Skeletal Structures and Origami Design

By Michelle Lau and Kaylee Xie

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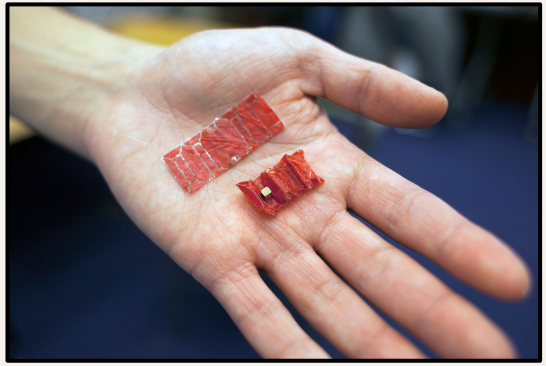
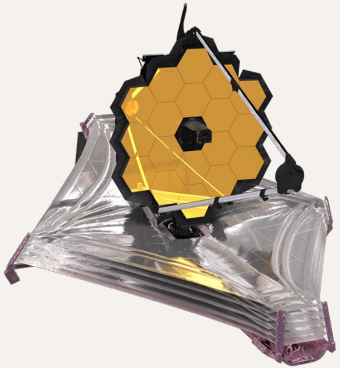
Why Origami?

Origami is a **real world application** of geometric principles that helps us construct physical structures.

Understanding **spatial and geometric intuition**



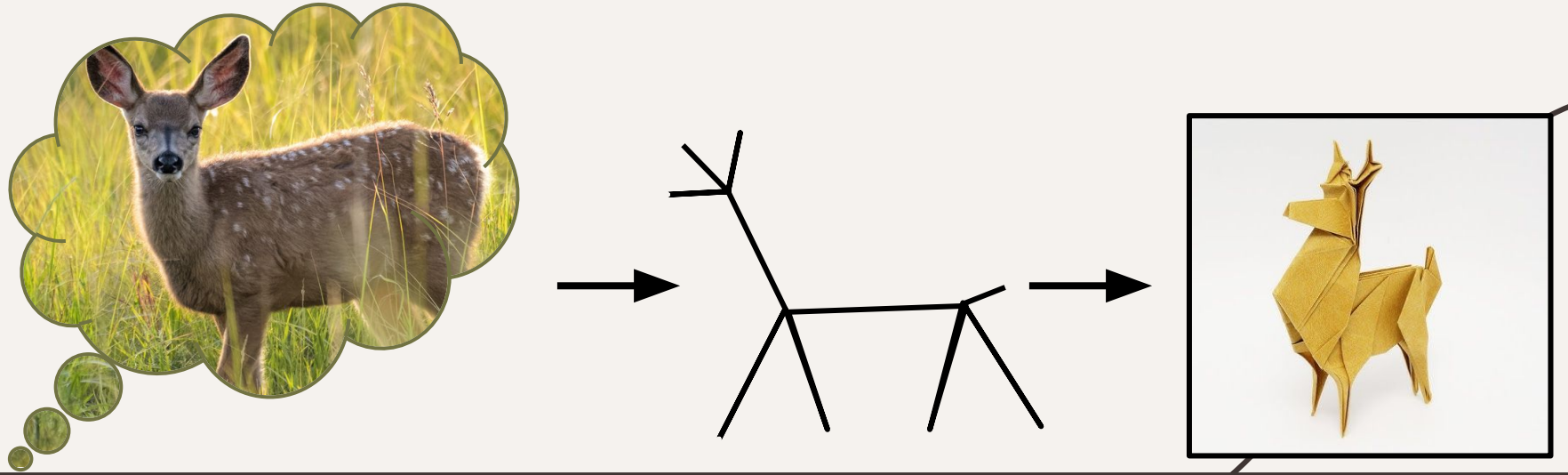
MIT's ingestible origami robot



JWST unfolds when in space

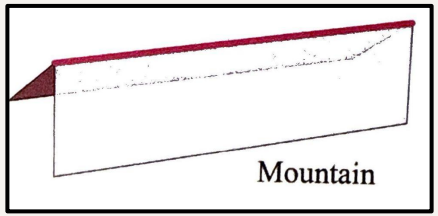
Objective

We want to take something **from an idea or concept into reality.**

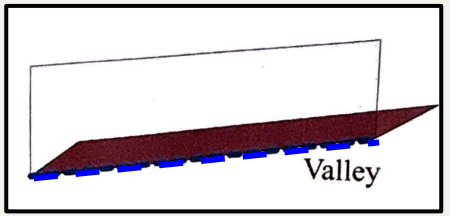


Terminology

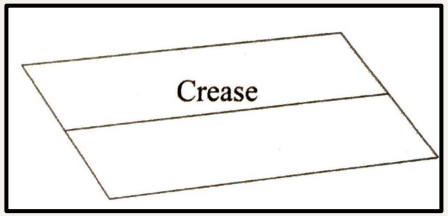
Mountain Fold



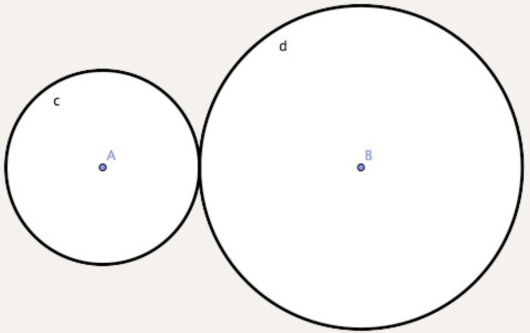
Valley Fold



Creases

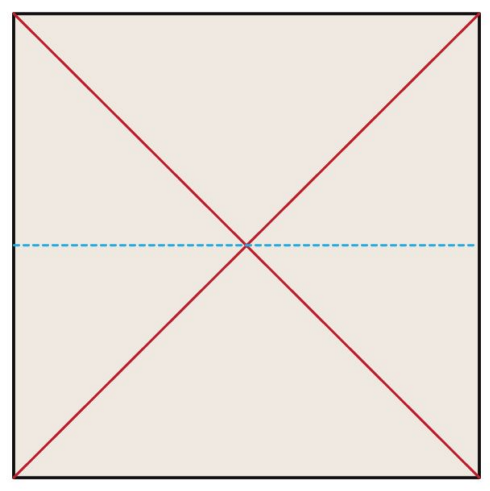


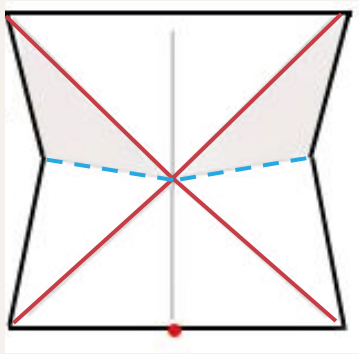
Tangent Circles



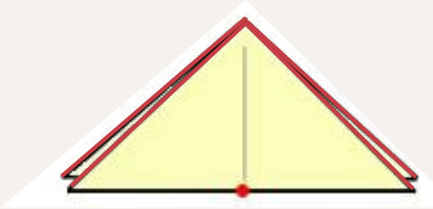
Terminology Applied

Base - a 2D diagram of the folds that create a structure





Final Folded Shape



RED = Mountain Fold

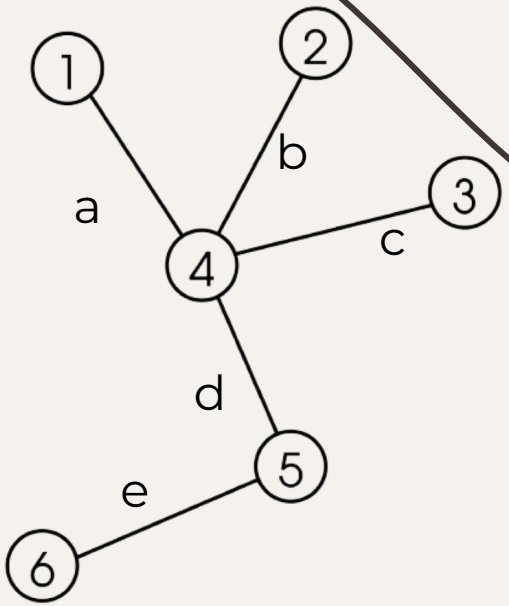
BLUE = Valley Fold

Folds Flat

Stick Figures

The **stick figure** is the basic frame, or “bones” of a structure.

It is represented by **a metric tree**



Metric Tree:

Tree → graph with no cycles

Metric → edges with lengths

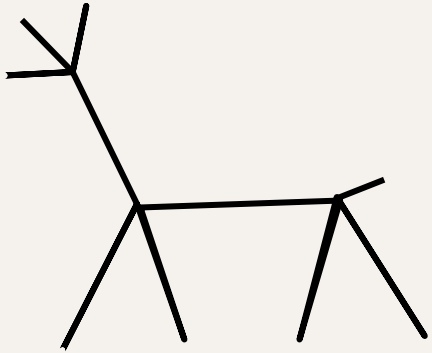
Vocab:

A **terminal edge**: line segment with 1 endpoint connected

Stick Figures

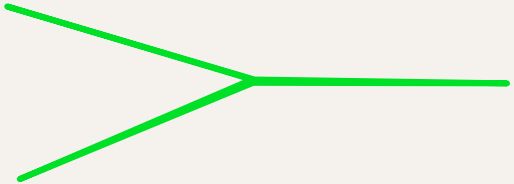
Think about a deer:

- What lines do you need to define it?

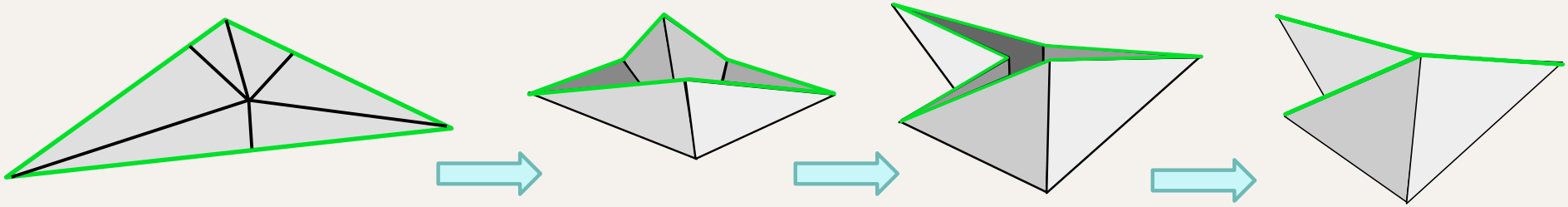


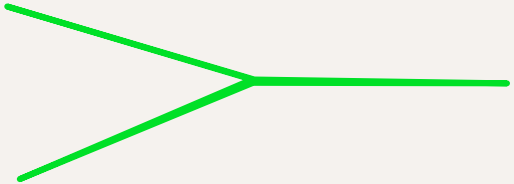
The stick figure for an origami deer as seen to the left, and the physical representation above.

Stick Figures → 3D



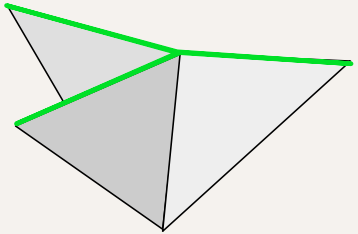
Stick figure → Polygon that props up stick figure



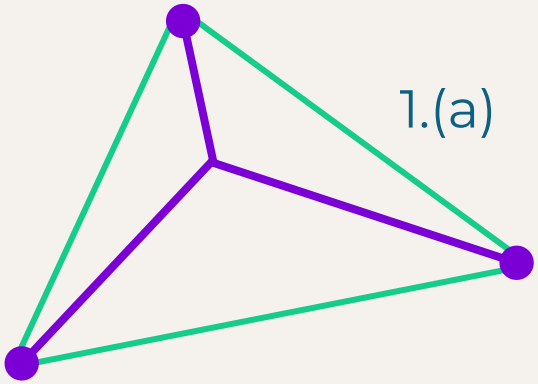


Claim

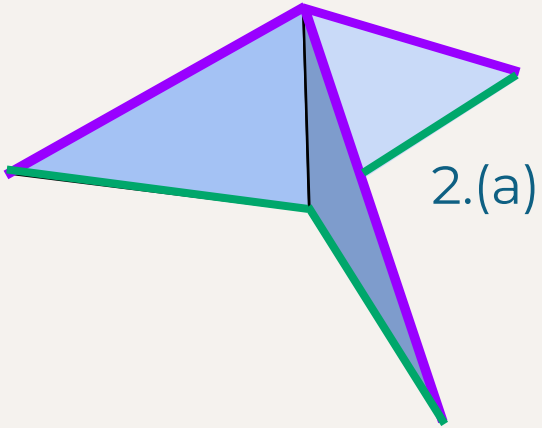
Given a stick figure, there is a base with a perimeter that creates the stick figure.



There are many stick figures that ‘make’ a triangle…

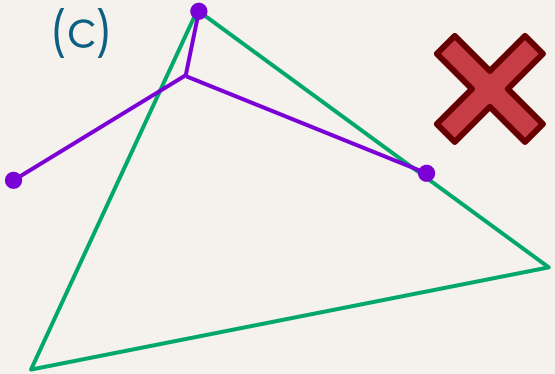


1.(a)

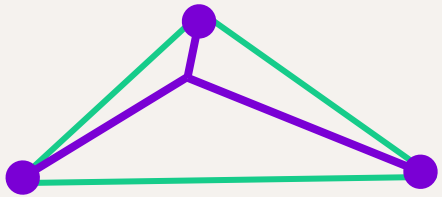


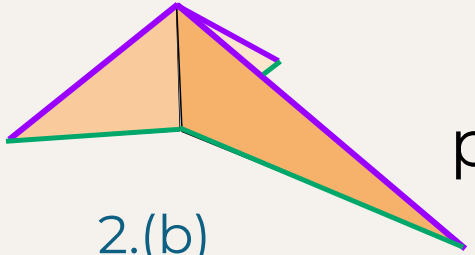
2.(a)

(c)



1.(b)

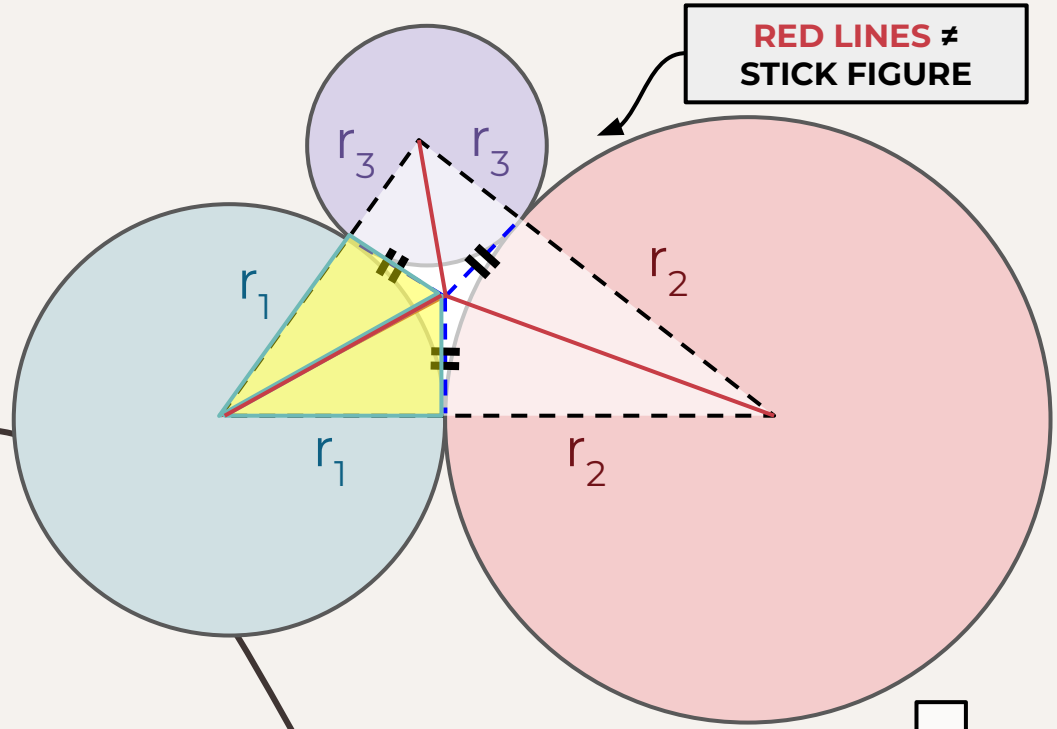




2.(b)

How do we find the polygon that recovers the given stick figure?

Circle packing



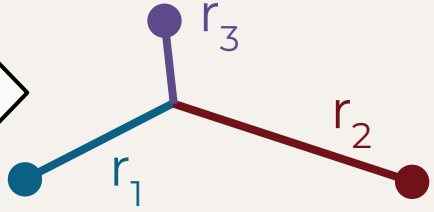
We are able to place circles centered at each vertex. Because the radii of the circles are the same length, this guarantees that the lengths will overlap correctly...

KEY

‖ -> Represents congruent lengths

-- -> represents height from the middle point

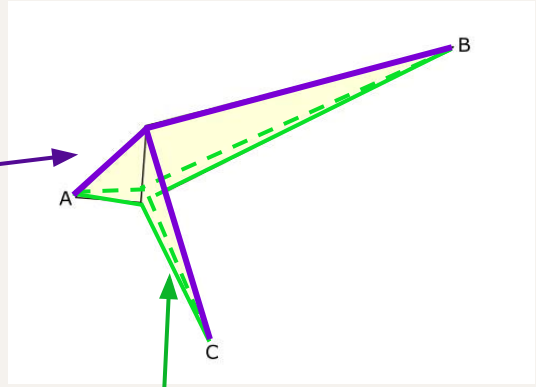
STICK FIGURE

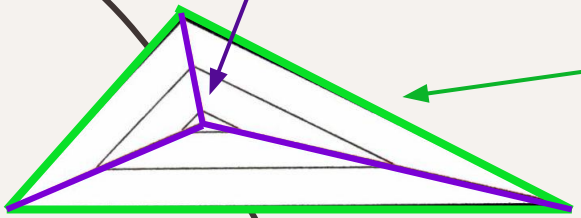


Creates stick figure with edge lengths **r_1, r_2, and r_3**

Skeletal Structure

Purple lines make up the **skeletal structure**





Green lines correspond to edges in **stick figure**

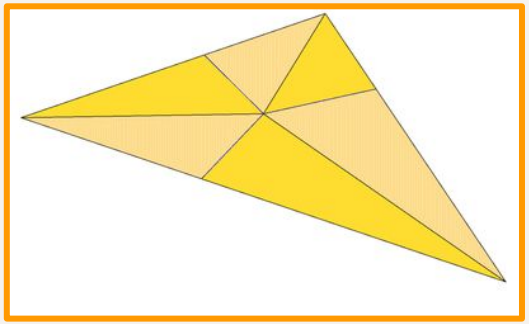
The **skeletal structure** is the collection of **ridge creases.**

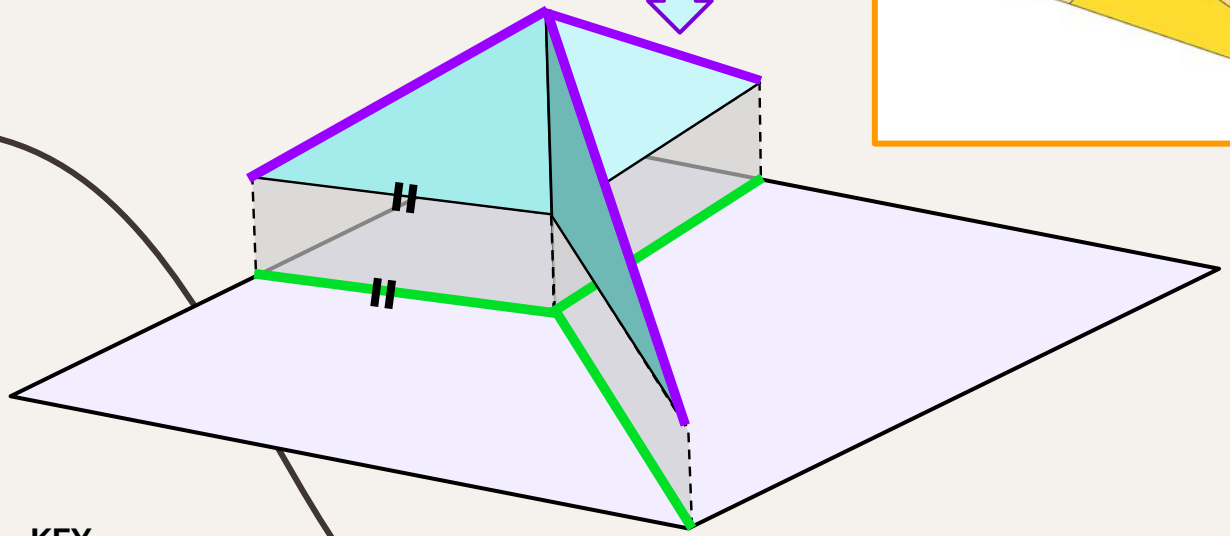
It is unique to each shape.

Definitions

Ridge creases = the lines/edges that extend from the plane of the stick figure

Skeletal Structure vs. Stick Figure





KEY

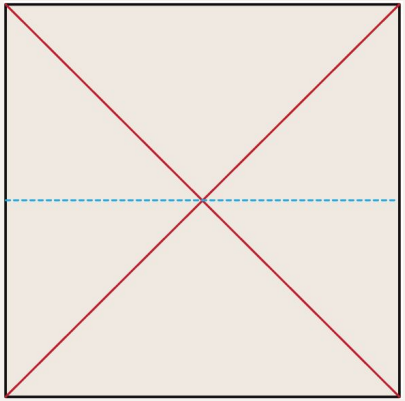
-> Represents **Stick Figure**

-> Represents **Skeletal Structure**

The **Skeletal Structure** consists of the **ridge creases** in a structure.

On the other hand, the **Stick Figure** is made from the **edges/perimeter** of the polygon folding together.

Uniaxial Base

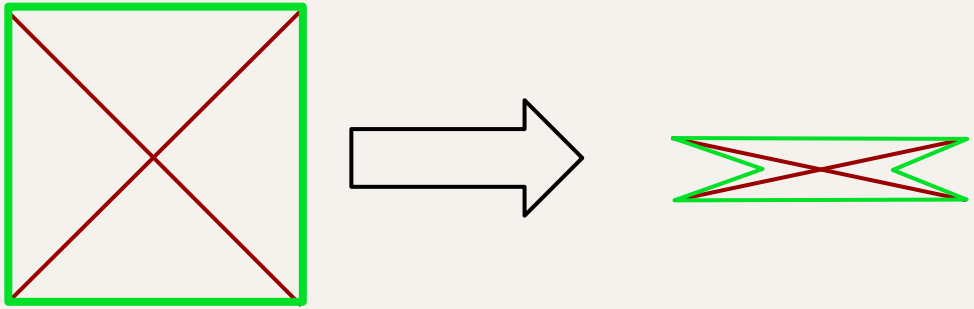


The Waterbomb Base is an example of a uniaxial base.

RED = Mountain Fold

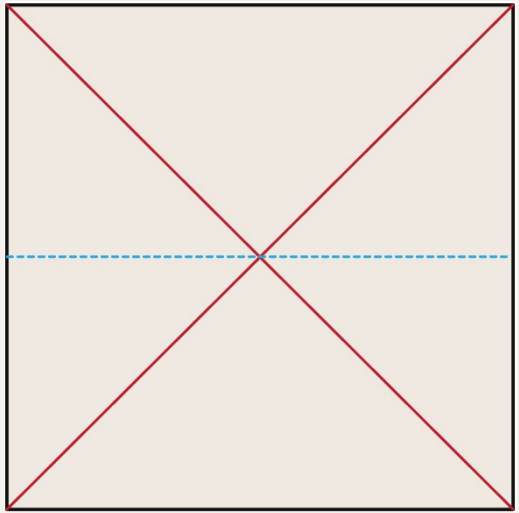
BLUE = Valley Fold

A base where the stick figure, or perimeter of the base, flat folds onto a **single** axis.



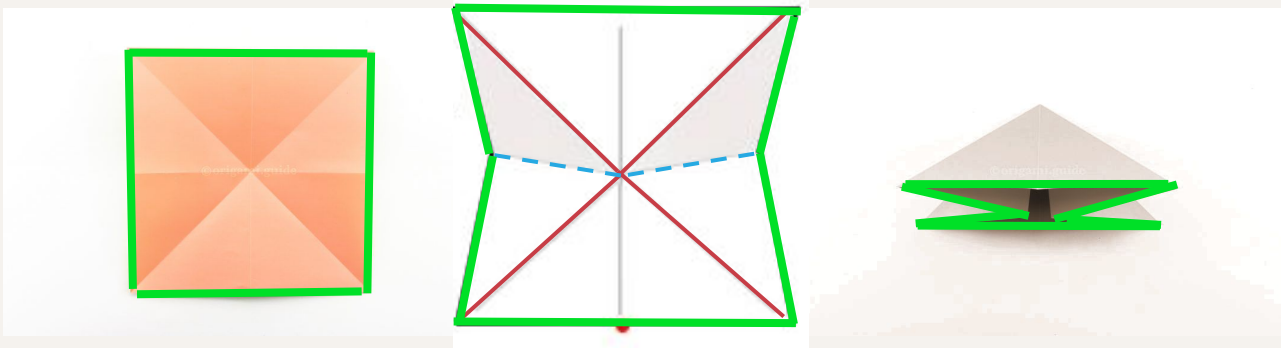
Reminder!

Base - a 2D diagram of the folds to create a structure



Uniaxial Base

This shows how the perimeter folds onto one axis.

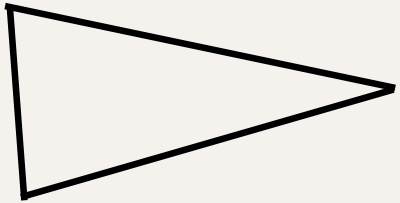


This is the bird’s eye perspective of the base

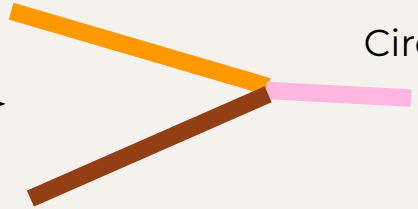
Final Shape!

This method can be used to create more complex bases, leading to a 3D representation of your stick figure!

Original shape

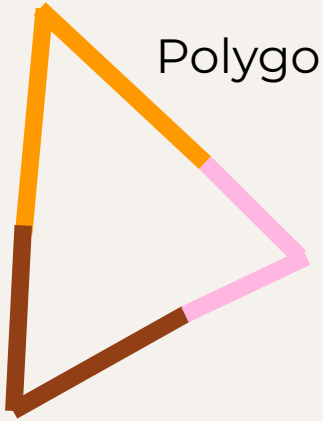


Stick figure

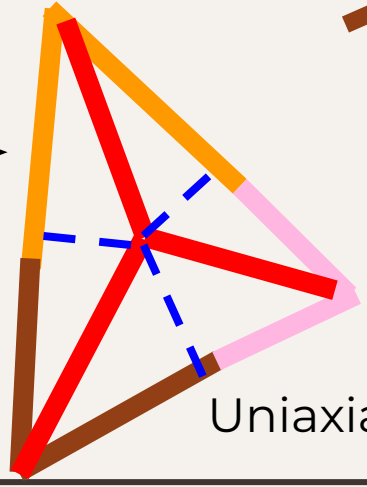


Circle Packing Method

Polygon

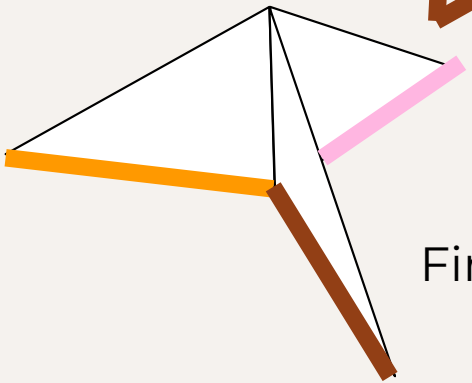


Skeletal structure and crease pattern

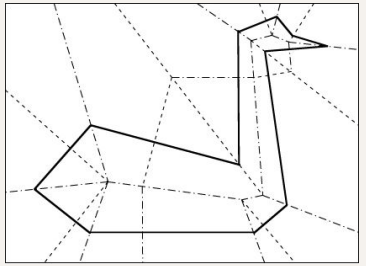


Uniaxial Base

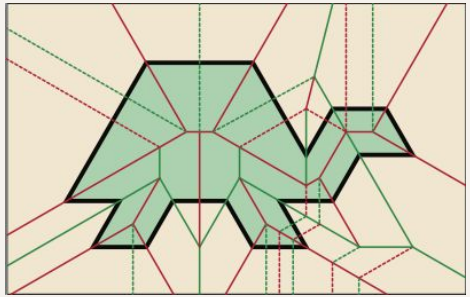
Fold!



Final Shape!



Thank you for listening!



Sources:

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