Origami for Engineering: Collapsing, Functional, and Strong

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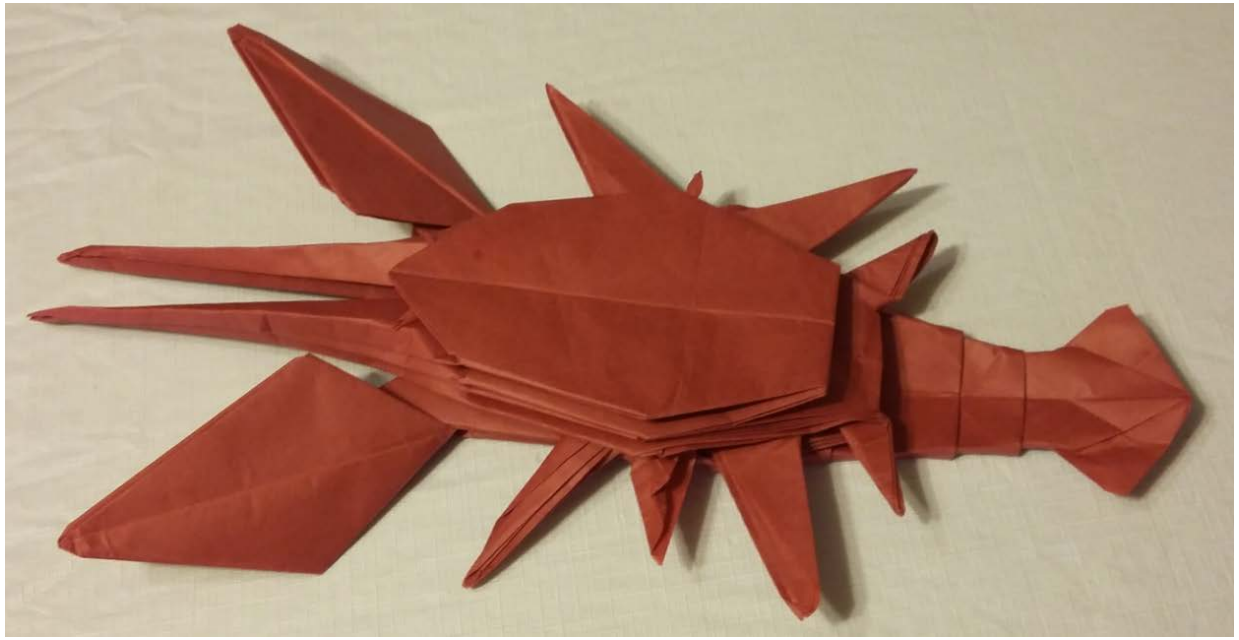
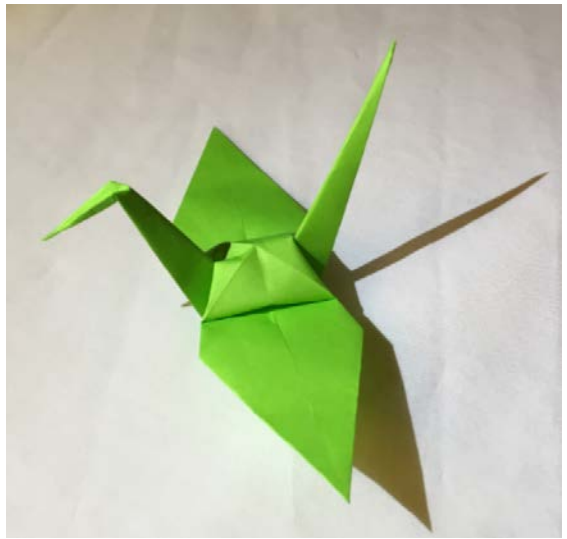
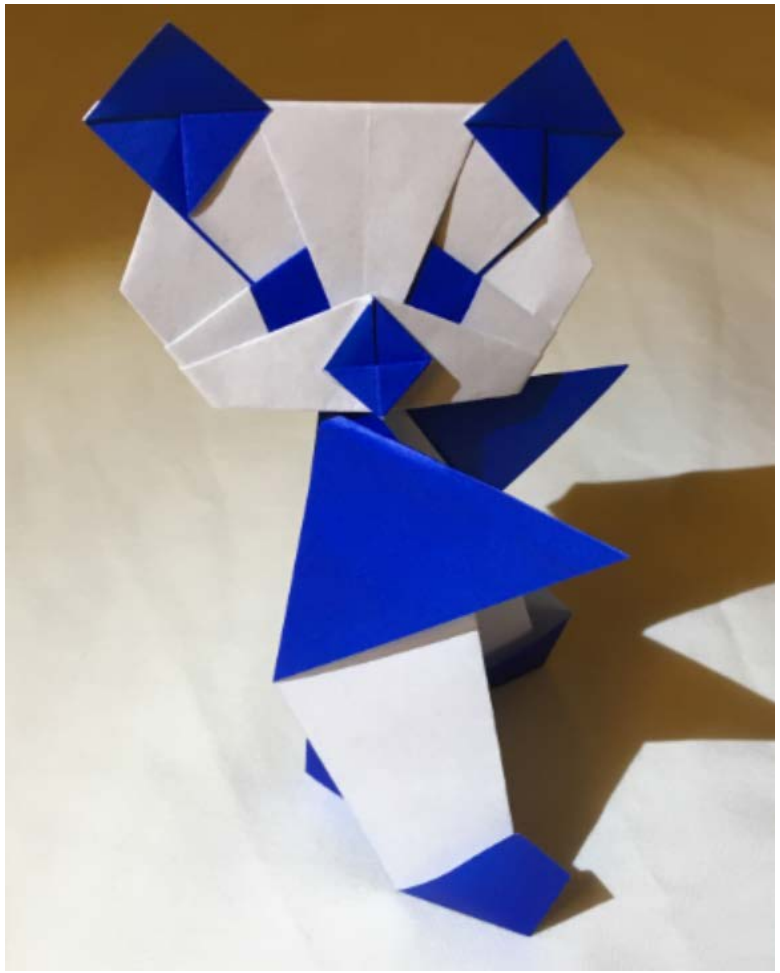
National Council of Teachers of Mathematics Annual Meeting

April 28, 2018
Washington, DC

Origami as an Art







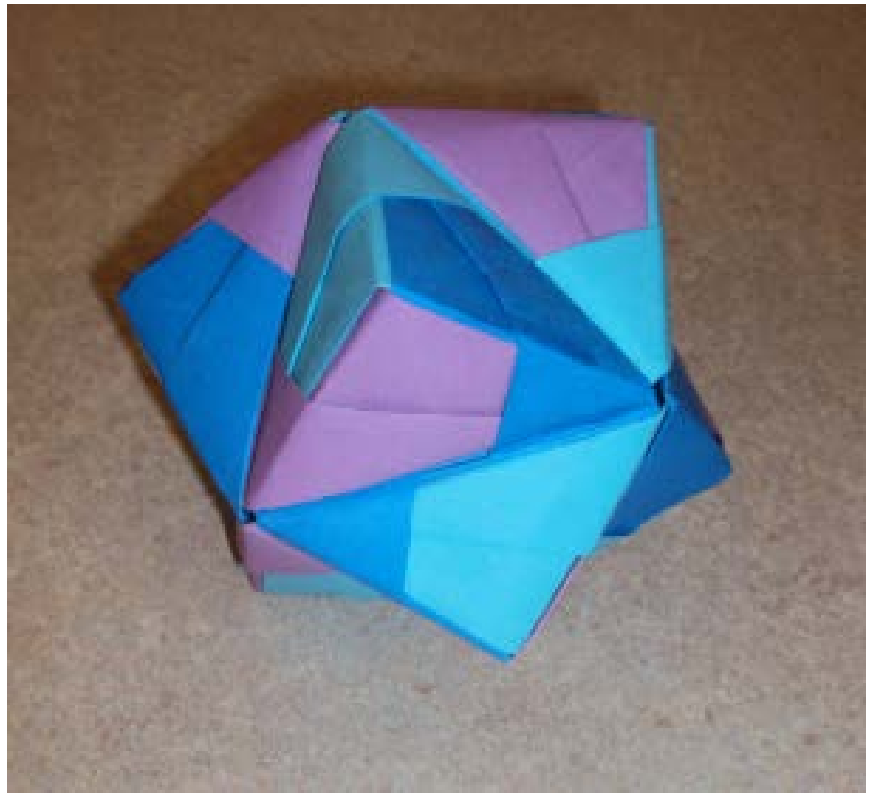
Modular Origami

In **modular origami**, or **unit origami**, a number of individual units, each folded from a single sheet of paper, are combined to form a compound structure.

Source: http://mathworld.wolfram.com/Origami.html

Examples

Cube
(6 units)



Stellated Octahedron
(12 units)

Examples

Stellated Icosahedron
(30 units)

Triangular Hexahedron
(3 units)

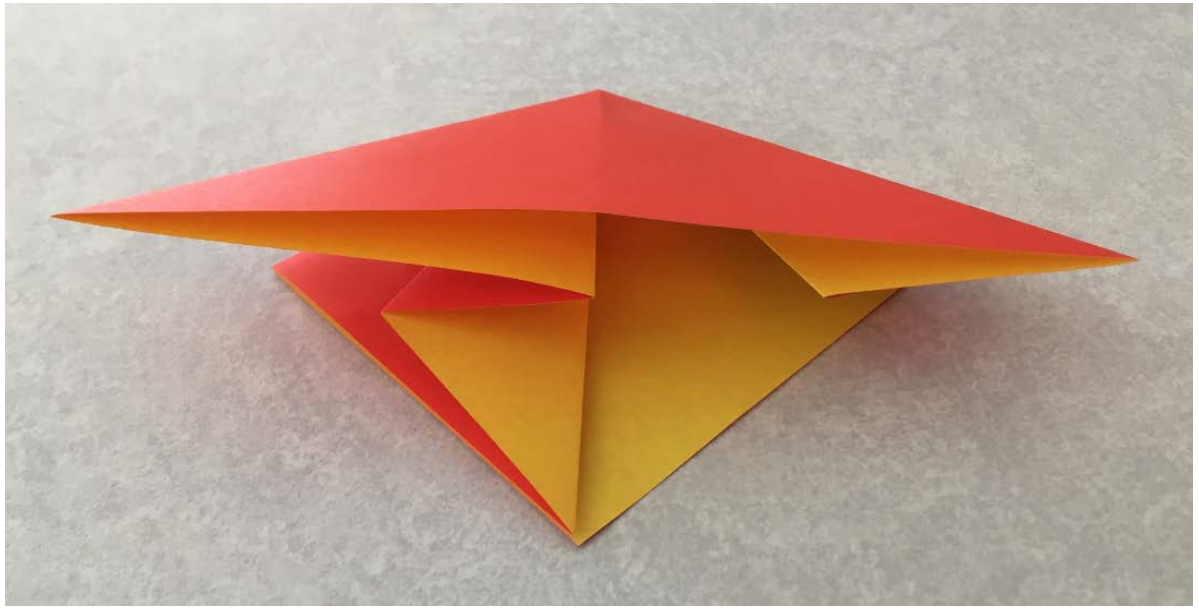
Axioms of Origami

O1: We can fold a line connecting any two points P and Q.
O2: We can fold any two points onto each other.
O3: We can fold any two lines onto each other.
O4: Given a point P and a line L, we can make a fold perpendicular to L passing through P.
O5: Given two points P and Q and a line L, we can make a fold that passes through P and places Q onto L.
O6: Given two points P and Q and two lines K and L, we can make a fold that places P onto line K and places Q onto line L.
O7: Given a point P and two lines K and L, we can fold a line perpendicular to K placing P onto L.

Source: Philipp Legner's *Mathematical Origami* (https://mathigon.org/downloads/origami.pdf)

Kawasaki-Justin-Husimi Theorem

A crease pattern is flat-foldable if and only if the alternating sum about a vertex is zero.

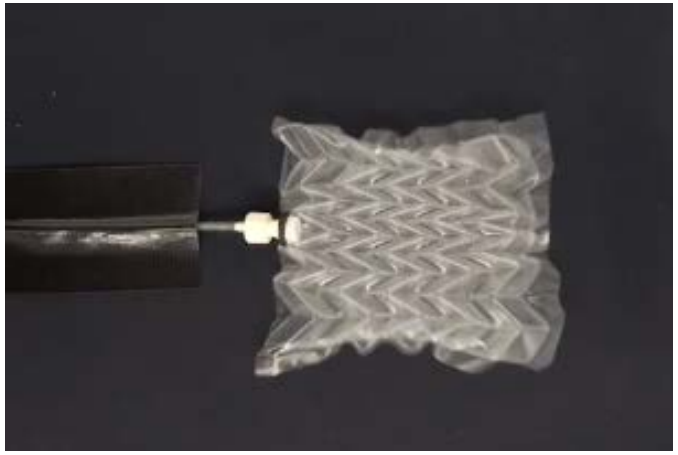


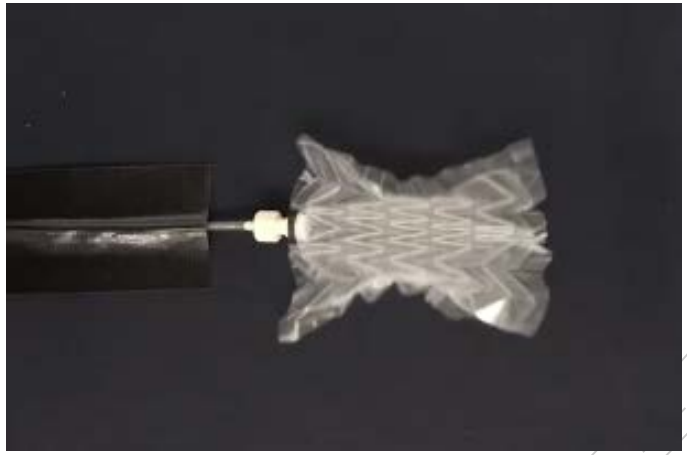
$$90^o - 45^o + 22.5^o - 22.5^o + 45^o$$

$$- 90^o + 22.5^o - 22.5^o = 0^o$$

Source: Kawasaki (1989); https://en.wikipedia.org/wiki/Kawasaki%27s_theorem

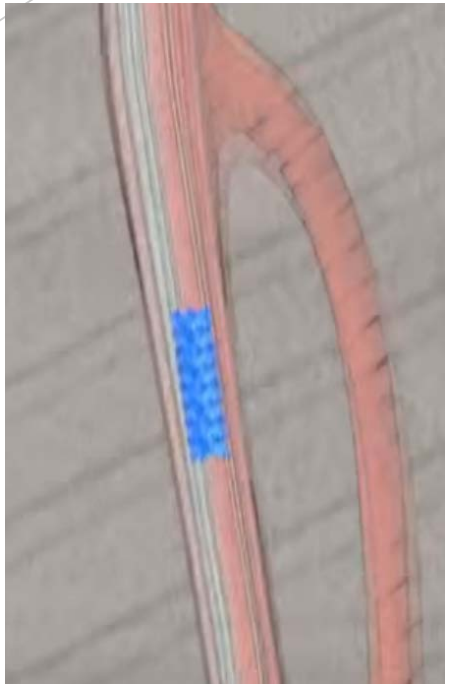
Functionality
Collapsibility
Strength

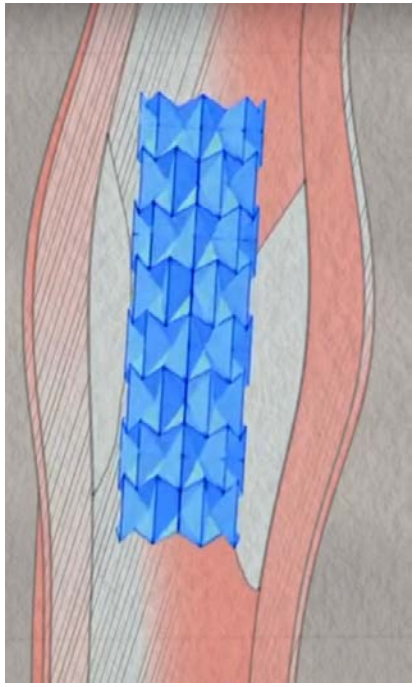


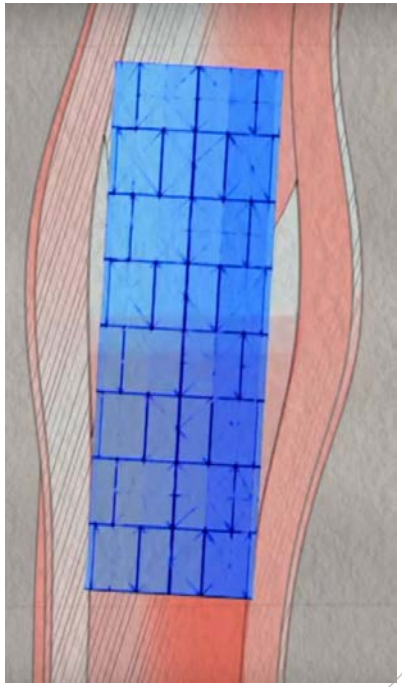


Source: Wyss Institute at Harvard University

Functionality Expandability





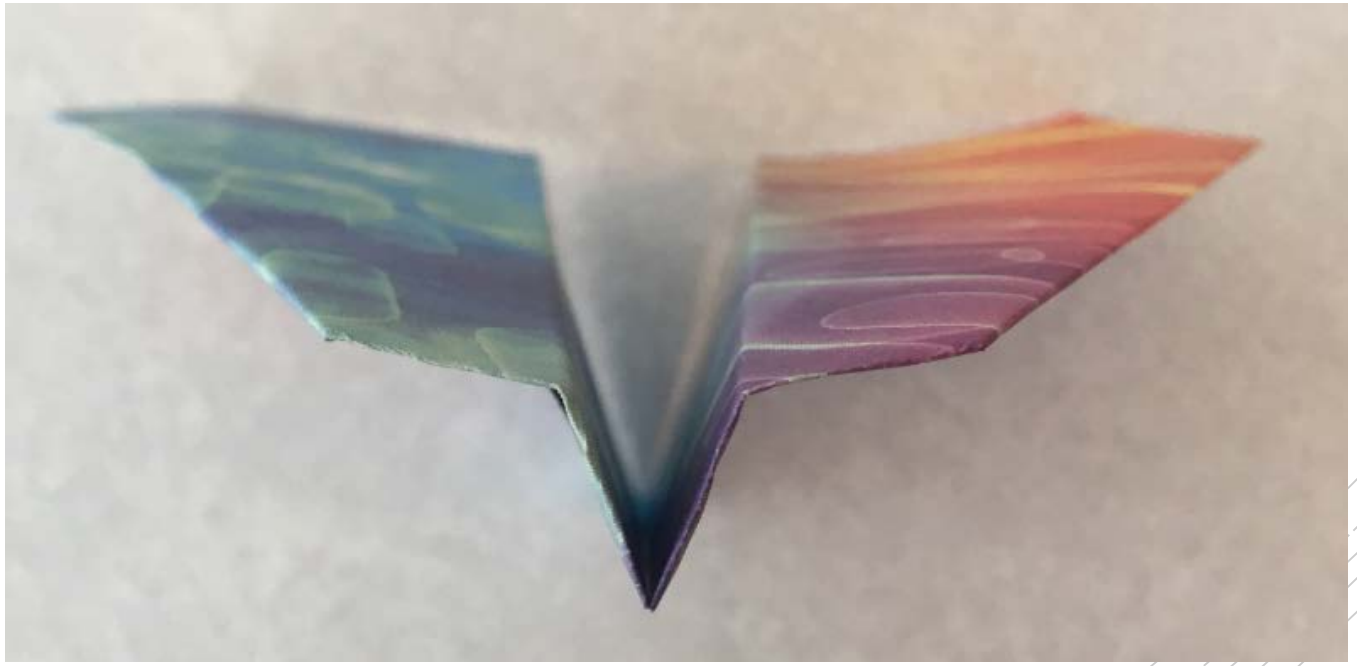


Source: "The Origami Revolution," *Nova* PBS, Season 44, Episode 5, Aired February 15, 2017.

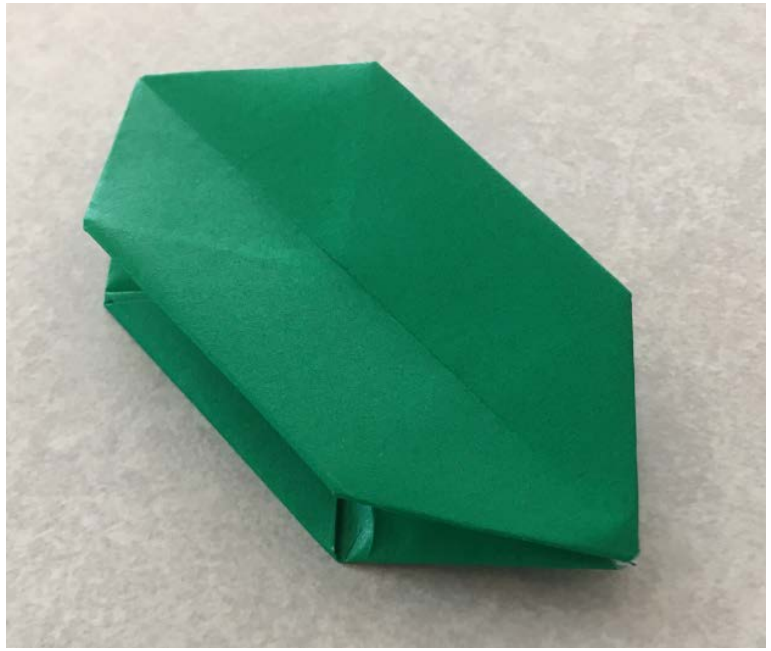
Functionality
Expandability
Strength

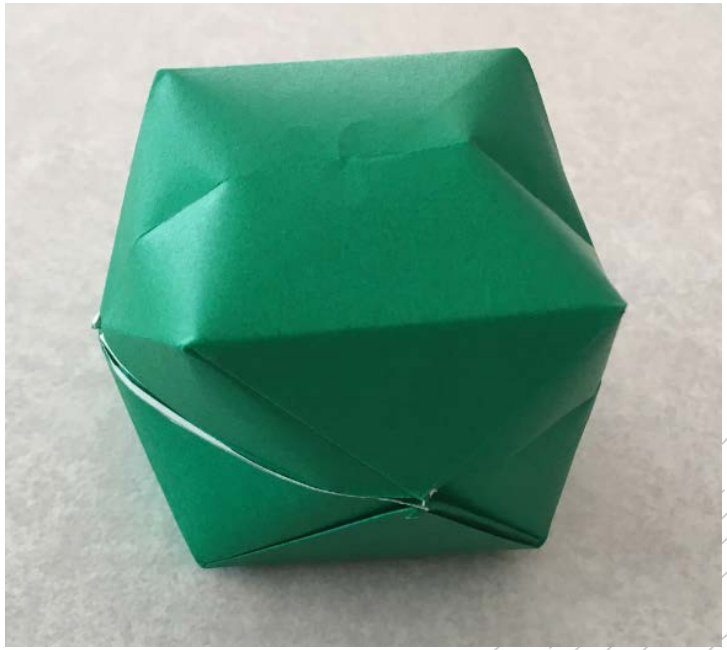
Source: Brigham Young University

Nakamura Lock

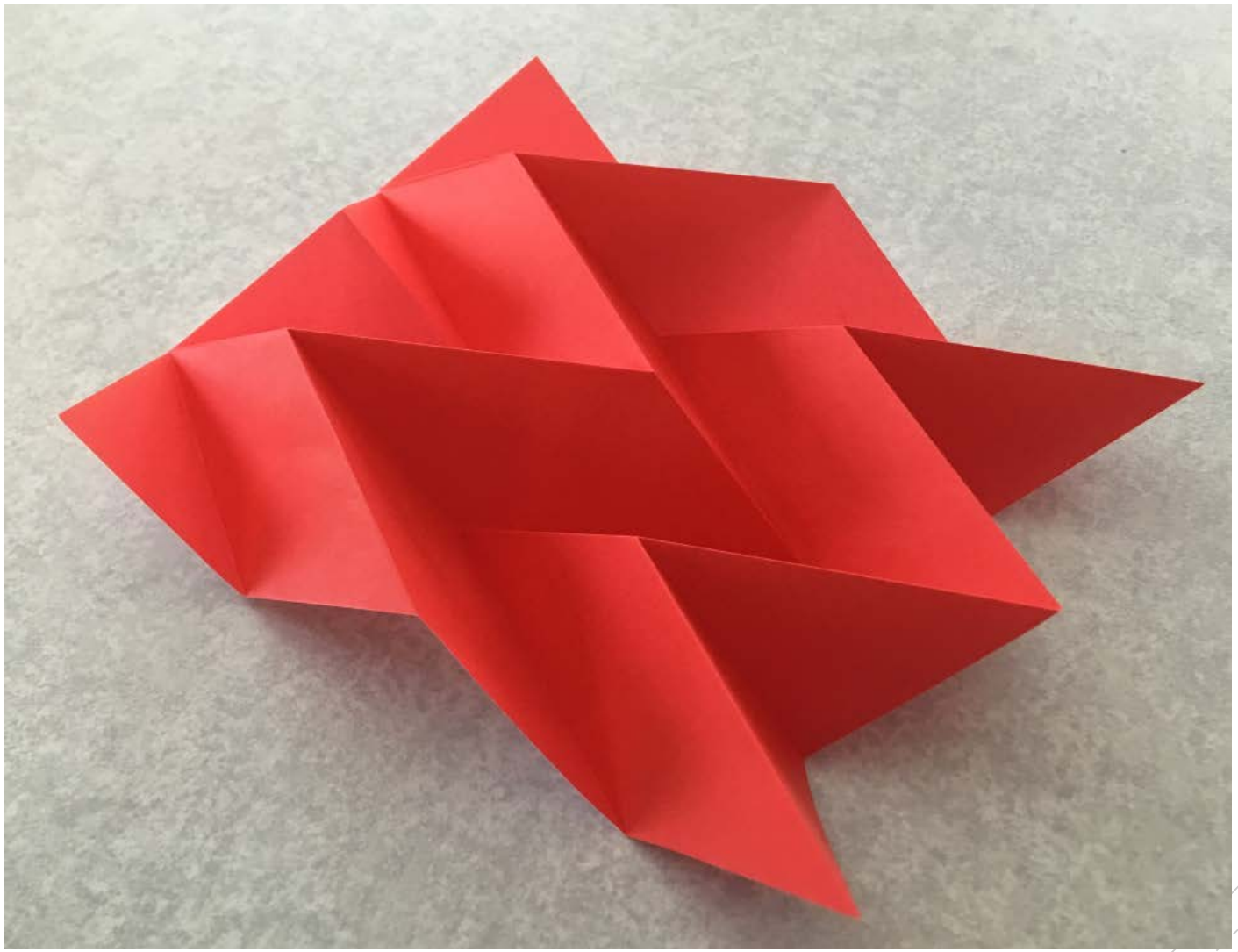


Water Bomb

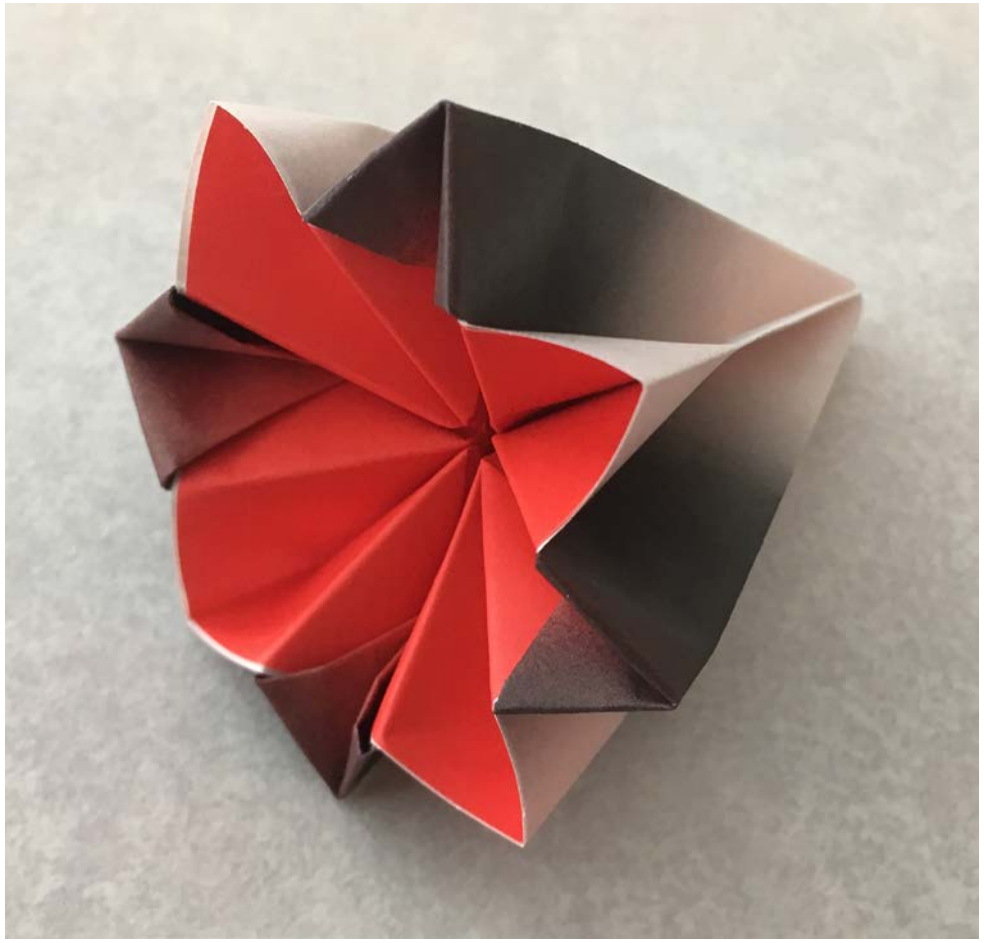




Miura Ori



Cone



Origami in the News

Origami-inspired engineering unfolds new ideas, **University of Notre Dame College of Engineering** (2018)

Inspired by origami, scientists build artificial muscle that lifts 1,000 times its own weight, ***LA Times*** (11/27/17)

Origami: Mathematics in creasing, ***The Conversation*** (1/6/15)

How the Future of Origami Engineering is Unfolding, ***Live Science*** (12/13/14)

BYU engineers turn to origami to solve astronomical space problem, ***Brigham Young University Mechanical Engineering*** (11/26/13)

The End

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