TARTU ÜLIKOOL

Paper folding in mathematics and STEAM

Tiina Kraav

lecturer of mathematics education

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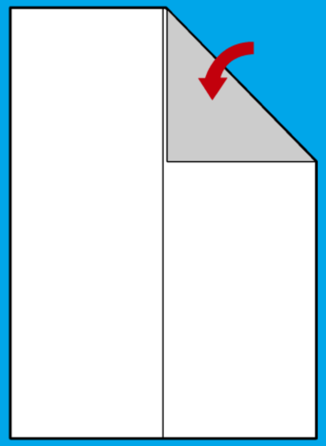
Paper folding/origami

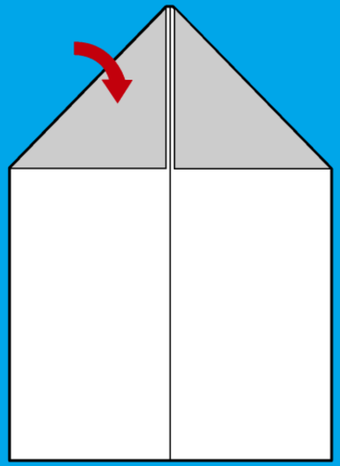


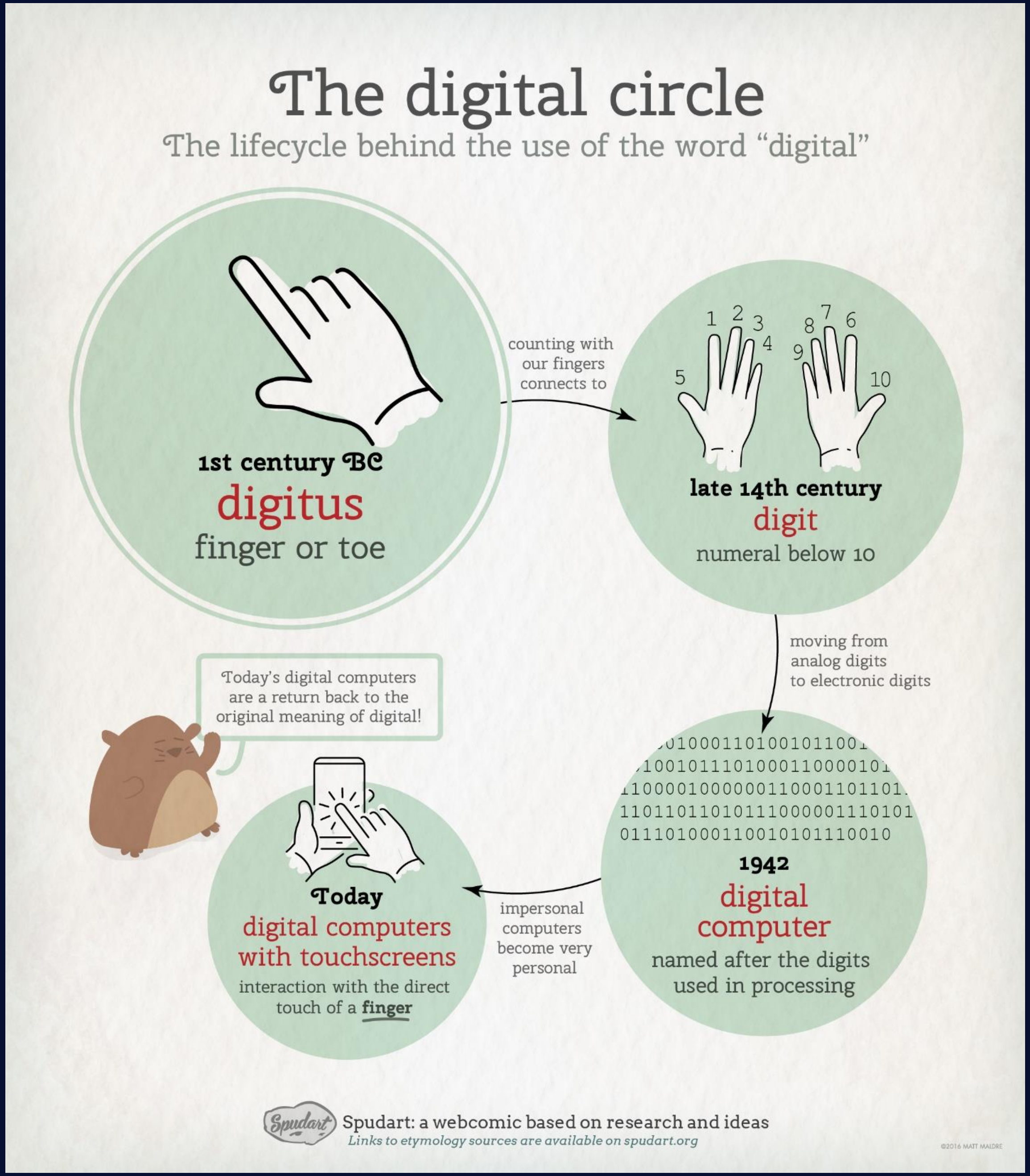
Origami (Japanese 折り紙, *ori* – folding, *kami* – paper) – art of **paper folding**.

Origami was first introduced in Japan in 1603.

The **small number** of basic origami folds can be combined in a variety of ways to make intricate designs. The best-known origami model is the Japanese **paper crane.** In general, these designs begin with a **square** sheet of paper.

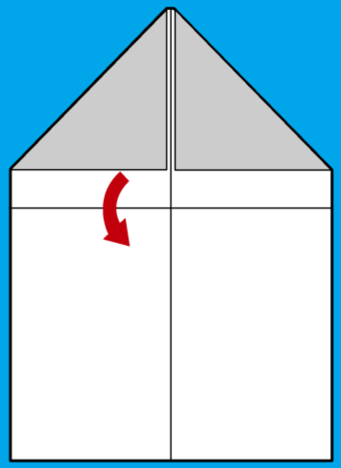
Paper folding develops the motor skills of the fingers, as precision and coordination of movements are important for the correctness of the final result. **Spatial competence**, **memory**, **algorithmic thinking** and **creativity** are developed.



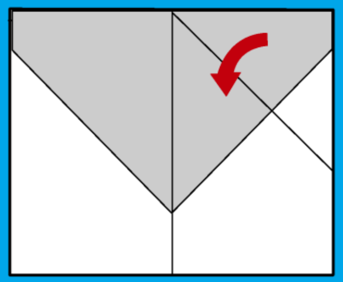


https://www.spudart.org/comic/digital-meaning/

Paper folding allows to learn in maths class:

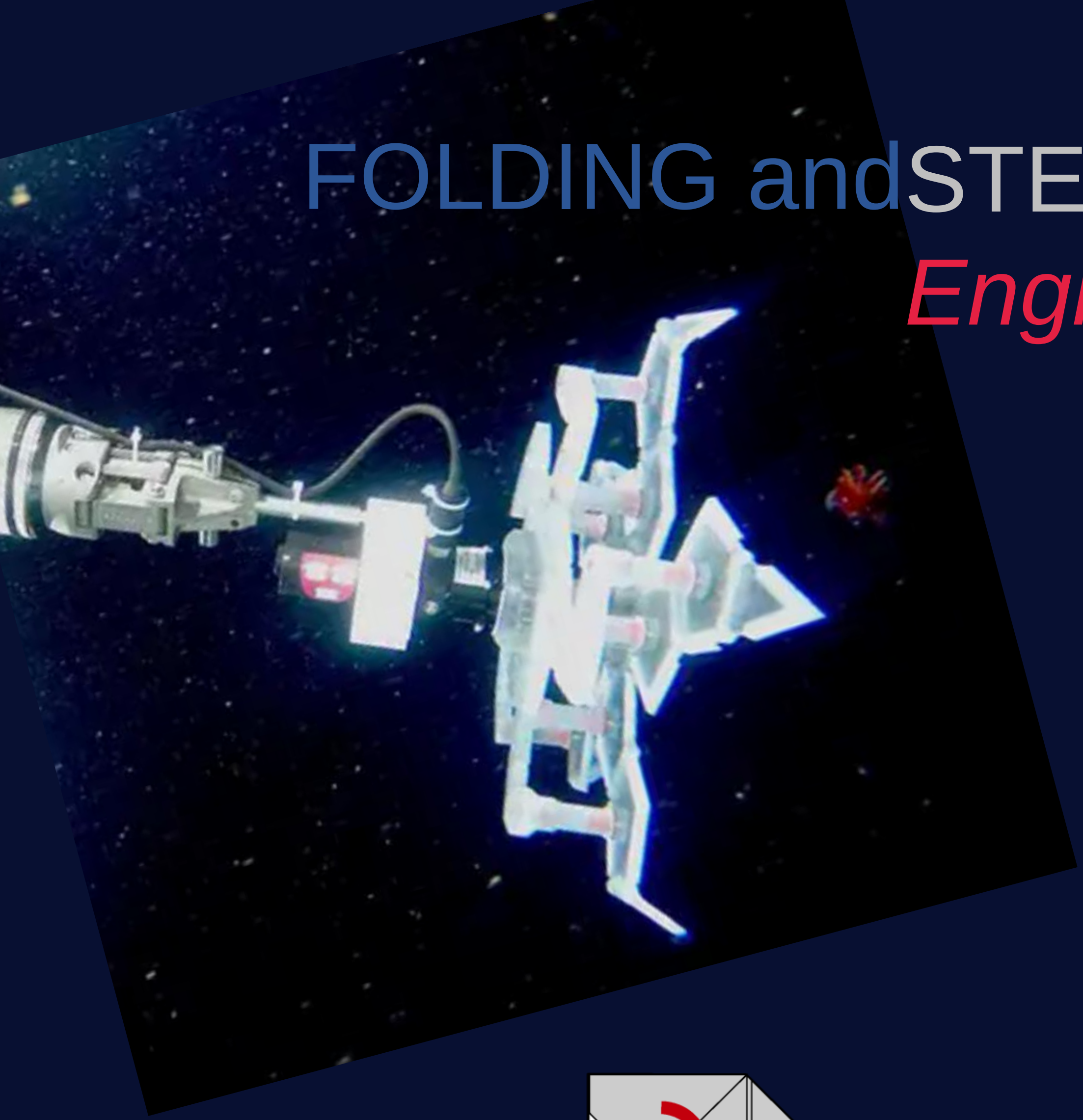


- visualising mathematical concepts;
- mathematical proving;
- posing problems and solving them creatively;
- formulating and testing hypothesis;
- developing mathematical mindset;
- …

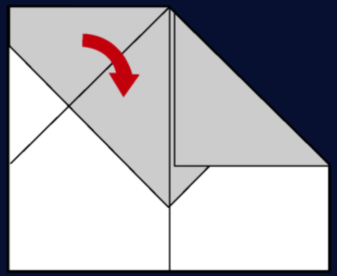


STEAM – *Science, Technology, Engineering, Art & Mathematics*

FOLDING and STEAM (*Science*, *Technology*, *Engineering*, *Art & Mathematics*)



The Deep-sea Grabber – invented by Robert Wood, roboticist at Harward University. It has five-fingered claw designed using origami. The Deep-sea Grabber is designed to rescue fragile sea creatures.

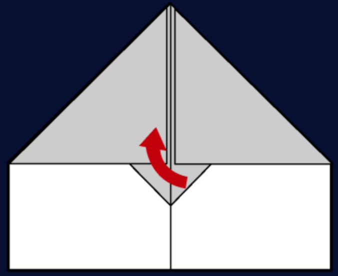


https://www.newscientist.com/article/2174576-robotic-grabber-catches-squidgy-deep-sea-animals-without-harming-them/

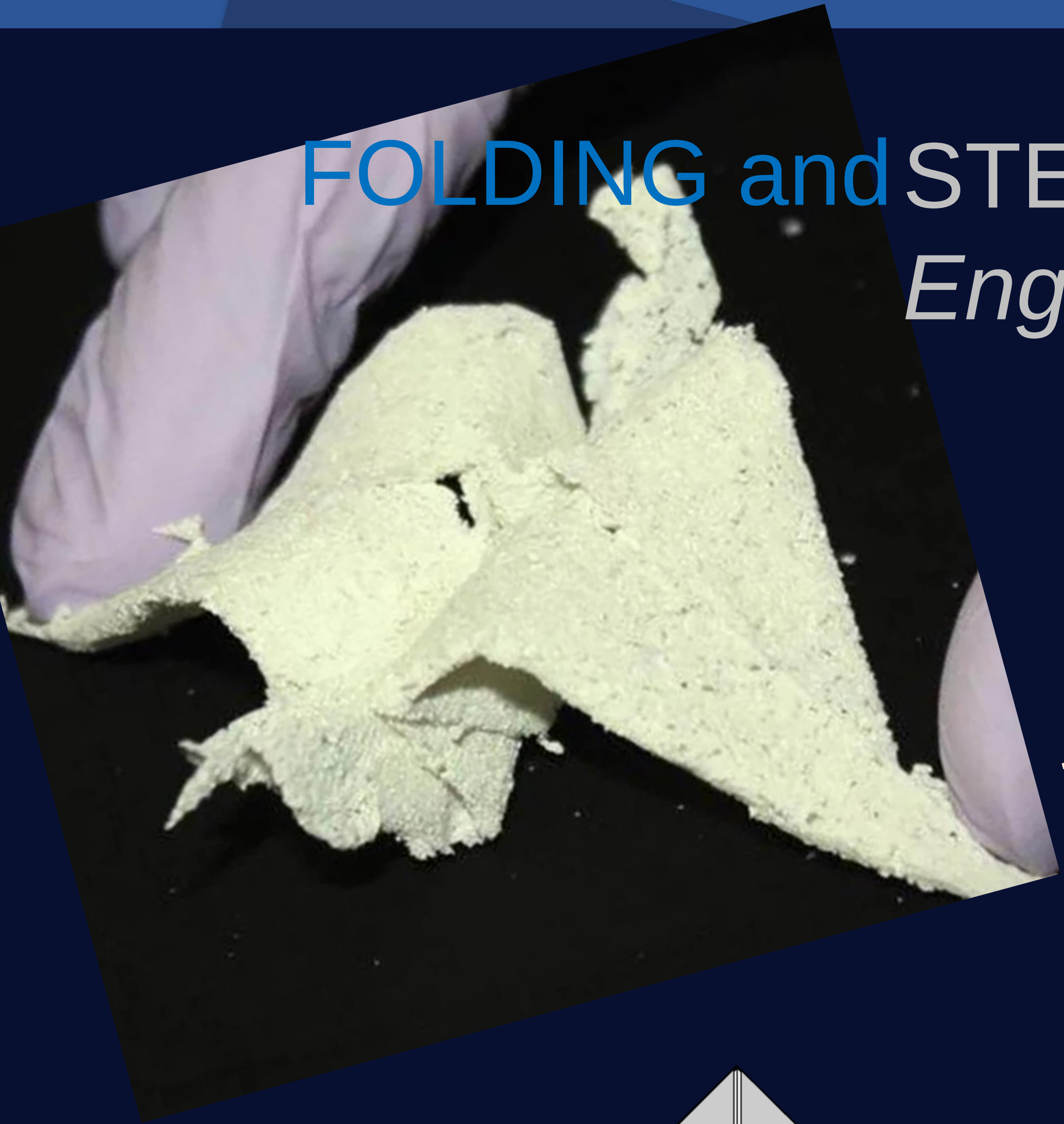
FOLDING and STEAM (*Science*, *Technology*, *Engineering*, *Art & Mathematics*)

Bulletproof shields – designed by engineering team at Brigham Young University using the Yoshimura folding pattern.

https://www.designboom.com/design/origami-bulletproof-shield-brigham-young-university-02-20-2017/

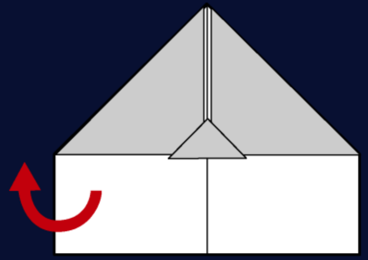


FOLDING and STEAM (*Science*, *Technology*, *Engineering*, *Art* & *Mathematics*)

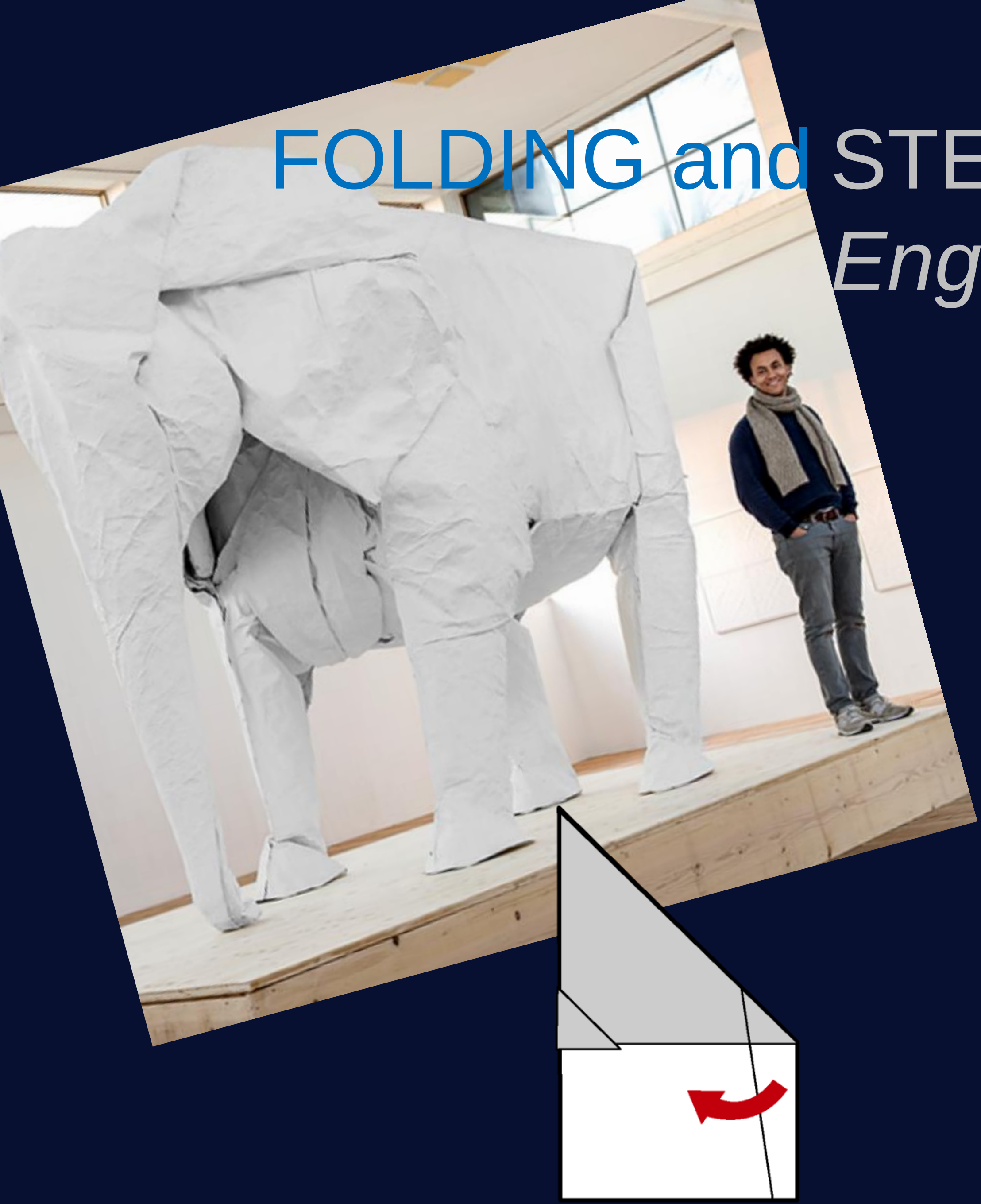


Tissue paper – origami research in the medical field at Northwestern University. Strong and thin paper from animal organs that can be folded and placed on diferent organs to help them to heal.

https://www.smithsonianmag.com/smart-news/bioactive-paper-could-help-repair-injured-muscle-and-organs-180964445/



FOLDING and STEAM (*Science, Technology, Engineering, Art & Mathematics*)



Sipho Mabona – south african origami artist, stands up for social issues.

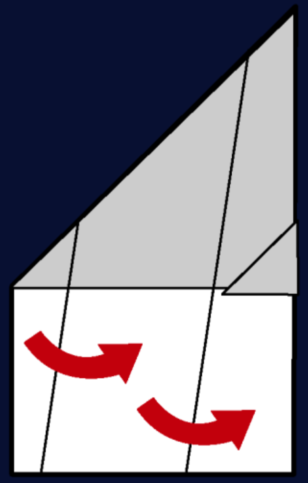
https://www.thisiscolossal.com/2014/03/white-elephant-sipho-mabona-2/

FOLDING and STEAM (*Science, Technology, Engineering, Art & Mathematics*)

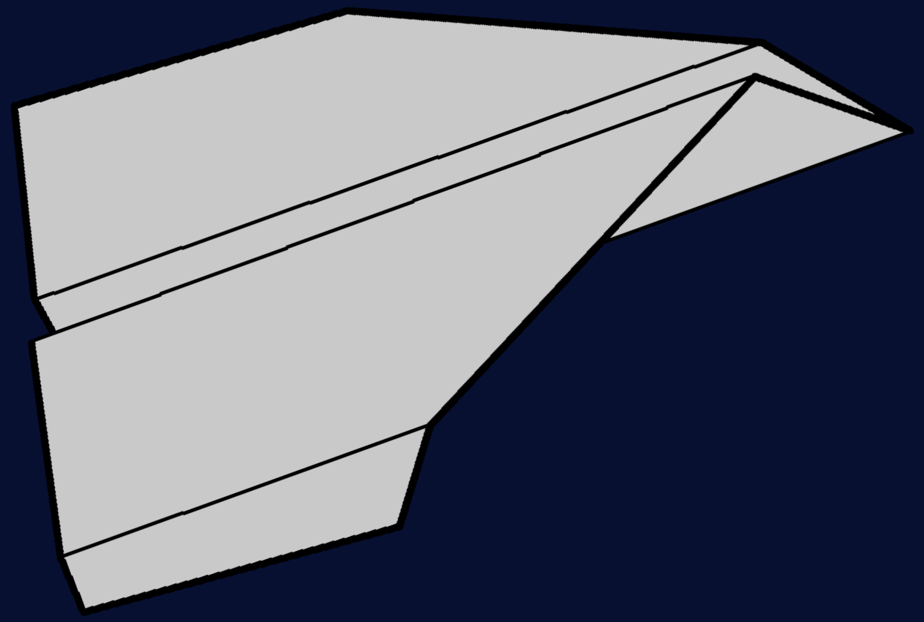
Anne Rudanovski – sculptor and professor at the Pallas School of Art, who uses paper and folding as one of her means of expression.

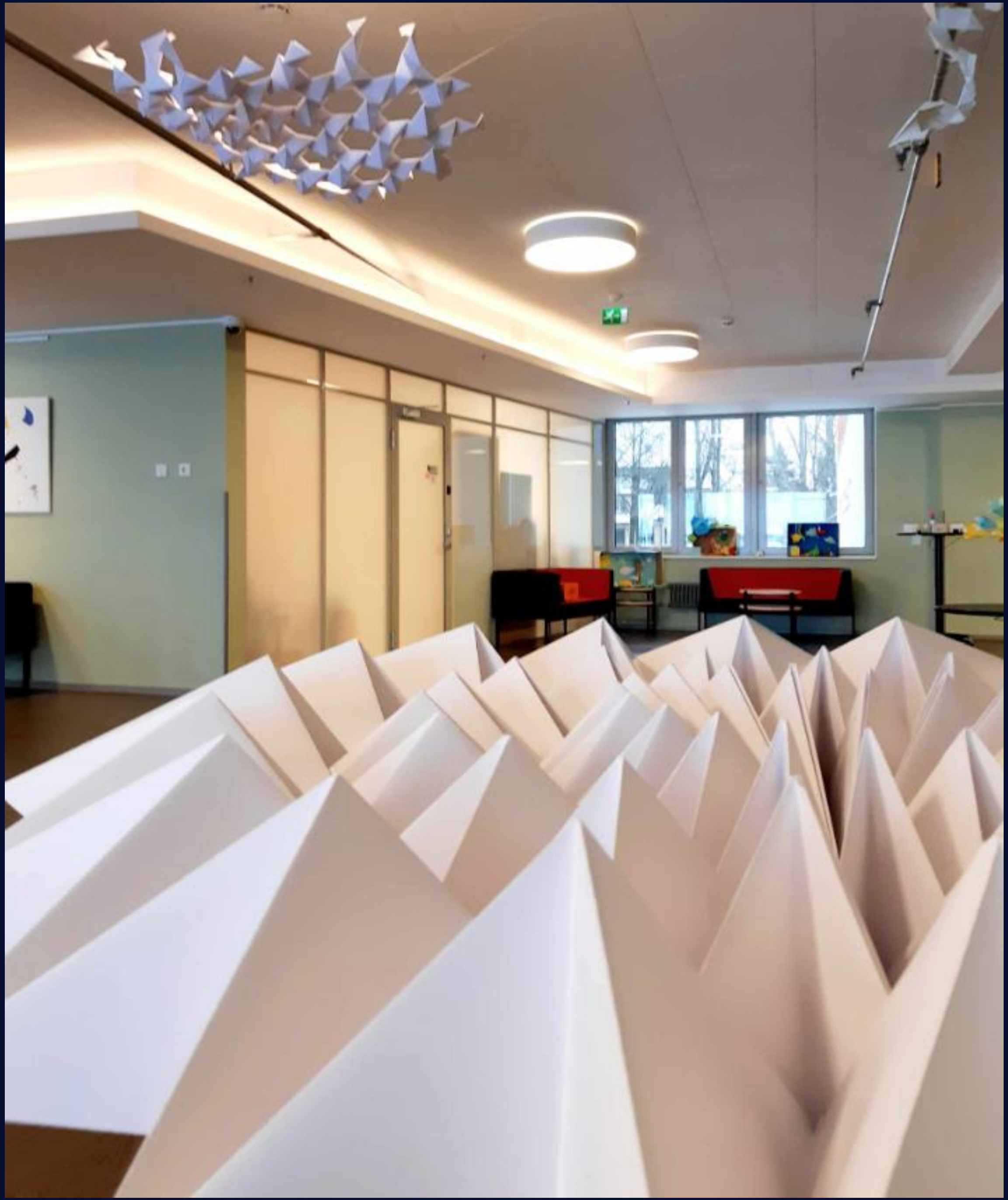
https://www.behance.net/rudanovski

Origami has been around for centuries and has natural applications spanning every aspect of STEAM.



Origami art was once a simple crane and now, it can be a life-size elephant.

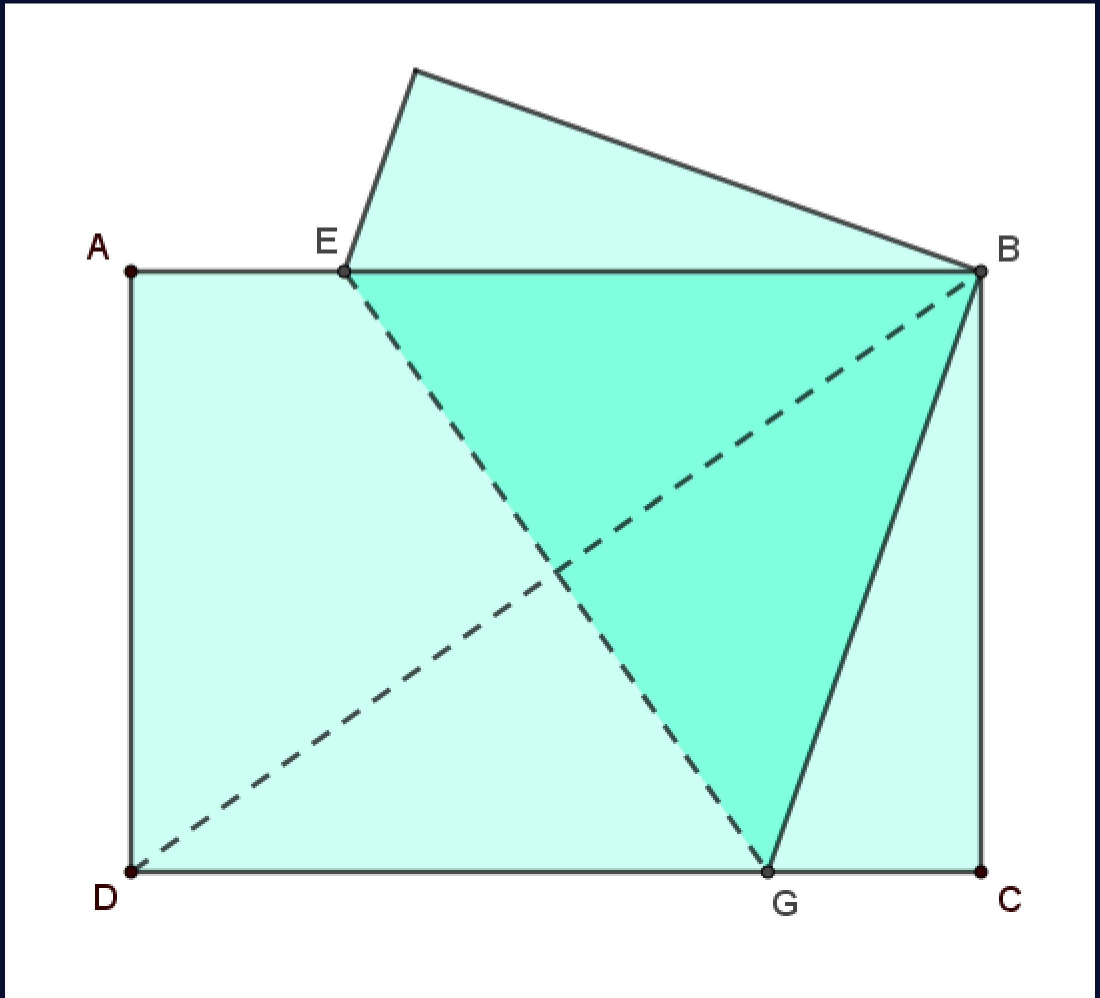






Task 1. Folding the diagonaal of a rectangle

How to fold a segment connecting two arbitrary points on opposite sides of a rectangle?

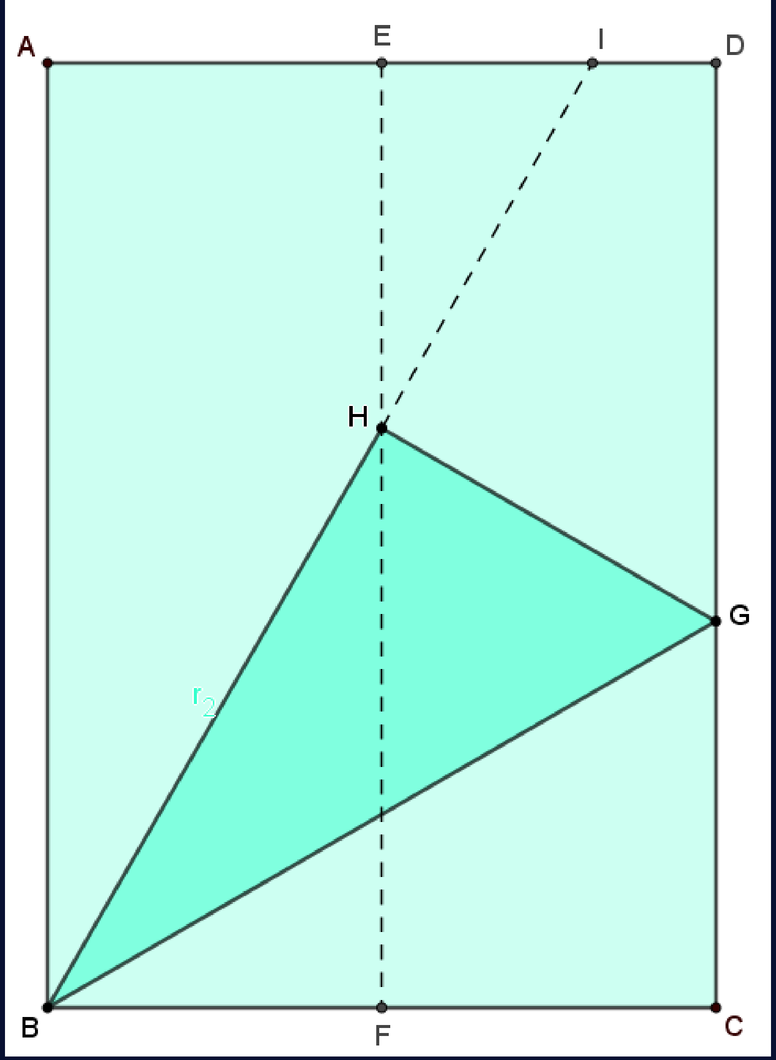


We place the opposite corners (B and D) of the rectangular sheet of paper together and fold the paper. What do we call the line that we get as the folding line?

Task 2. Folding the perpendicular bisector of a segment

How to fold the diagonal of a rectangle without any tools?

Task 3. Folding a regular triangle



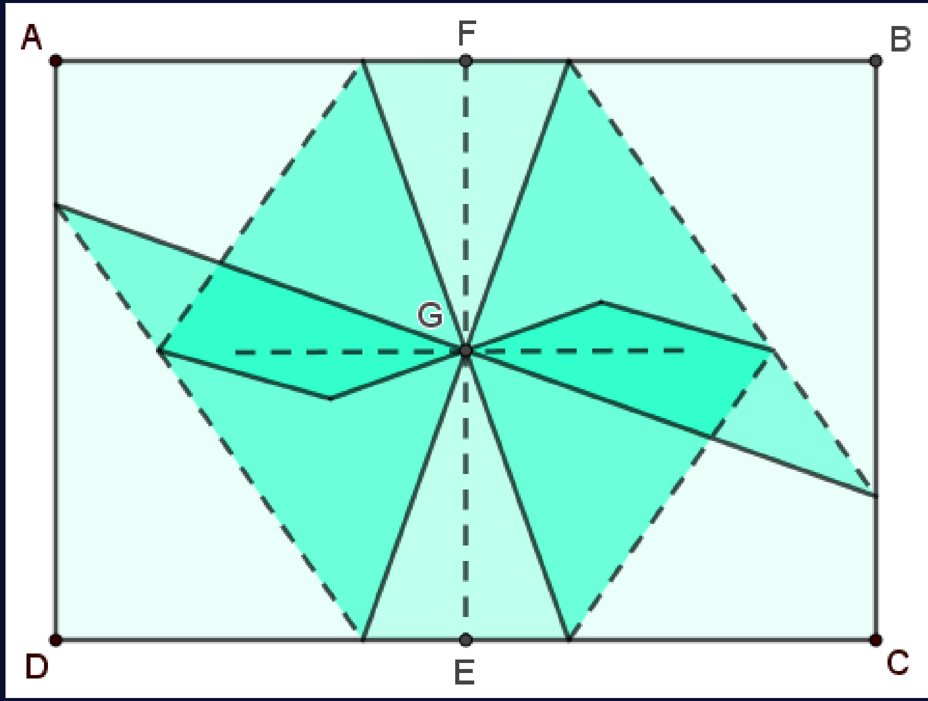
Placing the vertices A and D together, fold the segment AD along its perpendicular bisector EF.
Then unfold the paper again.

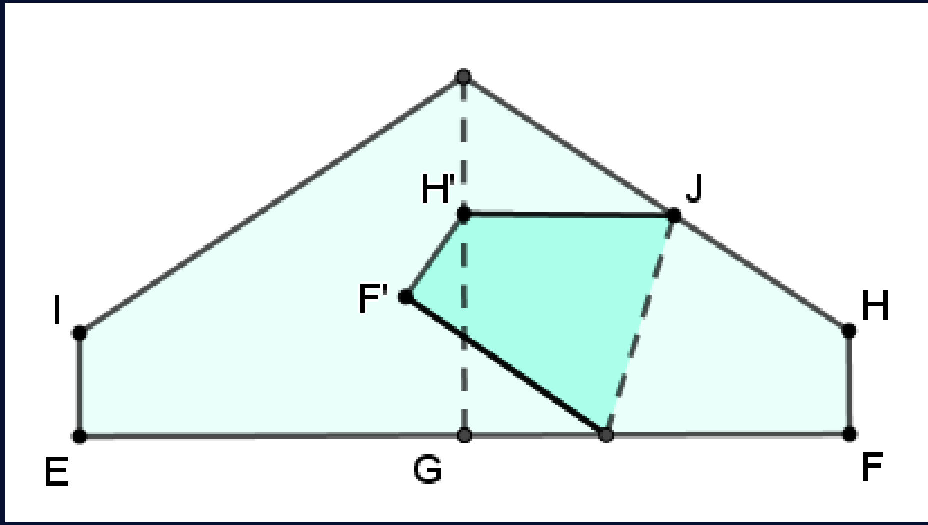
1) Find a point on the perpendicular bisector of segment CD such that the folding line passes through vertex B.
Then fold the paper (in the figure, point C has moved to point H, resulting in folding line BG).

2) Fold the segment AB of the rectangle to coincide with line BG.
Now you have obtained the desired triangle side BH.
Unfold the paper and repeat the same procedure with vertex B of the rectangle. As a folding line, you get the second side of the sought triangle.

Why did a regular triangle form? Find another way to fold a regular triangle in the situation where folding is done based on 1), but then differently.

Task 4. Folding a regular pentagon





Starting from the top at point C and moving clockwise, fold each of the rectangle's vertices to the intersection point G of the rectangle's side perpendicular bisectors.

Then fold the resulting shape along the perpendicular bisector of the longer side, so that the obtuse angles match up accordingly.

Find a point H' on the perpendicular bisector of side EF of the pentagon such that after folding vertex H onto it, JH' is parallel to side EF.

Then fold the paper accordingly. Repeat the same for vertex I.

Now you have obtained a regular pentagon.

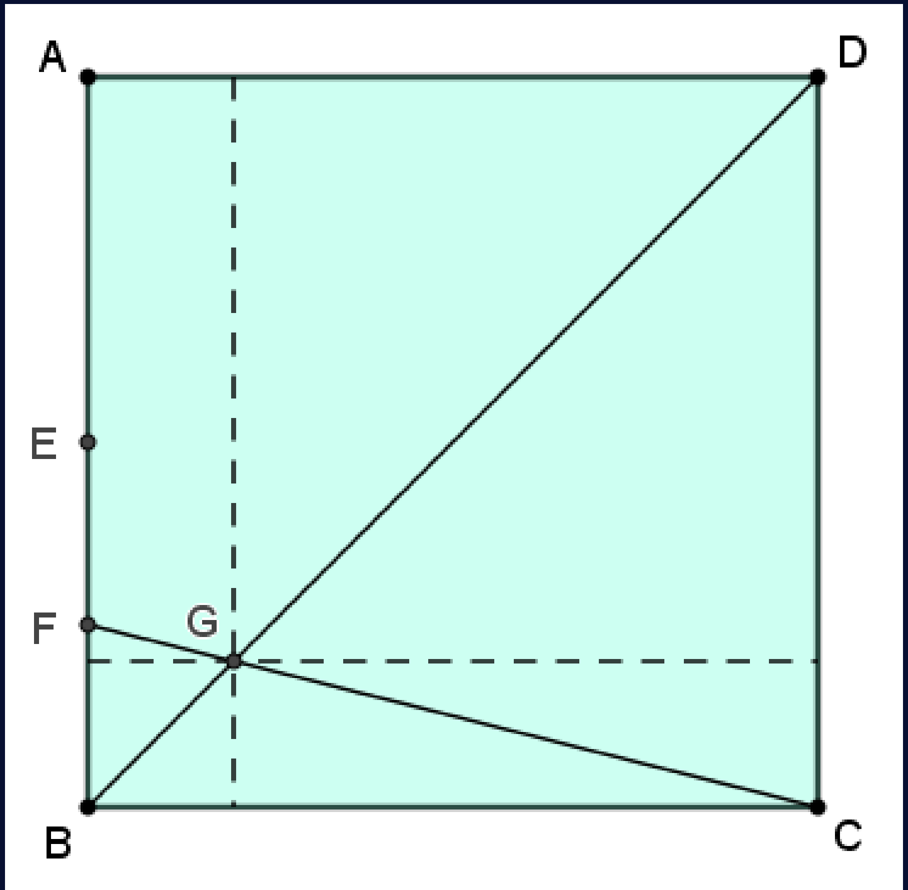
Are you sure? How do you justify it?

Moreover, you have obtained, through folding, a module for constructing a dodecahedron.

Task 5. Fold a regular hexagon.

Task 6. Fold a regular octagon.

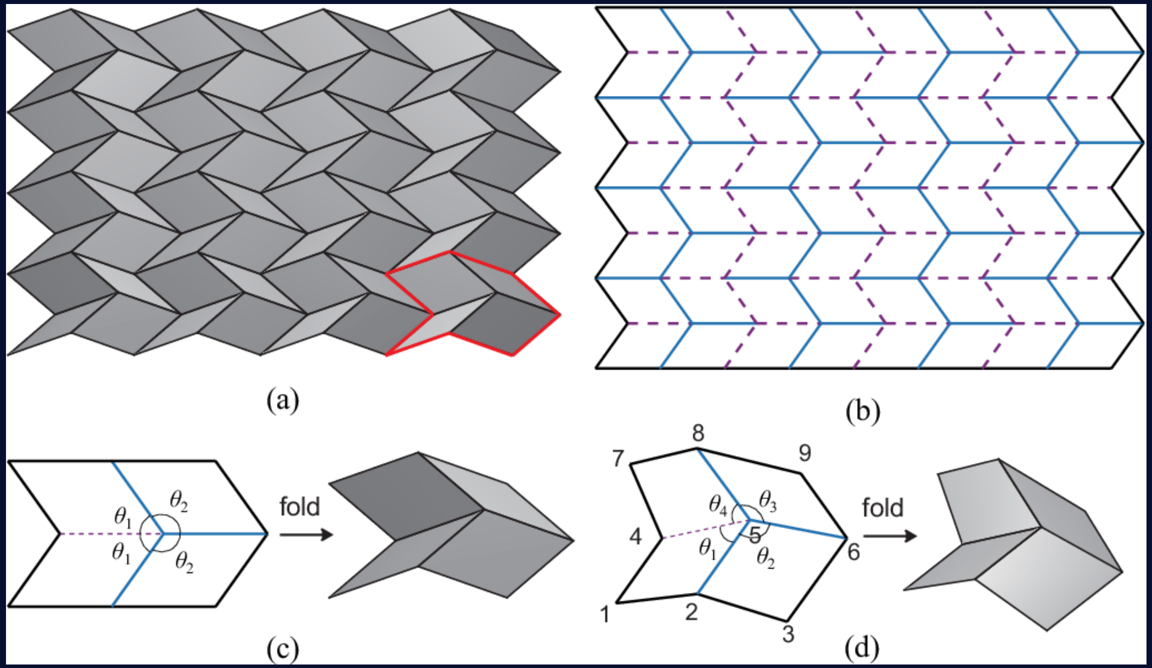
Task 7. Folding problem



a) Fold the diagonal of the square-shaped paper.
b) Mark the midpoint E of side AB.
c) Mark the midpoint F of segment EB.
d) Fold the segment connecting points C and F.
e) Mark the intersection G of the two folding lines.

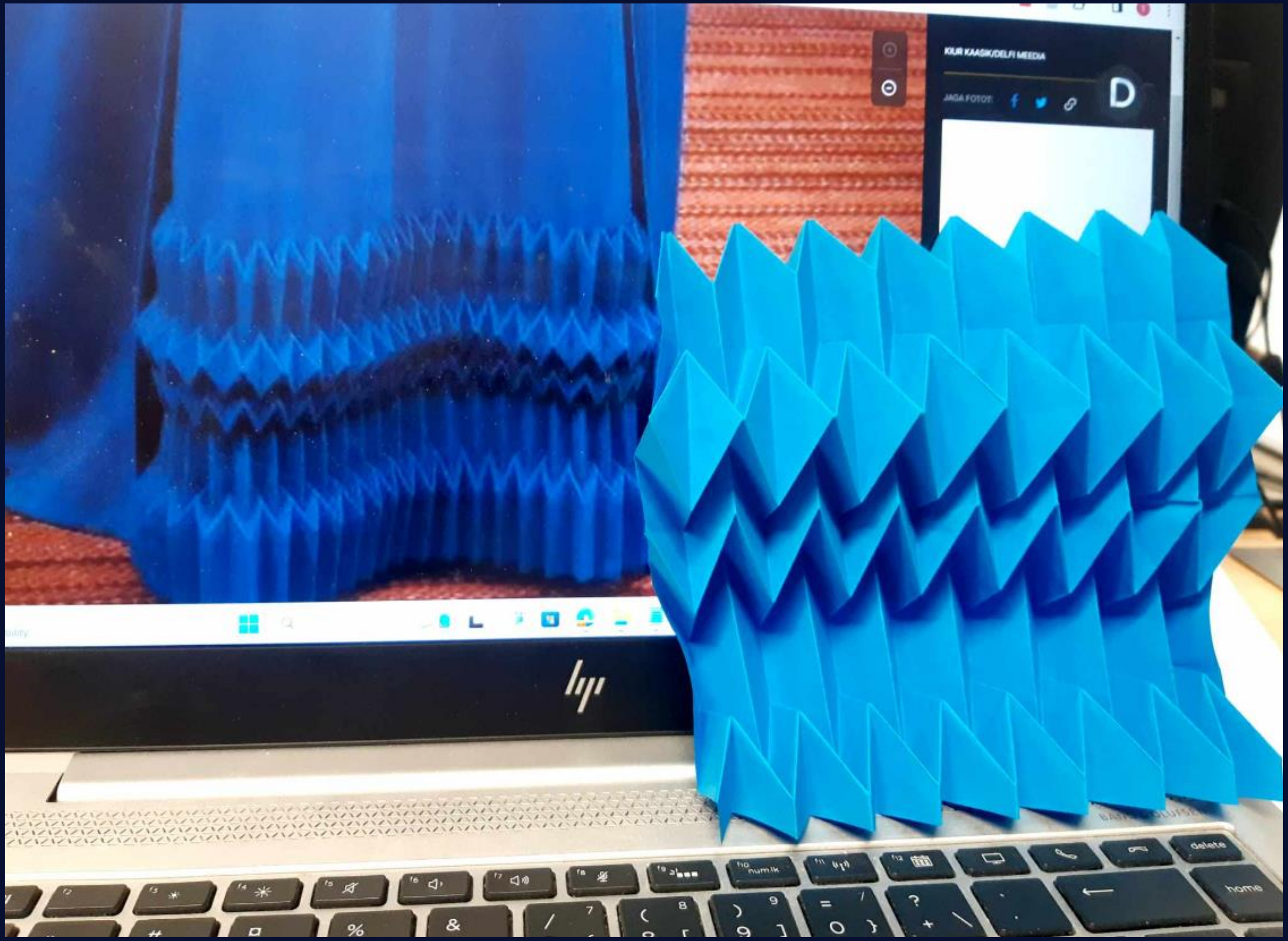
In what ratio do the perpendicular bisectors of the sides, drawn through the found intersection point (indicated with dashed lines in the diagram), divide these sides?

Miura fold

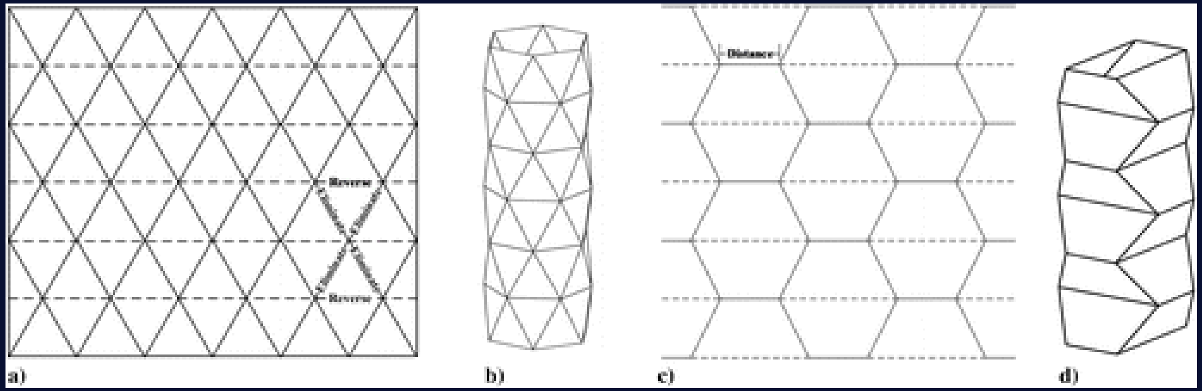


In the 1970s, Miura began working with Masamori Sakamaki on deployable surfaces, developing what became known as the **Miura fold**. This is a method of rigidly folding a flat surface, using a crease pattern subdividing the surface into parallelograms, so that it fits into a much smaller volume. Miura originally intended this method to be used in spacecraft for deployable membranes such as solaar panel arrays, but it has since found many other applications including in cartography, surgical devices, flat-foldable furniture, and electrical storage.

Miura fold



Yoshimura fold



The pattern is named after Yoshimaru Yoshimura (吉村慶丸), the Japanese researcher who provided an explanation for its development in a paper first published in Japan in 1951, and later republished in the United States in 1955.

Kiitos!