline 180 \\ + 90 \\ \hline 270 \\ + 90 \\ \hline \end{array}$$

# LET'S TILE WITH SQUARES

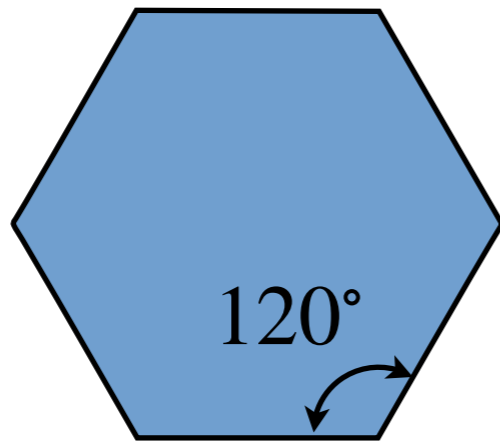
---



$$\begin{array}{r} 90 \\ + 90 \\ \hline 180 \\ + 90 \\ \hline 270 \\ + 90 \\ \hline 360 \end{array}$$

# LET'S TILE WITH HEXAGONS

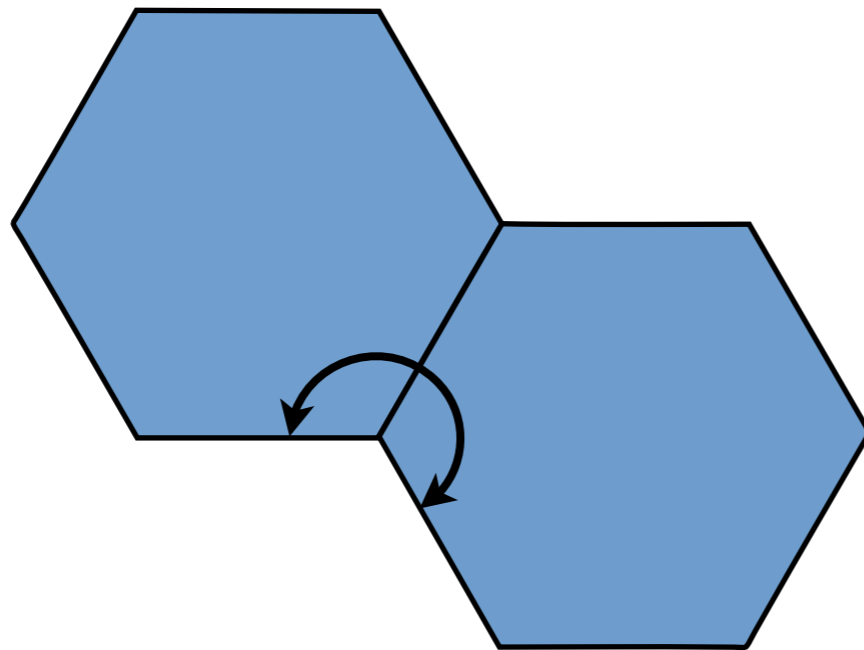
---



**120**

# LET'S TILE WITH HEXAGONS

---

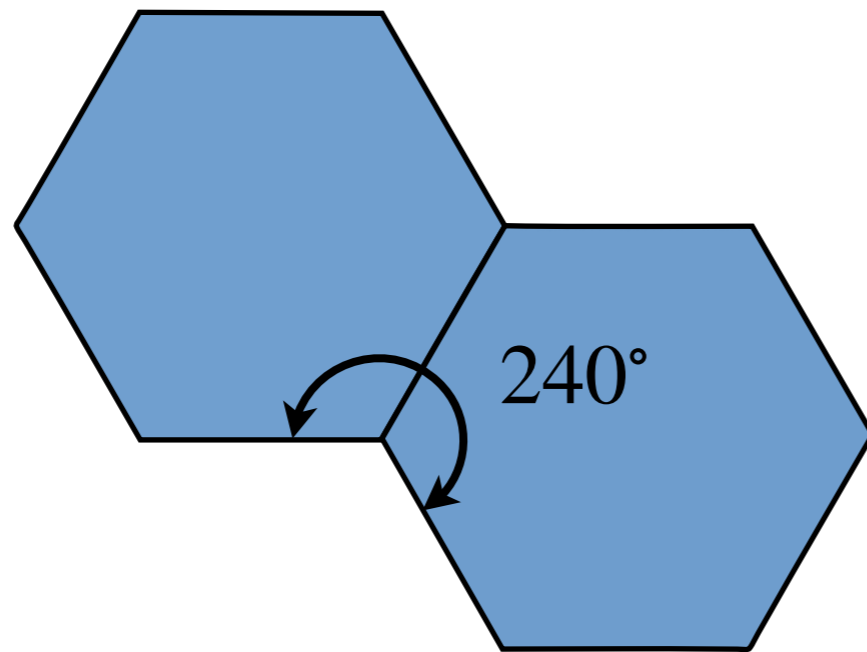


$$\begin{array}{r} 120 \\ + 120 \\ \hline \end{array}$$



# LET'S TILE WITH HEXAGONS

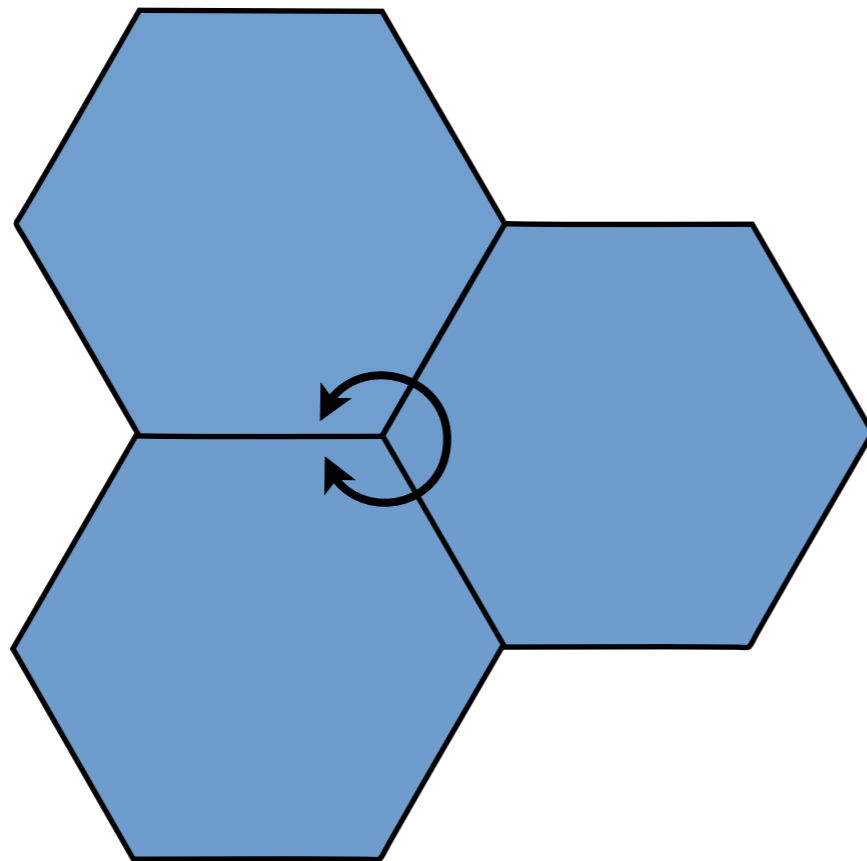
---



$$\begin{array}{r} 120 \\ + 120 \\ \hline 240 \end{array}$$

# LET'S TILE WITH HEXAGONS

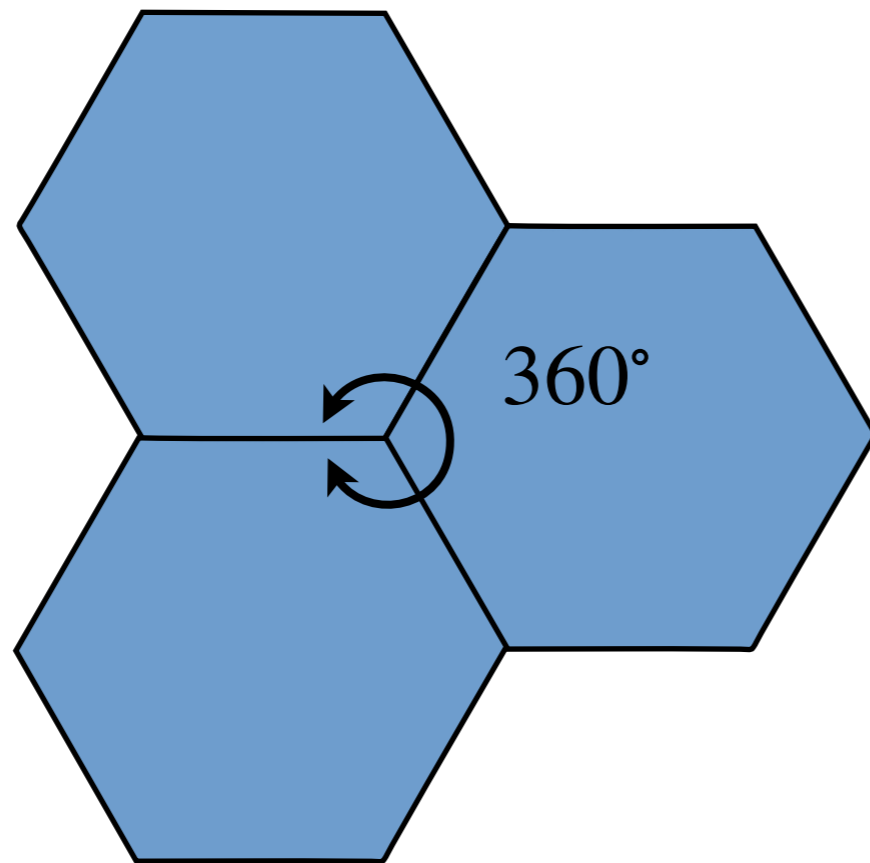
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$$\begin{array}{r} 120 \\ + 120 \\ \hline 240 \\ + 120 \\ \hline \end{array}$$

# LET'S TILE WITH HEXAGONS

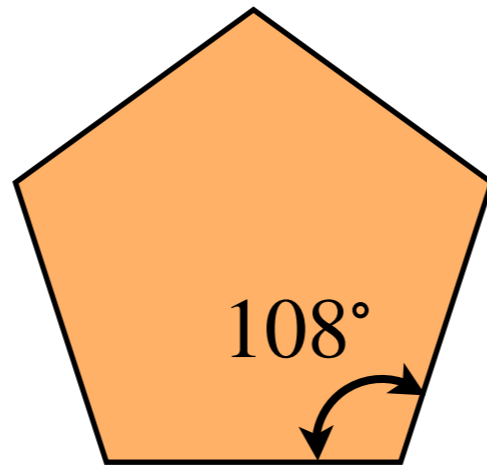
---



$$\begin{array}{r} 120 \\ + 120 \\ \hline 240 \\ + 120 \\ \hline 360 \end{array}$$

# LET'S TILE WITH PENTAGONS

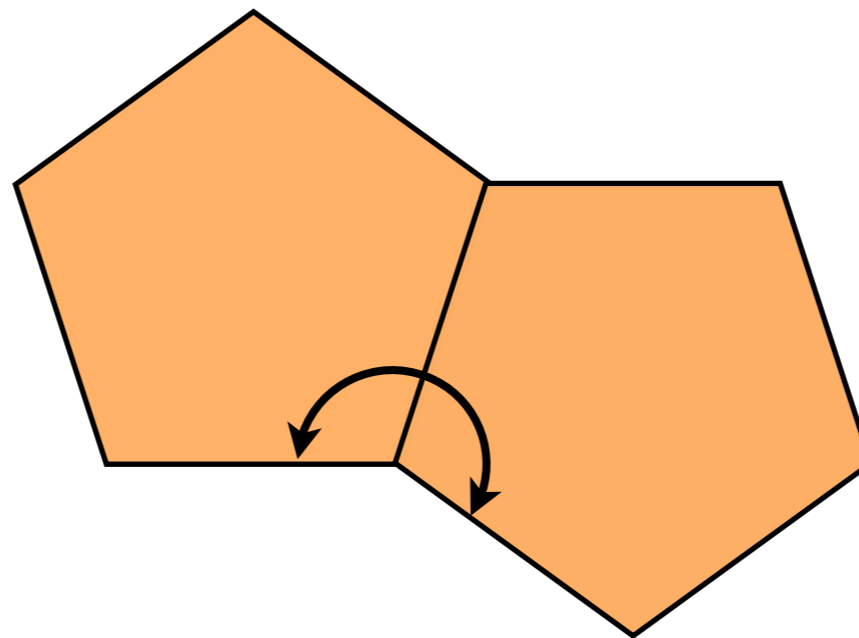
---



**108**

# LET'S TILE WITH PENTAGONS

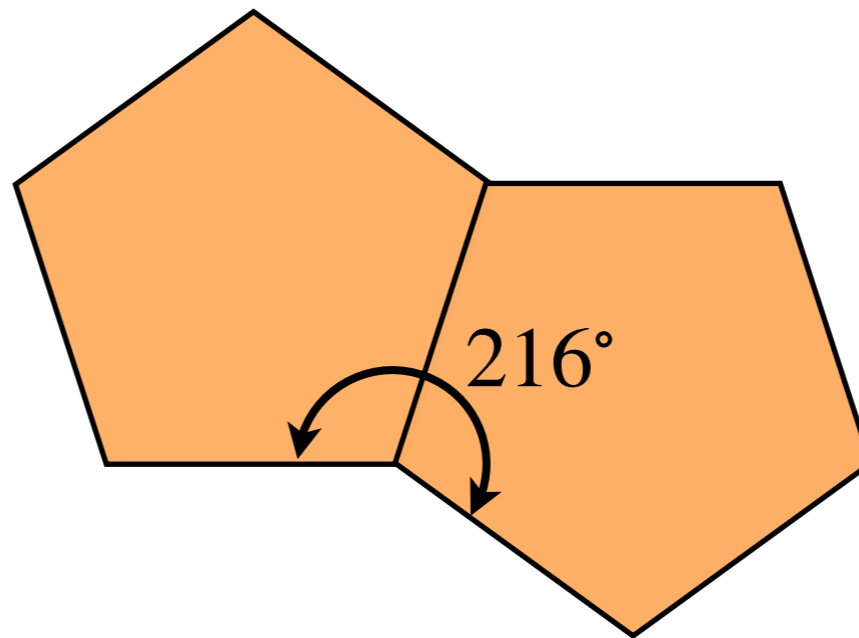
---



$$\begin{array}{r} 108 \\ + 108 \\ \hline \end{array}$$

# LET'S TILE WITH PENTAGONS

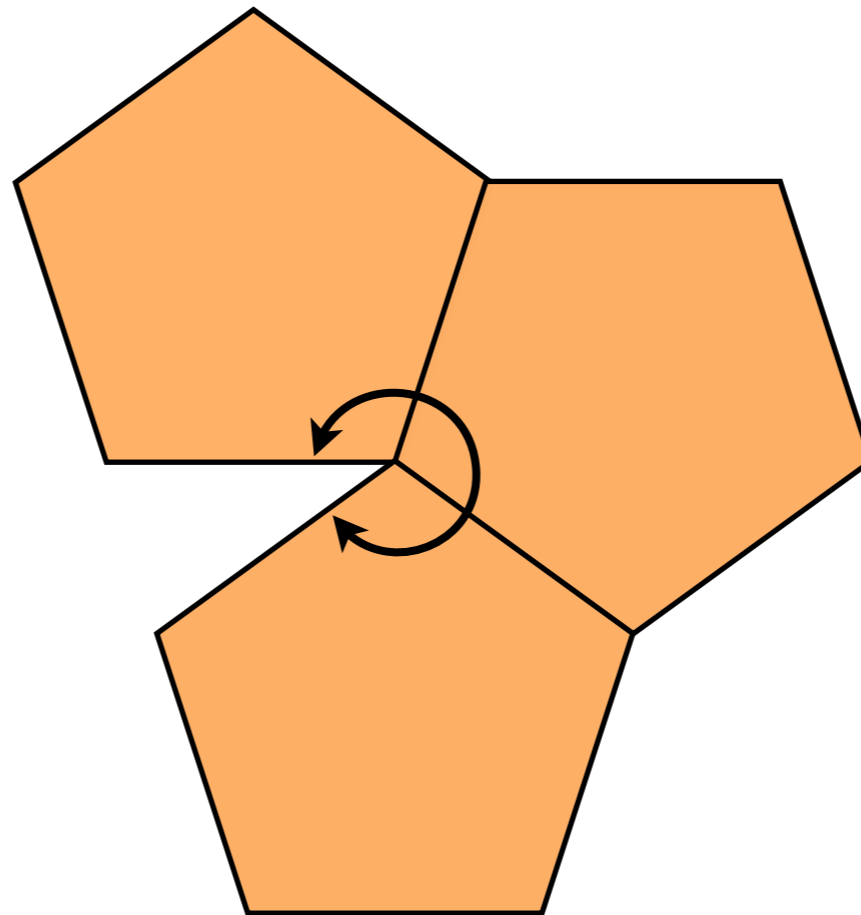
---



$$\begin{array}{r} 108 \\ + 108 \\ \hline 216 \end{array}$$

# LET'S TILE WITH PENTAGONS

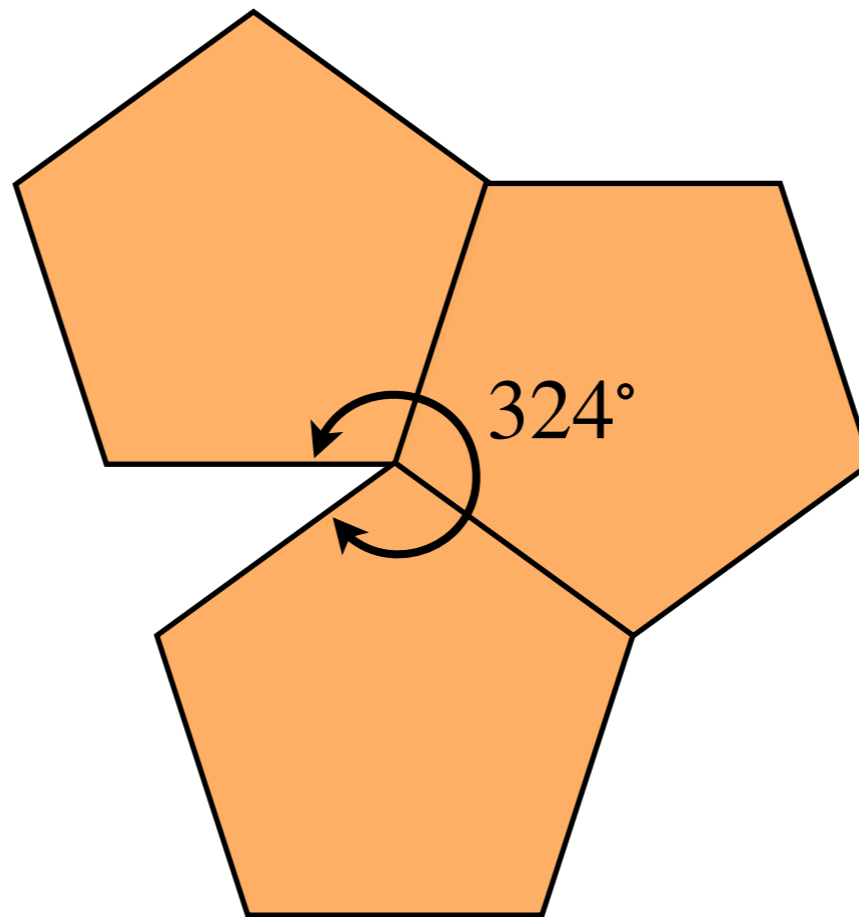
---



$$\begin{array}{r} 108 \\ + 108 \\ \hline 216 \\ + 108 \\ \hline \end{array}$$

# LET'S TILE WITH PENTAGONS

---



$$\begin{array}{r} 108 \\ + 108 \\ \hline 216 \\ + 108 \\ \hline 324 \end{array}$$



# COMPLEX TILINGS

---



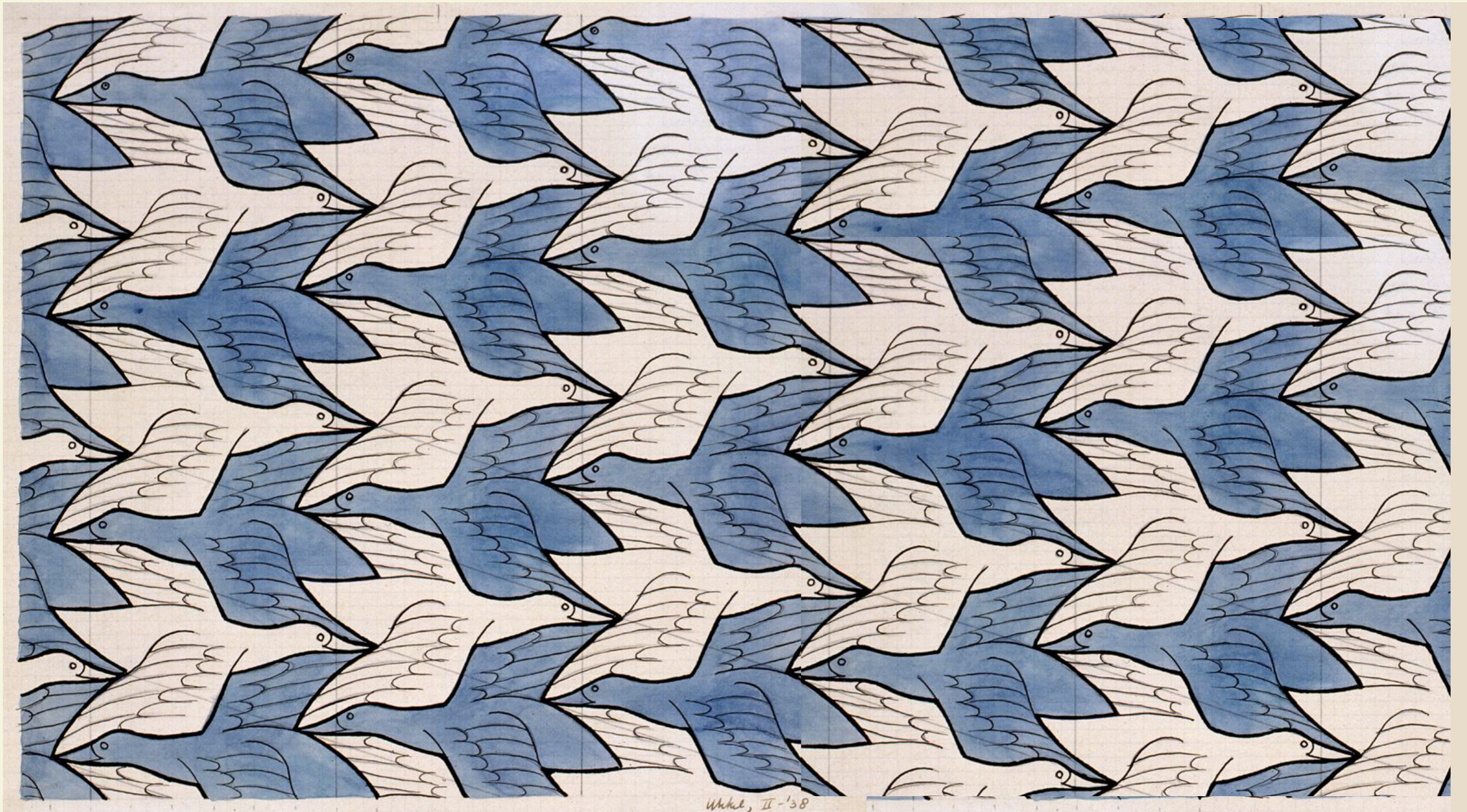
# COMPLEX TILINGS

---



# COMPLEX TILINGS

---

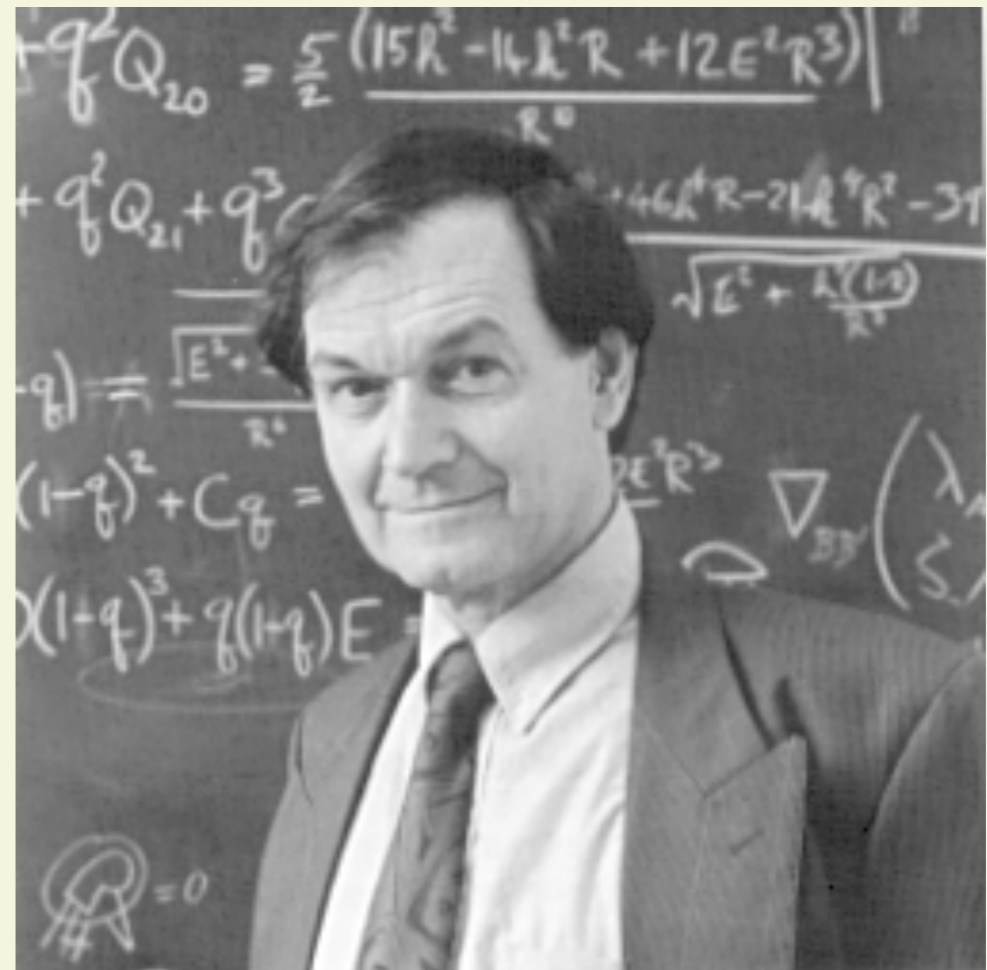


# WHO MADE THOSE TILINGS?

---



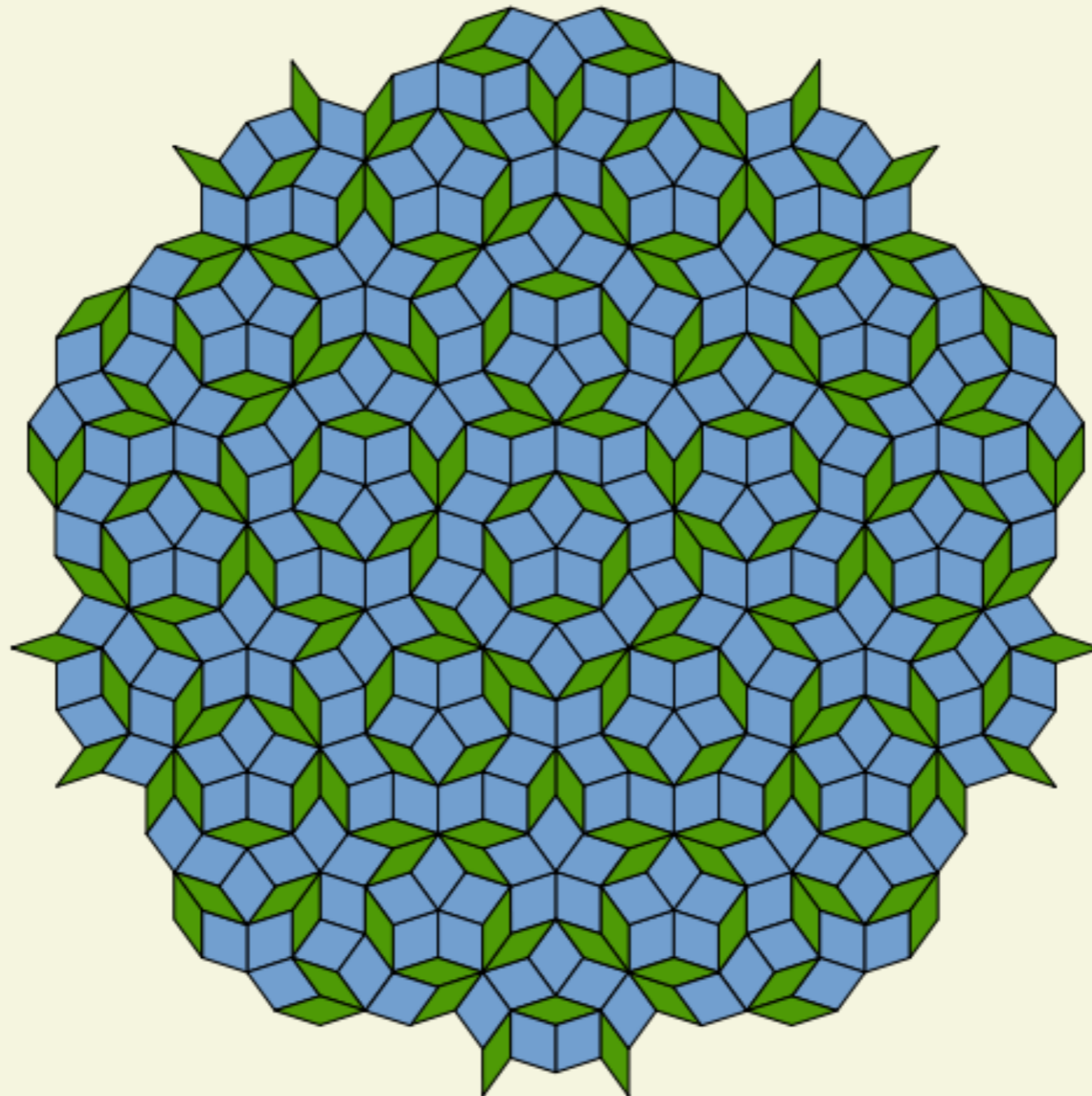
**MC. ESCHER**



**ROGER PENROSE**

# PENROSE TILING

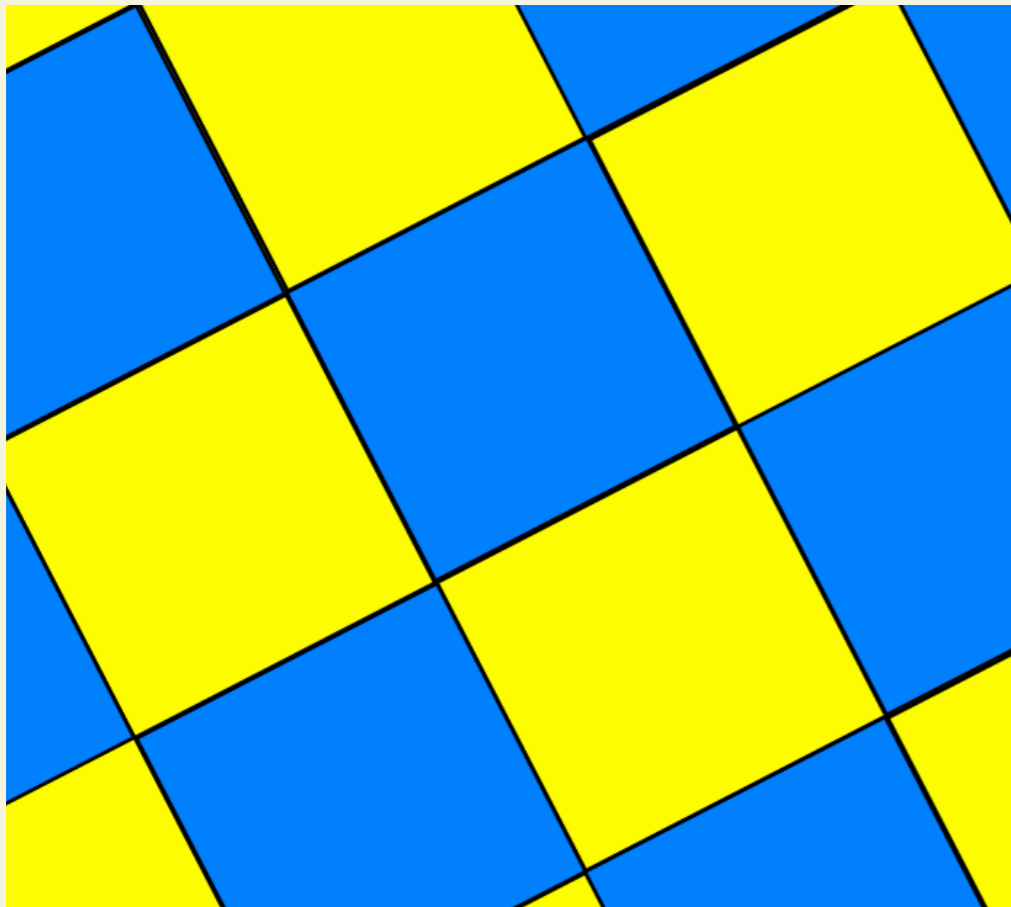
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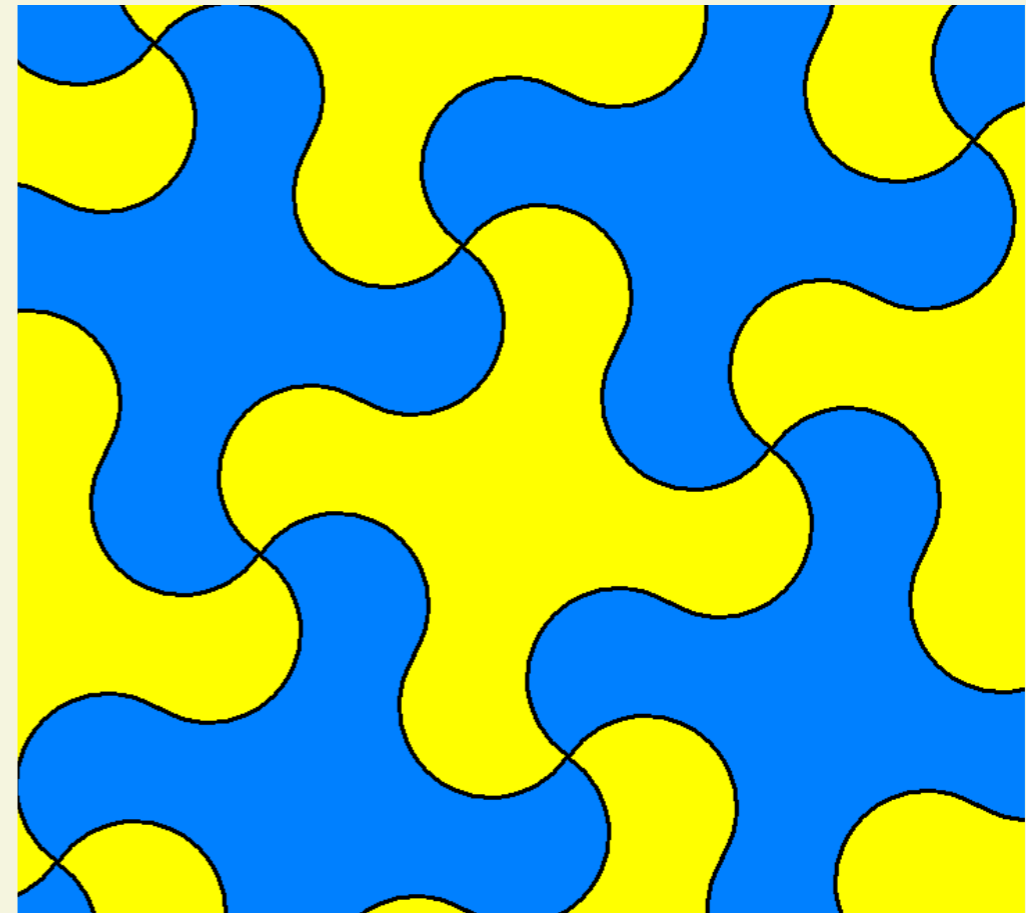
# HOW TO MAKE A COMPLEX TILING

---

**RULE: CANNOT CHANGE SYMMETRY OF TILING**



**ORIGINAL TILING**

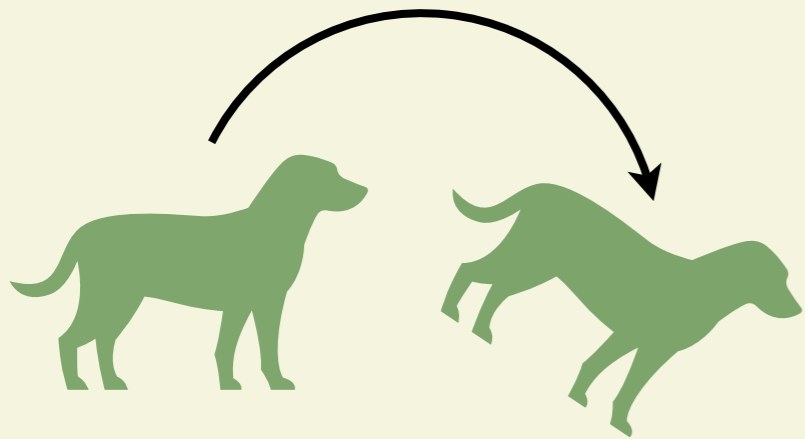


**DEFORMED TILING**

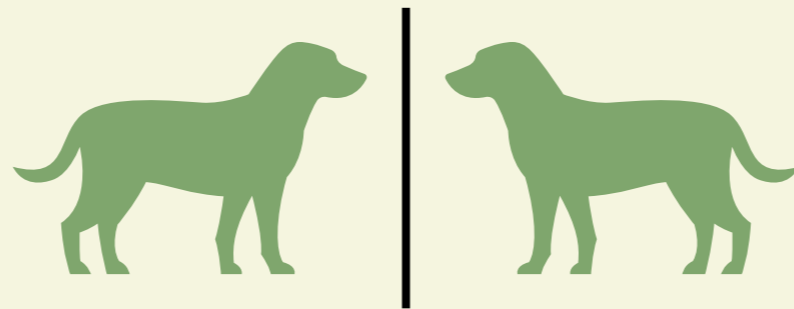
# WHAT IS A SYMMETRY?

---

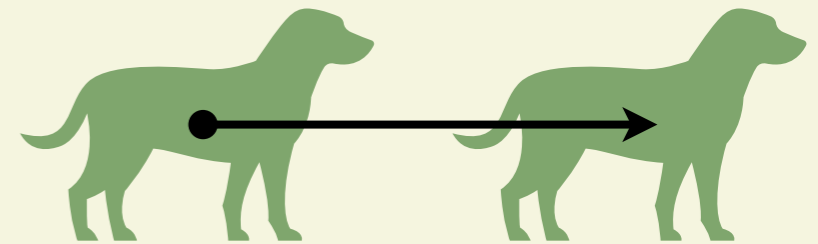
WHEN A SHAPE LOOKS THE SAME  
AFTER MAKING A MOVE SUCH AS



**ROTATION**



**REFLECTION**

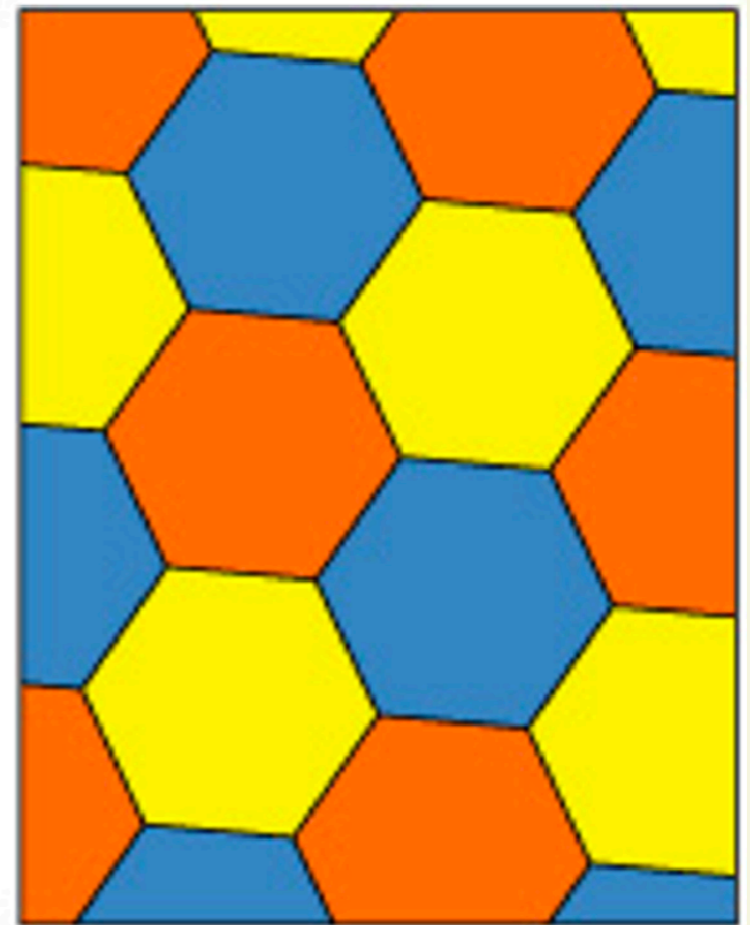
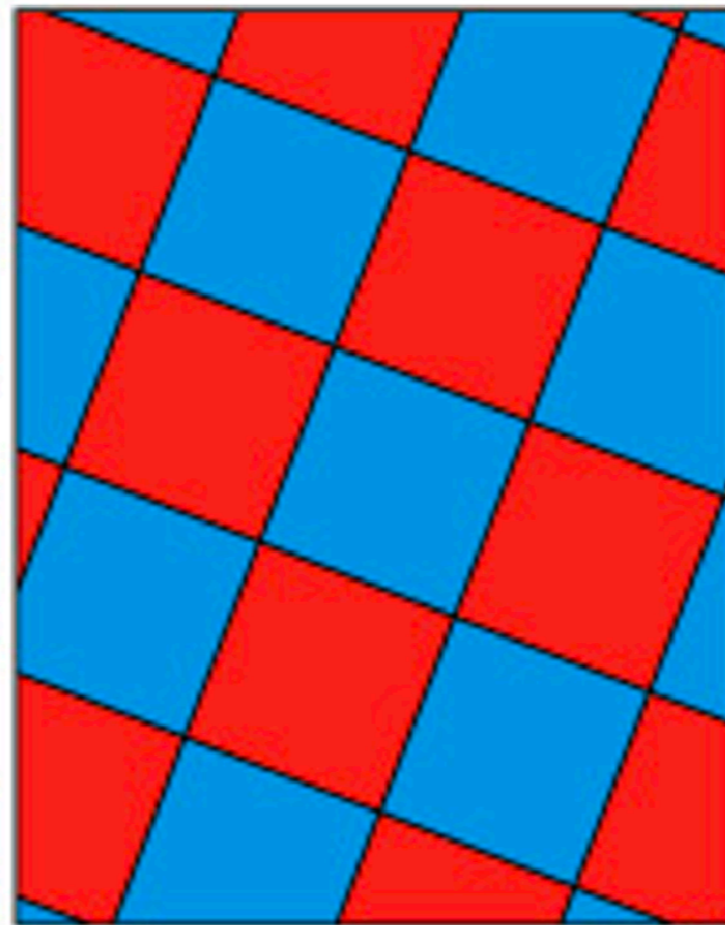
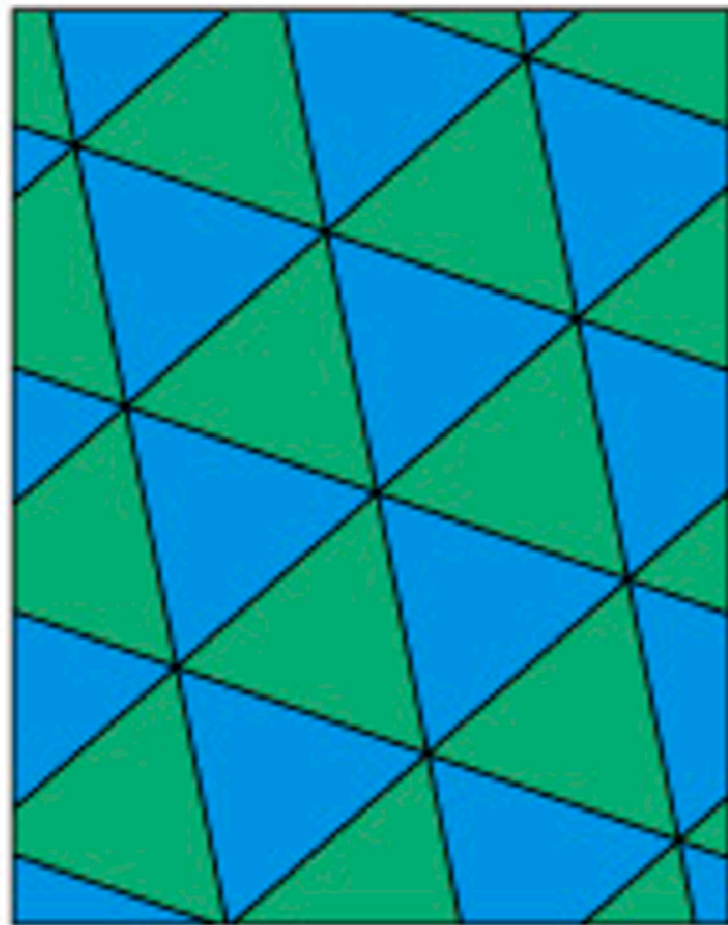


**SHIFT**

# SYMMETRY IN TILINGS

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WHAT KINDS OF SYMMETRIES DO OUR  
TILINGS HAVE?





# WHAT SYMMETRIES DO YOU SEE?

---



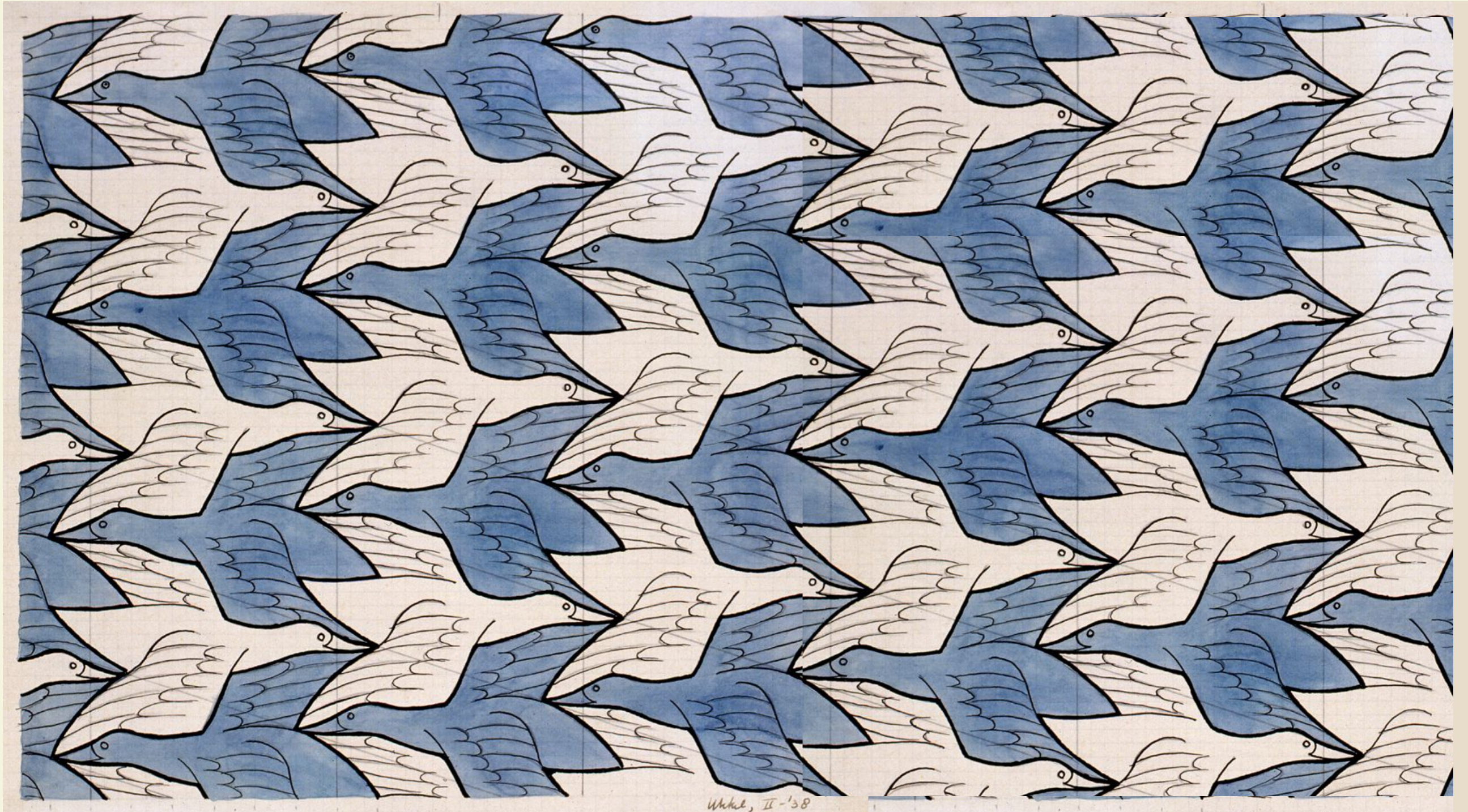
# WHAT SYMMETRIES DO YOU SEE?

---



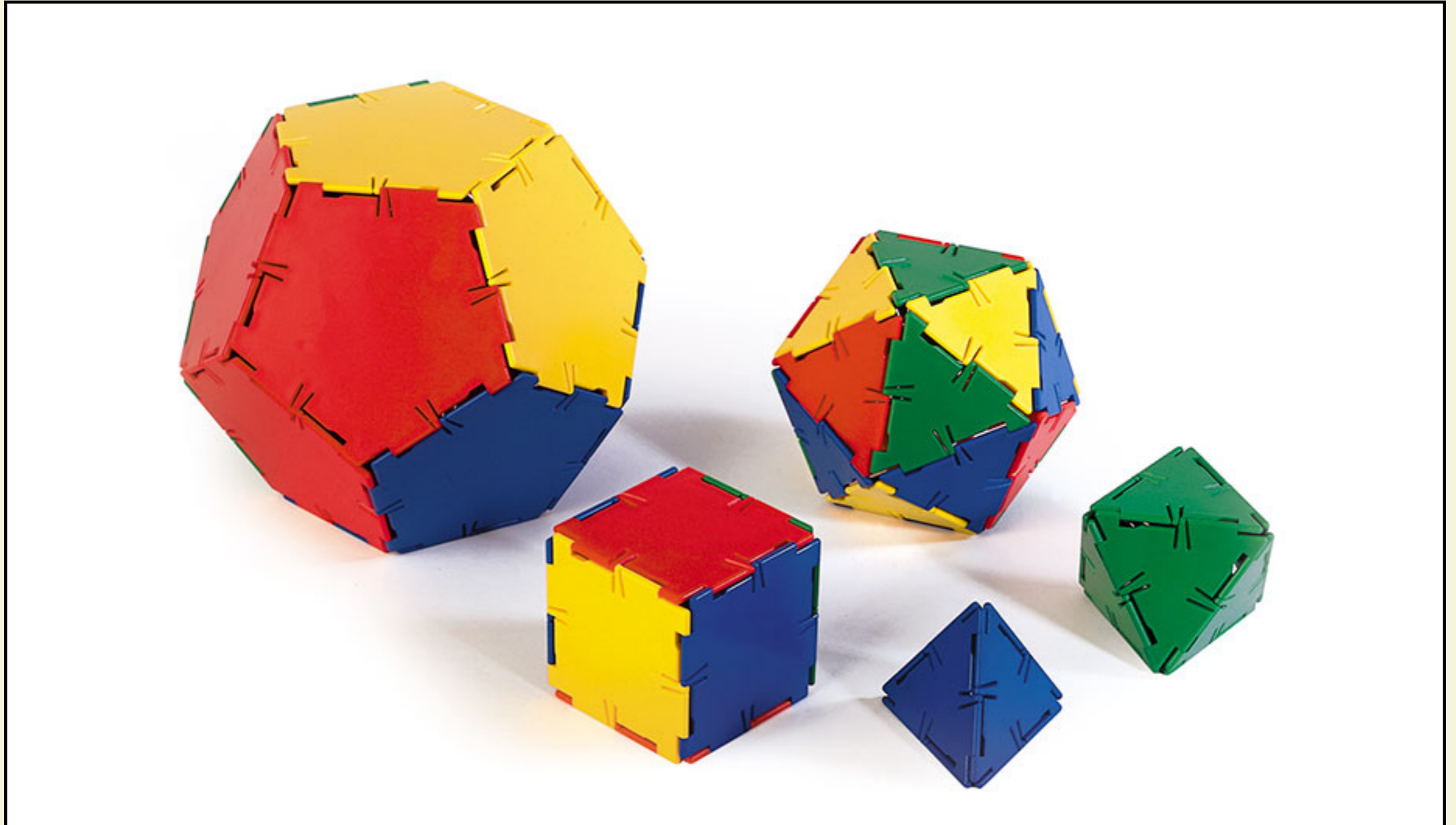
# WHAT SYMMETRIES DO YOU SEE?

---



# BEYOND TILING FLAT SURFACES?

---



# BEYOND TILING FLAT SURFACES?

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