

# Origami for Engineering: Collapsing, Functional, and Strong

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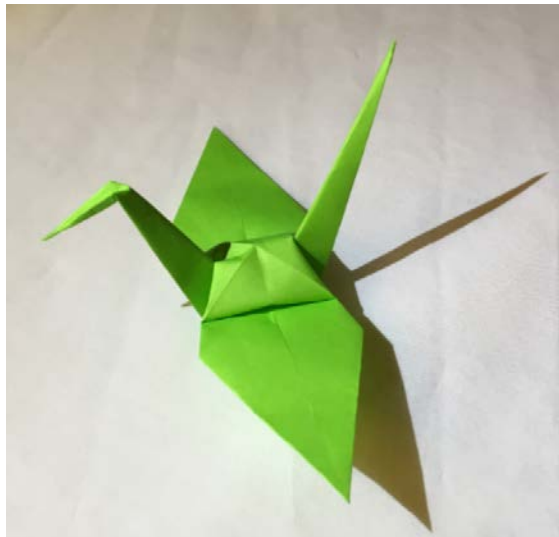
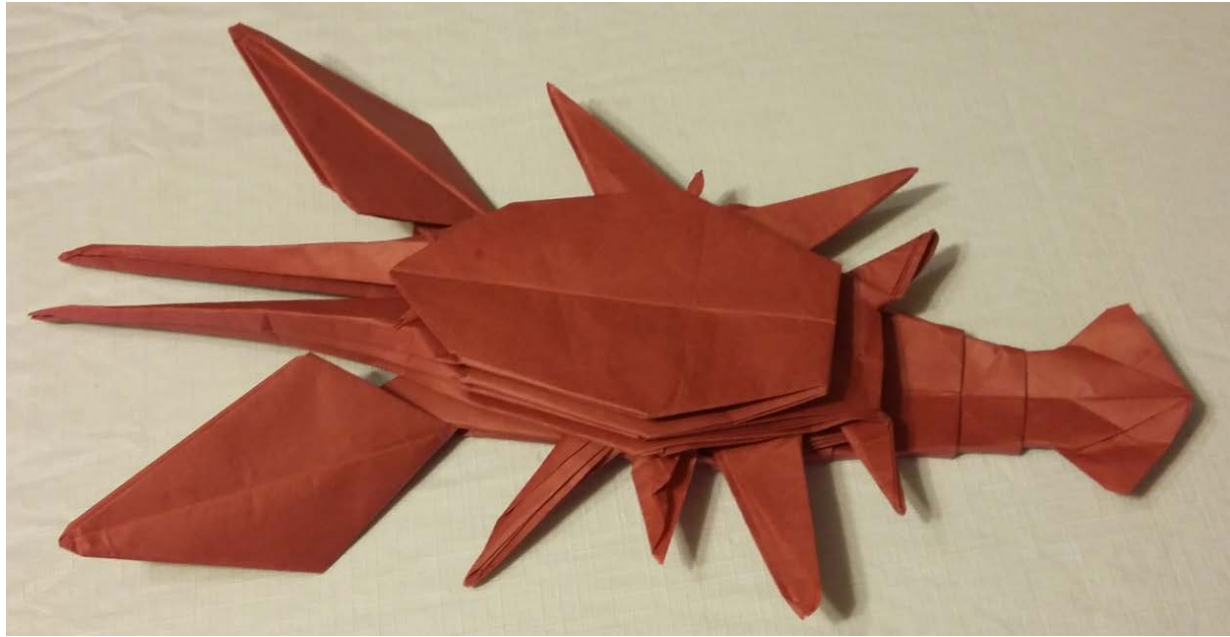
**44<sup>th</sup> Annual Conference**

**November 17, 2018**

**Orlando, Florida**

The background features a series of concentric circles in light gray, some solid and some dashed, creating a ripple effect. A large, solid red speech bubble is centered on the page, pointing downwards. The text "Origami as an Art" is written in white inside the speech bubble.

# Origami as an Art



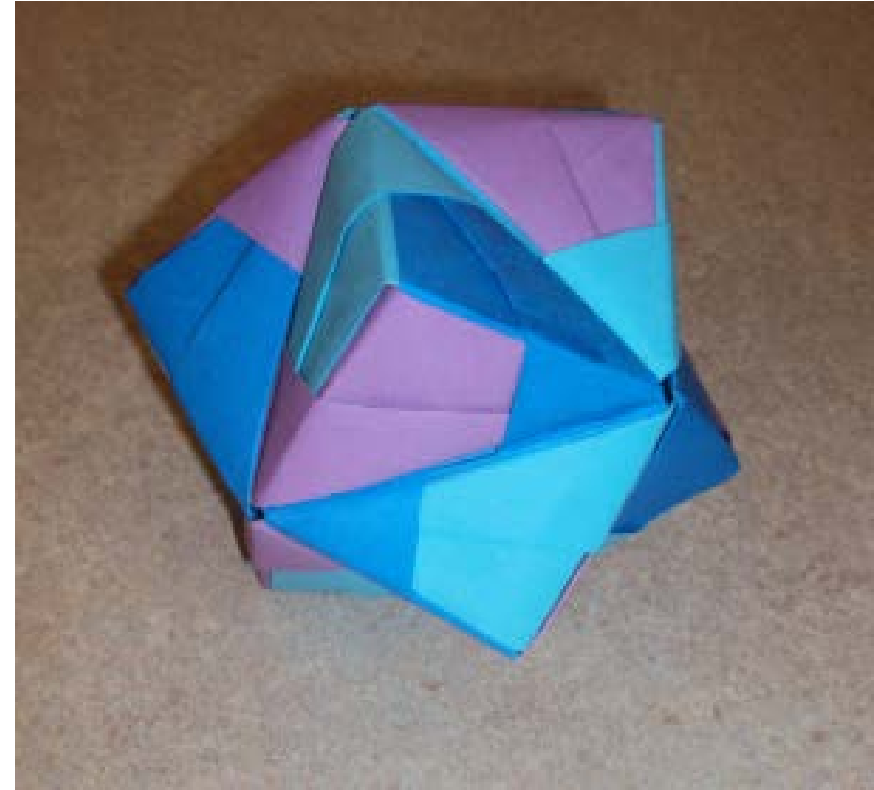
## Modular Origami

**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.**

# Examples



**Cube**  
(6 units)



**Stellated Octahedron**  
(12 units)

# Examples



Stellated Icosahedron  
(30 units)



Triangular Hexahedron  
(3 units)

The background features a series of concentric circles in light gray, some solid and some dashed, creating a ripple effect. A prominent red callout box is centered on the page, containing the title text. The box has a rectangular top and a pointed bottom, resembling a speech bubble or a callout.

# 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  $L$ .

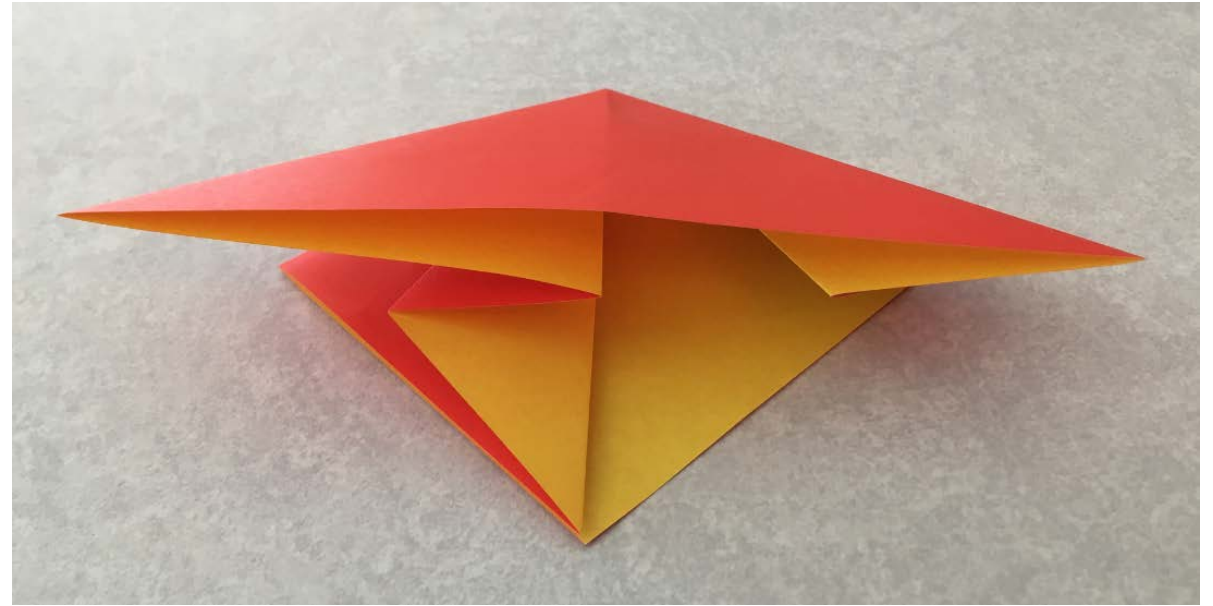


The background features several concentric circles of varying radii, some solid and some dashed, creating a ripple effect. A prominent red callout box is centered on the page, containing the text 'Kawasaki-Justin-Husimi Theorem'.

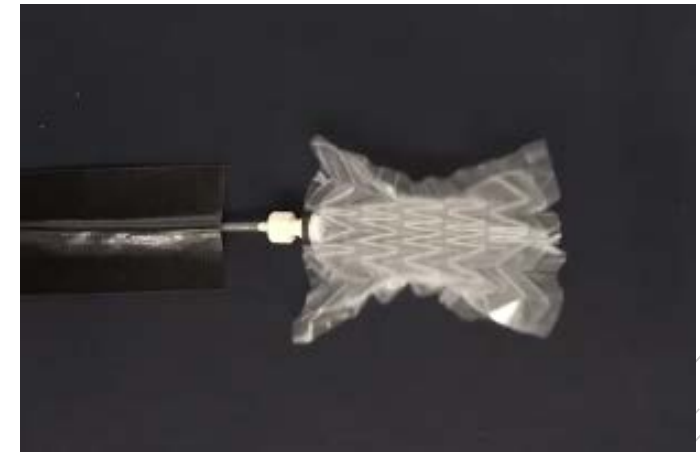
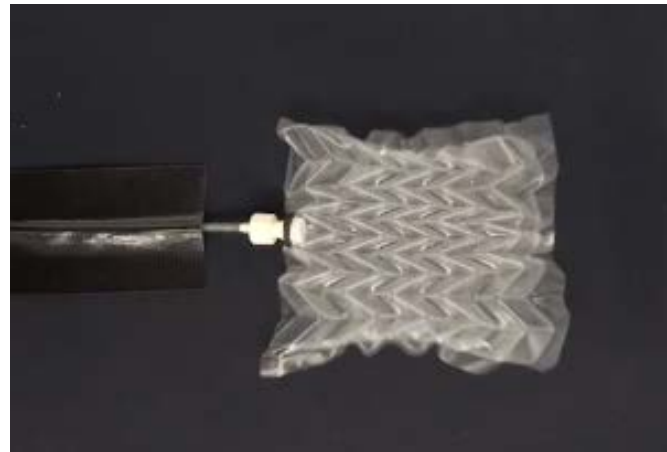
# Kawasaki-Justin-Husimi Theorem

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

$$90^\circ - 45^\circ + 22.5^\circ - 22.5^\circ + 45^\circ - 90^\circ + 22.5^\circ - 22.5^\circ = 0^\circ$$

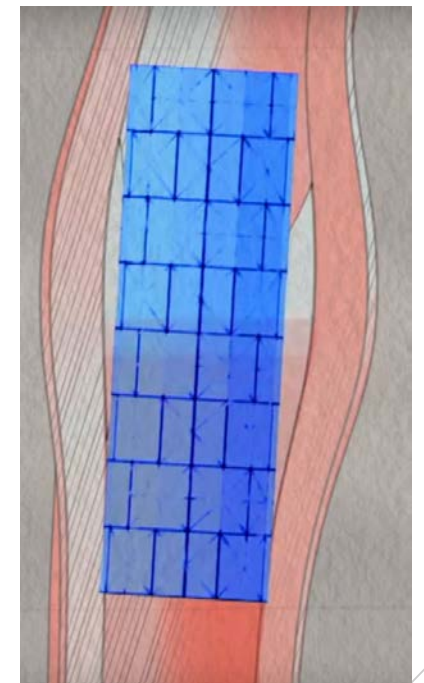
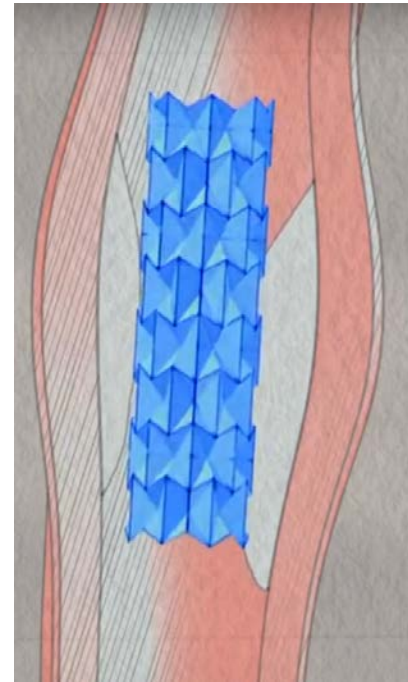


Functionality  
Collapsibility  
Strength



Source: Wyss Institute at Harvard University

# Functionality Expandability



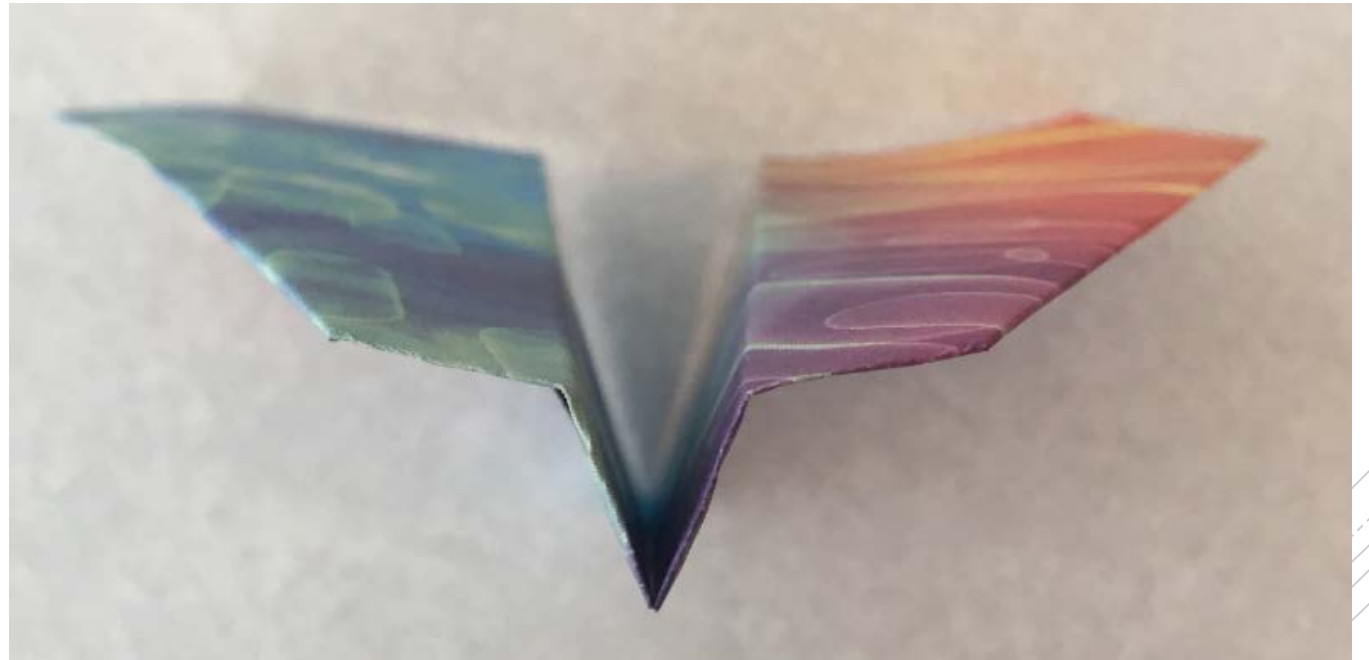
Source: "The Origami Revolution," *Nova* PBS,  
Season 44, Episode 5, Aired February 15, 2017.

Functionality  
Expandability  
Strength

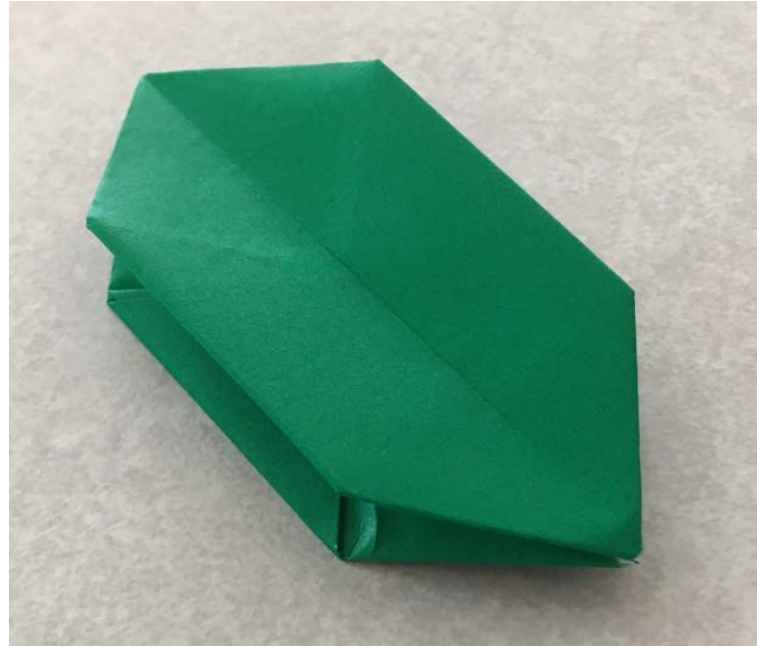


Source: Brigham Young University

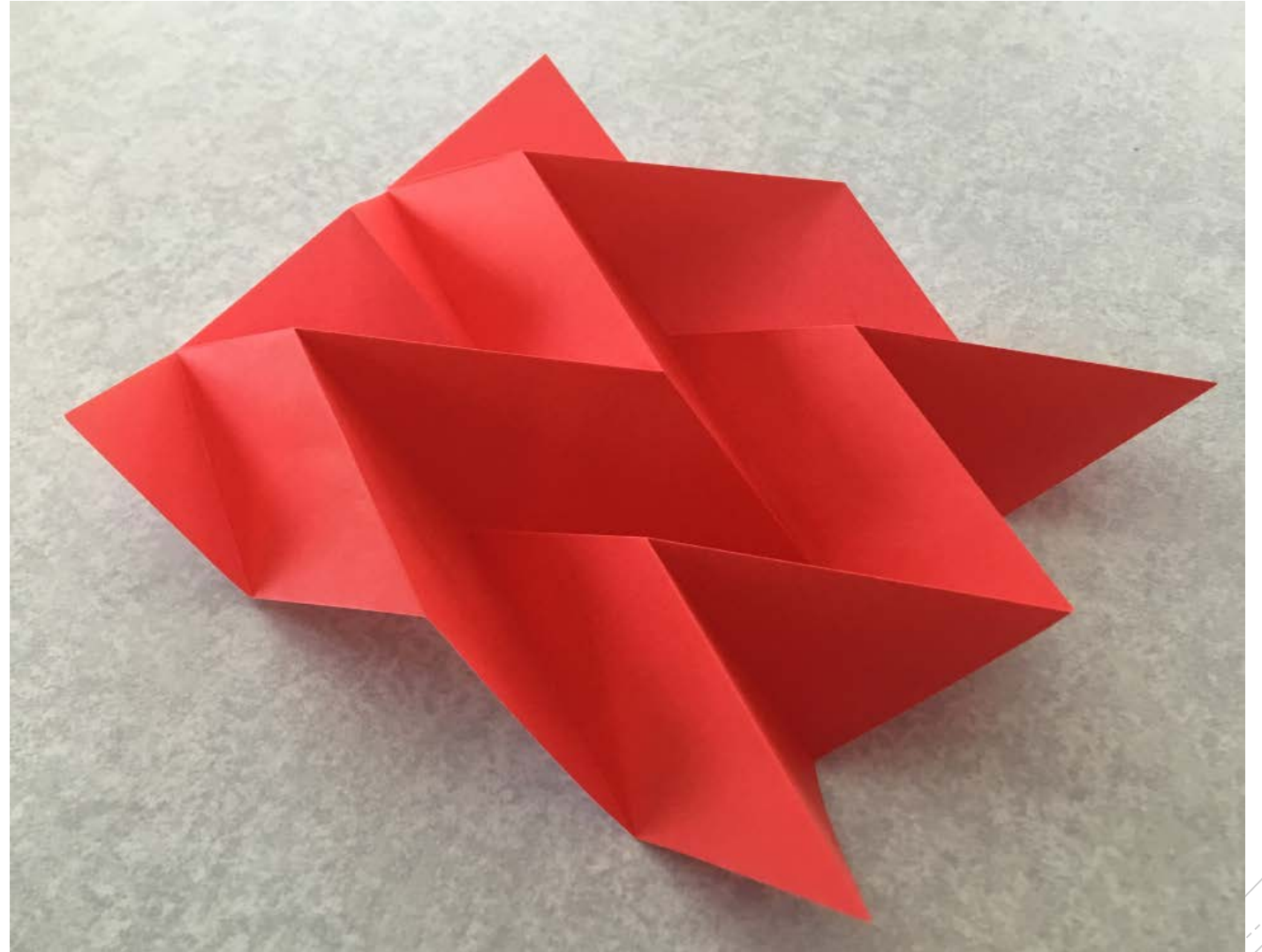
Nakamura  
Lock



# Water Bomb

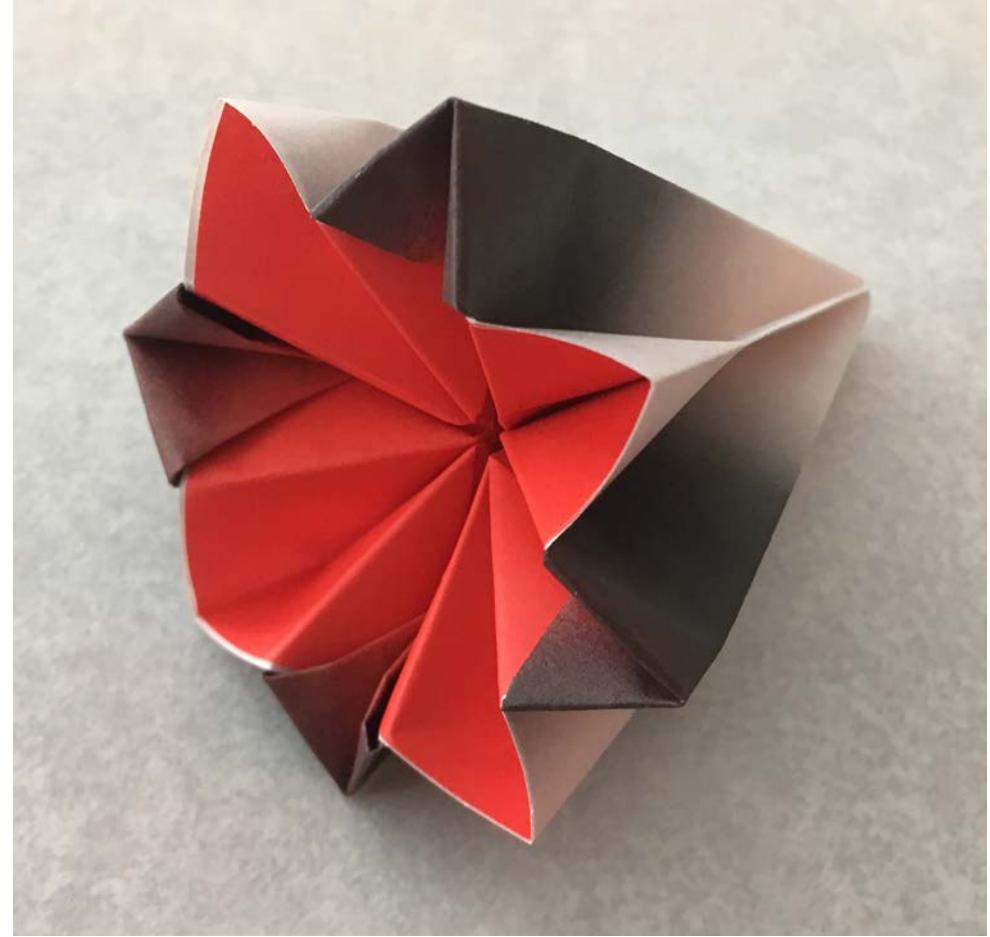


Miura Ori





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)

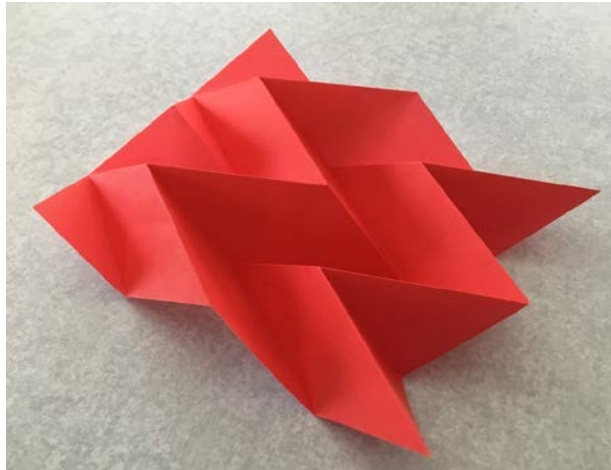
Origami: Mathematics in creasing, **The Conversation** (1/6/15)

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)

**Miura-ori**

<https://youtu.be/lvE-1RS3VrY>



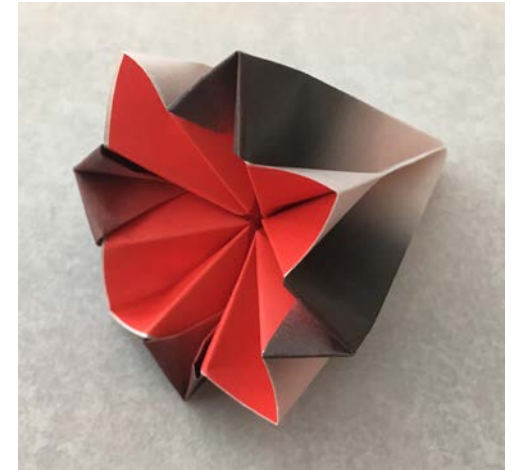
**Water Bomb**

<https://youtu.be/CAdJLsy1gHQ>



**Cone**

<https://youtu.be/9Xy8kivLRll>



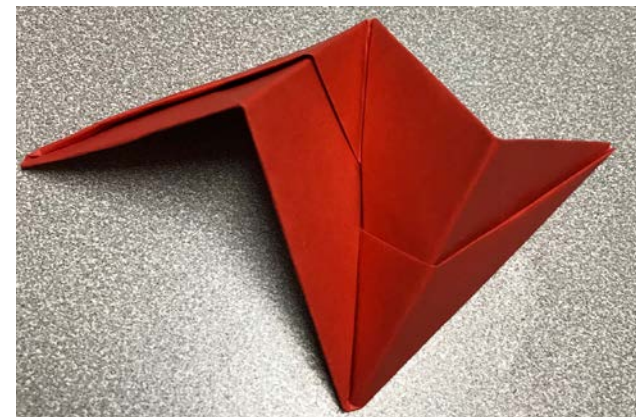
**Nakamura Lock**

[https://youtu.be/fiii\\_FnFdw0](https://youtu.be/fiii_FnFdw0)



**Basic Unit**

[https://youtu.be/0zdZk8wl8\\_I](https://youtu.be/0zdZk8wl8_I)



# The End

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