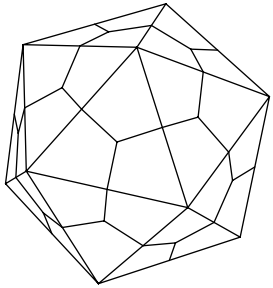
EQUATION DICE



ORIGAMI EDITION

Don’t worry.

We are going to make this complicated thing,
really simple.

Please consider the environment before printing

"There are no miracle people. It just so happened they got interested in this thing and they learned all this stuff - They're just people!"

~ Richard Feynman

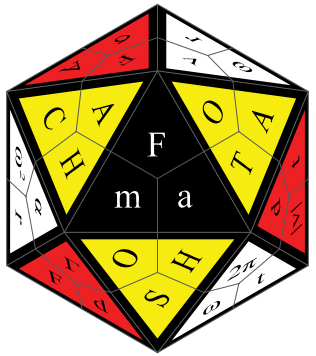
1.

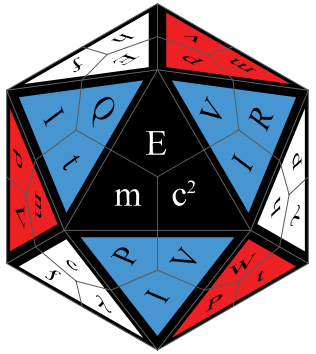
Icosahedron

You are going to make this.

It is an equation die, for physics.

(Top)

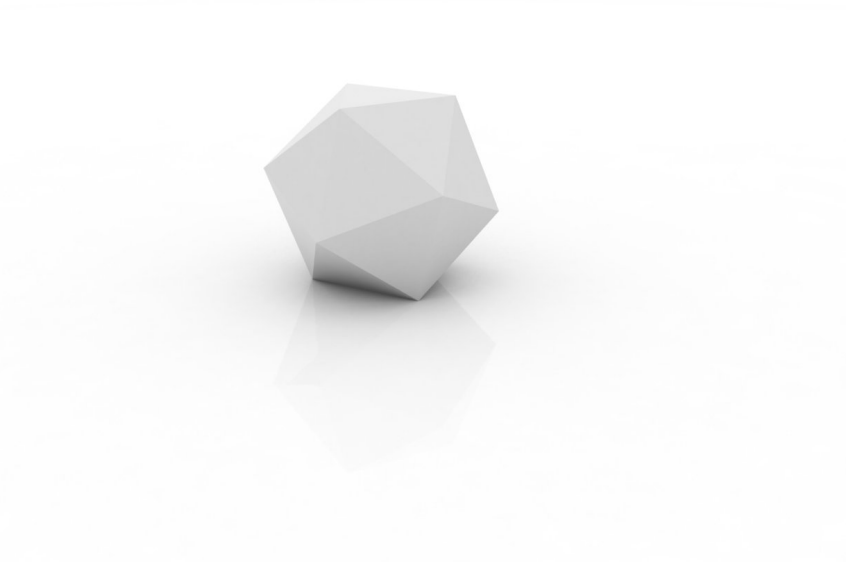




(Bottom)

The shape is called an Icosahedron.

~ ICO for short.



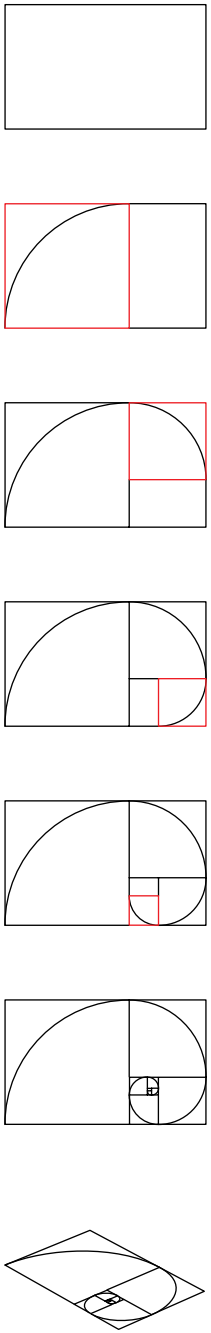
2.

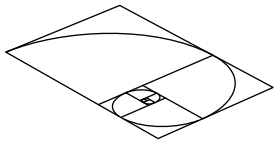
Golden Ratio

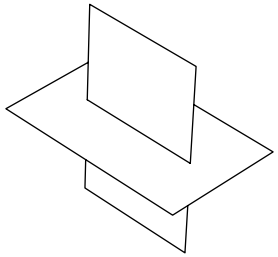
"The Golden ratio has inspired thinkers of all disciplines like no other number in the history of mathematics".

~ Mario Livio

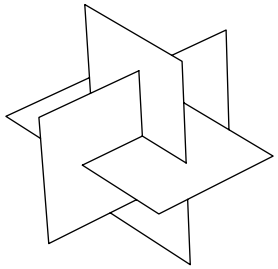
ICO has humble beginnings,
within the Golden Rectangle.

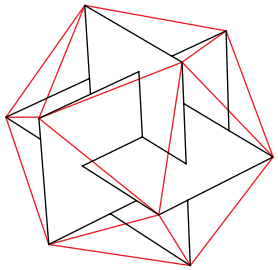






These golden proportions give rise to an Icosahedron.





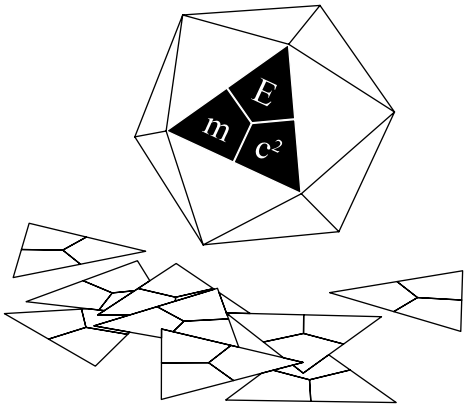
3.

Magic Triangles

"The laws of Nature are written in the language of mathematics…the symbols are triangles, circles and other geometrical figures, without whose help it is impossible to comprehend a single word".

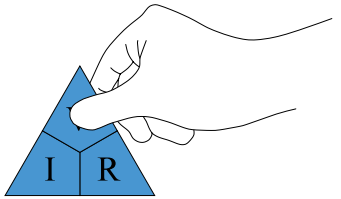
~ Galileo Galilei

Each triangular face contains a different equation.

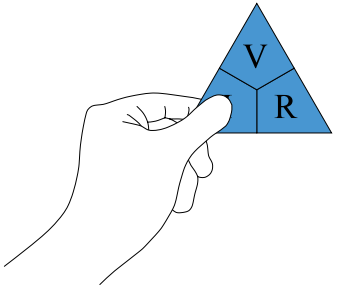


The triangle helps to rearrange the equations correctly.

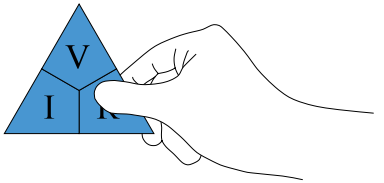
- Cover one term with your thumb to reveal if you need to multiply or divide.



$$V = IR$$

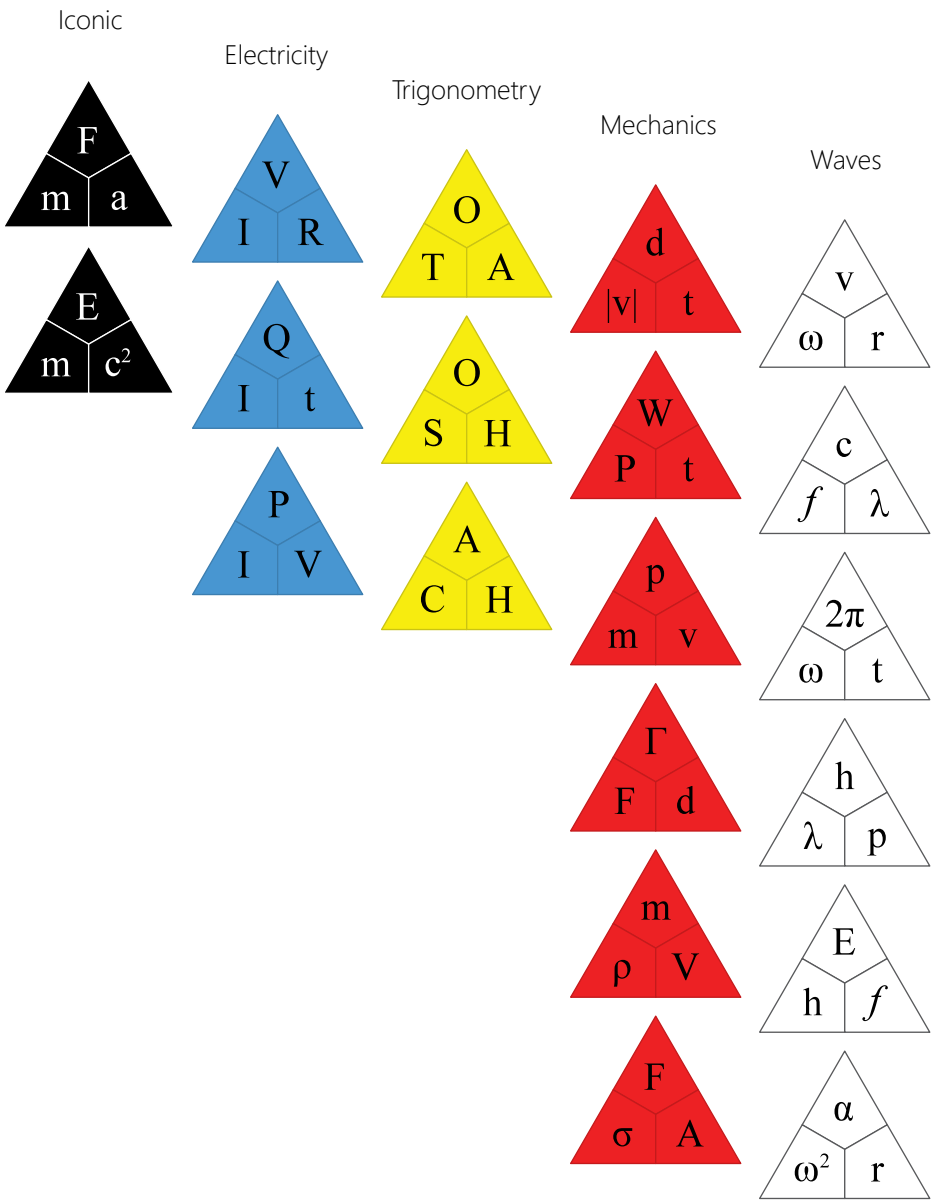


$$I = \frac{V}{R}$$



$$R = \frac{V}{I}$$

The equations are divided into five categories.



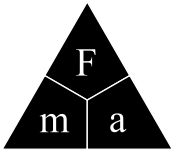
4.

Nomenclature

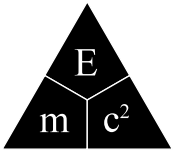
"In science, each new point of view calls forth a revolution in nomenclature".

~ Friedrich Engels

Here are two Iconic equations,
from Isacc Newton & Albert Einstein.

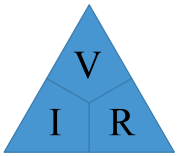


force = mass × acceleration

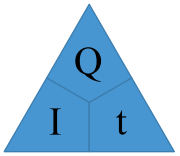


energy = mass × speed of light squared

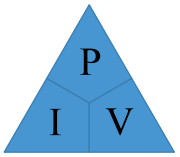
Three Electrical equations from Ohm, Ampere and Coulomb.



voltage = *current* × *resistance*

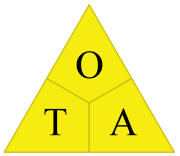


charge = *current* × *time*

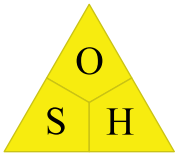


power = *current* × *voltage*

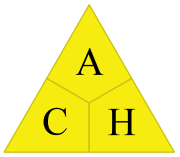
Three equations of Trigonometry,
from Pythagoras of Samos.



$$tangent\ \theta = \frac{opposite}{adjacent}$$

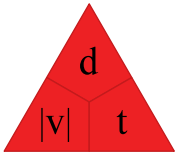


$$sine\ \theta = \frac{opposite}{hypotenuse}$$



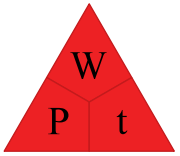
$$cosine\ \theta = \frac{adjacent}{hypotenuse}$$

Six equations of Mechanics, from Newton, Joule, Pascal and many others.

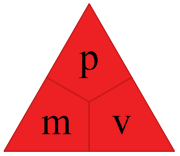


$$speed = \frac{distance}{time}$$

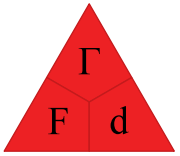
(speed is the modulus of velocity)



$$power = \frac{work}{time}$$

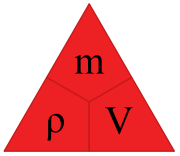


$$momentum = mass \times velocity$$

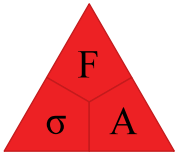


$$torque = force \times distance$$

(torque is a moment acting around a pivot)



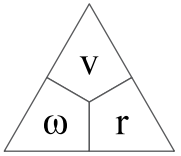
$$density = \frac{mass}{volume}$$



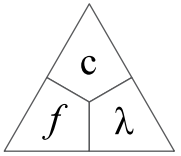
$$stress = \frac{force}{area}$$

(stress or pressure)

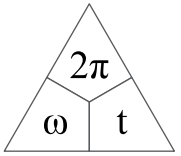
And six equations for quantum mechanics, waves and spinning objects.



tangential velocity = angular velocity × radius

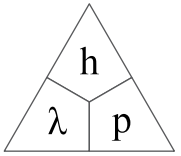


wave speed = frequency × wavelength



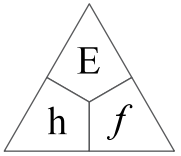
$$\textit{angular velocity} = \frac{2\pi}{\textit{time}}$$

(2π is the angular distance around a circle, in radians)

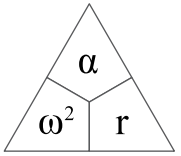


$$\textit{de Broglie wavelength} = \frac{\textit{Planck's constant}}{\textit{momentum}}$$

(Pronounced de Broy)



photon energy = Planck's constant × frequency



$$\frac{\textit{centripetal}}{\textit{acceleration}} = \textit{angular velocity squared} \times \textit{radius}$$

Nomenclature.

~ Key to symbols

Symbol	Quantity	Unit	Category
2π	2π radians = 360 degrees	deg or rad	
c	wavespeed	ms^{-1}	
E	energy	J	
f	frequency	Hz	
h	Planck's constant (6.63×10^{-34})	Js	
p	momentum	kg ms^{-1} or Ns	△ *Waves*
r	radius	m	
t	time	s	
v	velocity	ms^{-1}	
α	centripetal acceleration	ms^{-2}	
λ	de Broglie wavelength (λ=h/p)	m	
λ	wavelength	m	
ω	angular velocity	rad s^{-1}	
I	current	A	
P	power	W	
Q	charge	C	▲ *Electricity*
R	resistance	Ω	
t	time	s	
V (blue)	voltage	V	
a	acceleration	ms^{-2}	
c	speed of light	ms^{-1}	
E	energy	J	▲ *Iconic*
F	force	N	
m	mass	kg	
A (yellow)	adjacent	m	
C	cos θ	deg or rad	
H	hypotenuse	m	▲ *Trigonometry*
O	opposite	m	
S	sin θ	deg or rad	
T	tan θ	deg or rad	
|v|	speed (magnitude of velocity)	ms^{-1}	
a	acceleration	ms^{-2}	
A (red)	area	m^2	
d	distance	m	
F	force	N	
p	momentum	kg ms^{-1} or Ns	
P	power	W	▲ *Mechanics*
t	time	s	
v	velocity	ms^{-1}	
V (red)	volume	m^3	
W	work	J	
Γ	torque (moment)	Nm	
ρ	density	kg m^{-3}	
σ	tensile stress (pressure)	Pa	

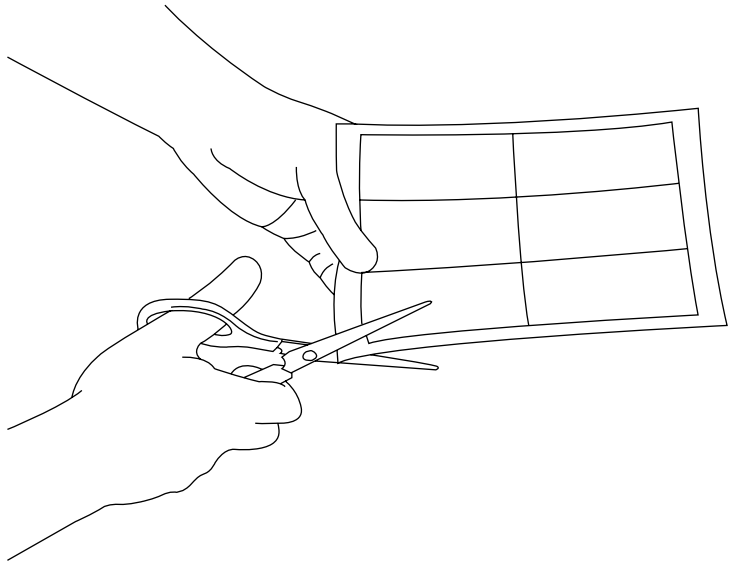
5.

Cutting

"Creativity is intelligence having fun".

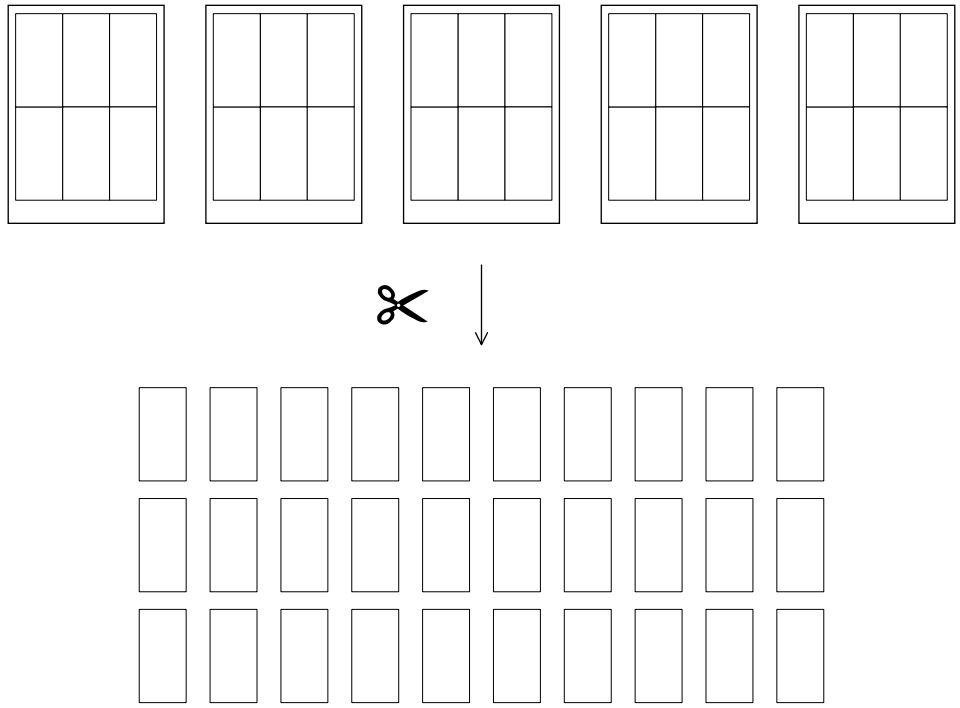
~ Albert Einstein

Cut out each piece along the **solid** black lines, using a pair of scissors. There are 6 pieces on each sheet, 5 sheets, 30 pieces in total.



ICO is made from paper thin enough for folding but thick enough for overall structural strength.

The dotted black lines on each piece are for folding. They are offset slightly to allow for the paper thickness.



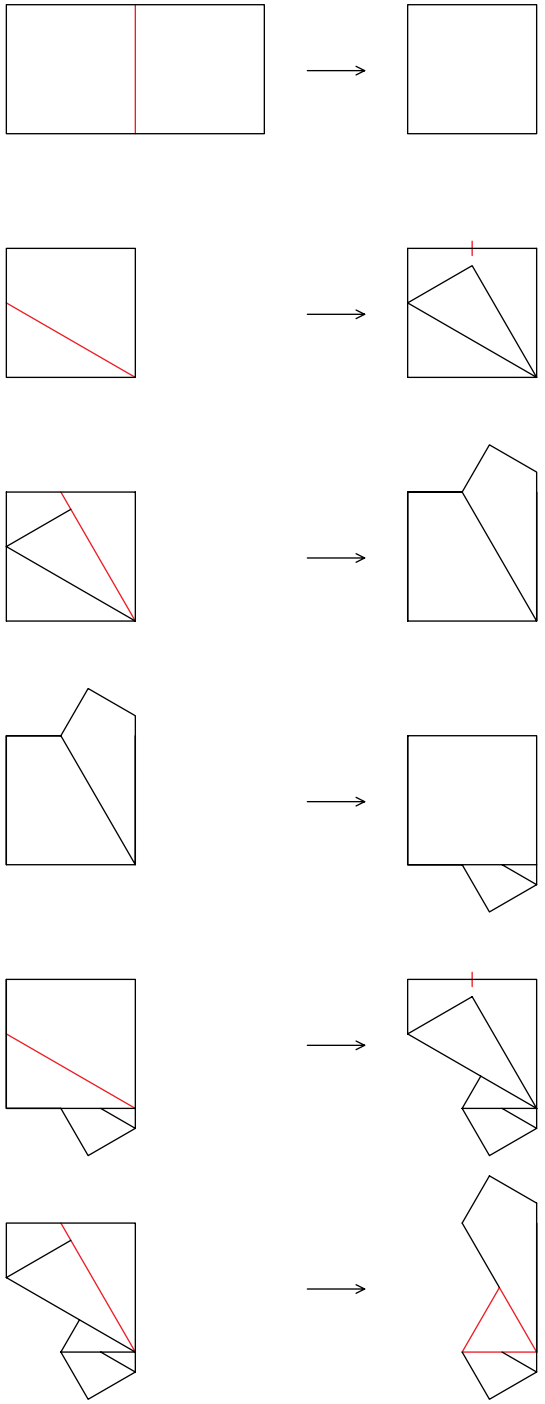
6.

Folding

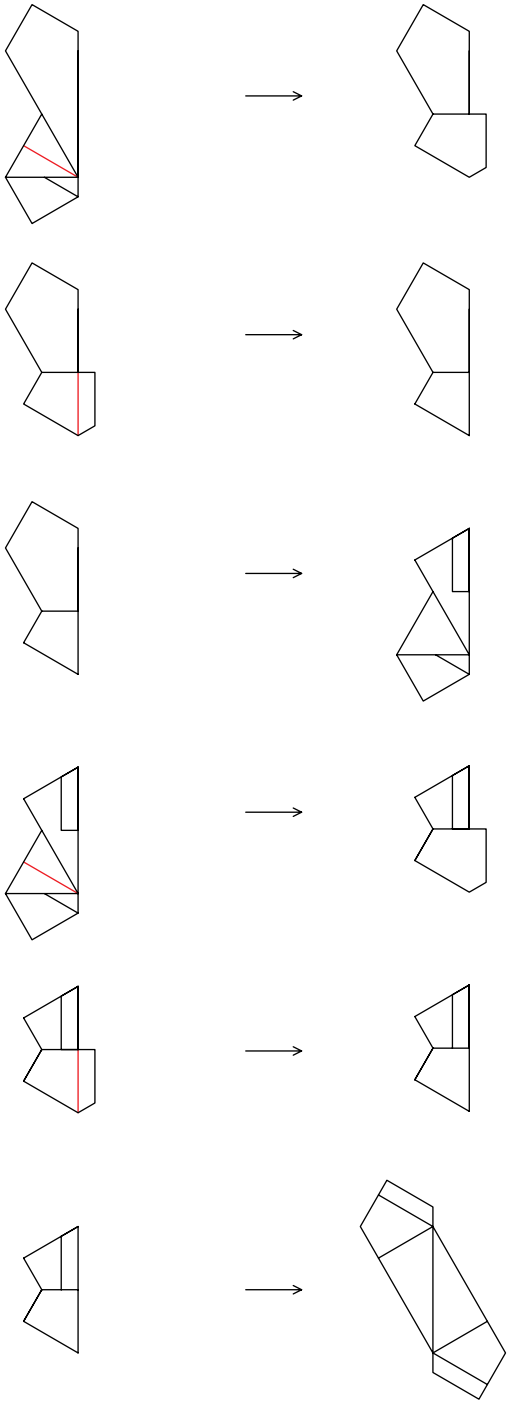
"My origami creations, in accordance with the laws of nature, require the use of geometry, science, and physics".

~ Akira Yoshizawa

Here is a summary of the folding steps...



...for each origami piece.



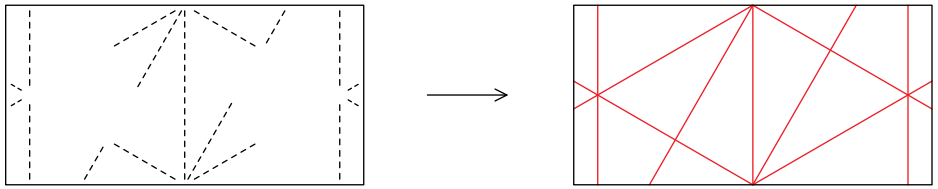
1.

Folds will be made in each of 30 separate paper pieces. Score-lines are provided for guidance.

~ These score-lines are broken in places and do not run to the edges, this is intentional and serves to improve the aesthetic finish of the final model.

~ The folds you make, however, will be unbroken and will continue to the edges.

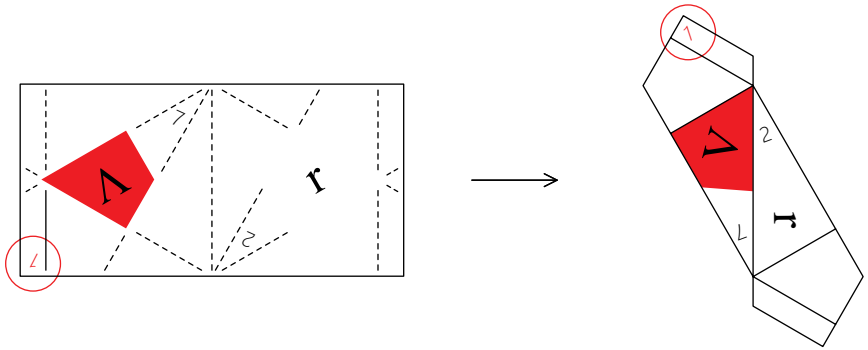
~ The score-lines are offset slightly to allow for the thickness of the paper.



2.

It is important that each piece is assembled in numerical order.

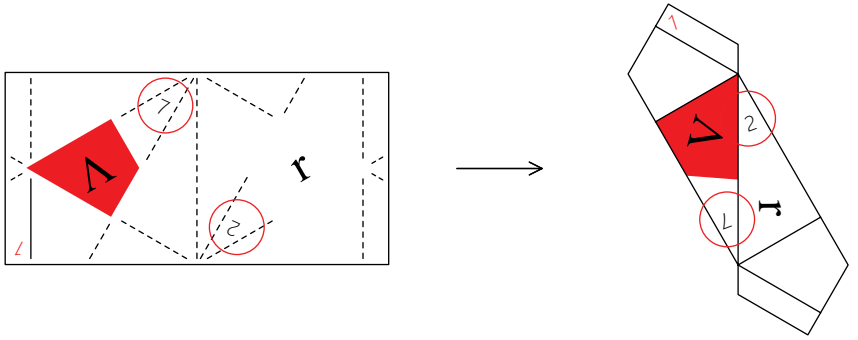
~ The piece number is shown in red on the tab at one end.



3.

Other numbers (shown in black) appear elsewhere on the pieces.

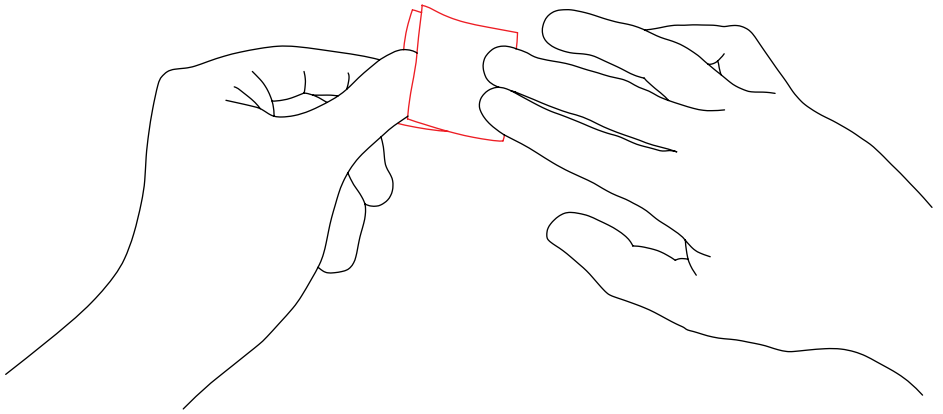
~ These will be used during assembly as shoulder locators for joining pieces together.



4.

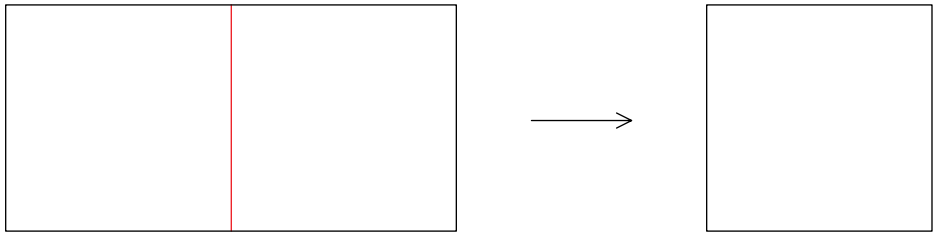
Use clean, dry hands when folding and assembling to avoid damaging the pieces.

~ Ensure all folds are precise and tightly pressed in order to achieve clean, sharp edges.



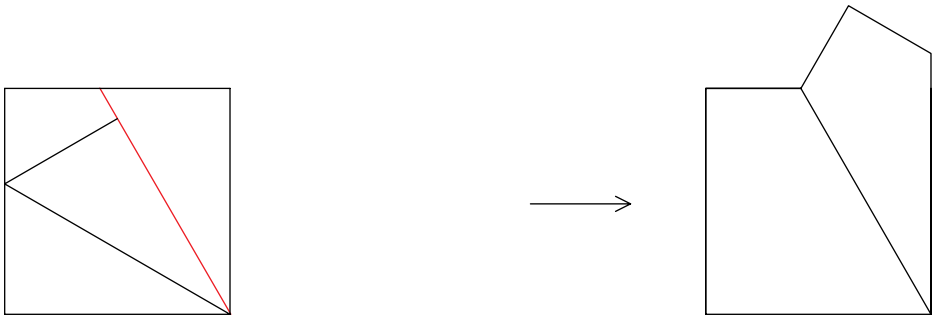
5. Fold in half.

~ Firstly, fold so that the symbols are facing outward, and then back the other way, so they face inward.



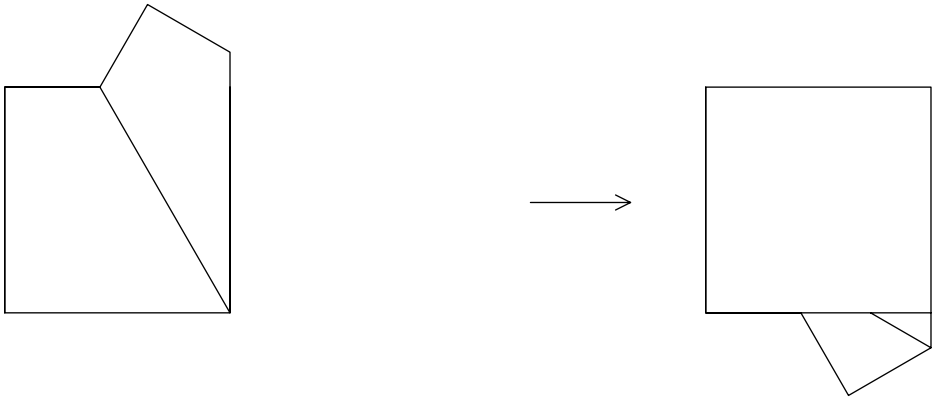
6. With the symbols facing inward, fold the bottom-left corner towards the centre, so it lines up with the middle.

7. Fold the segment in half, so that the edges line up on the right.



8. Flip the piece over.

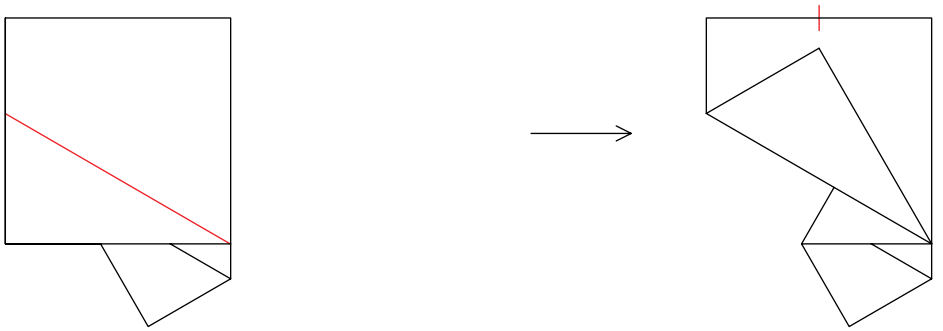
~ You can now repeat the previous two steps as follows...



9.

First repeat step 6, folding the bottom-left corner towards the centre.

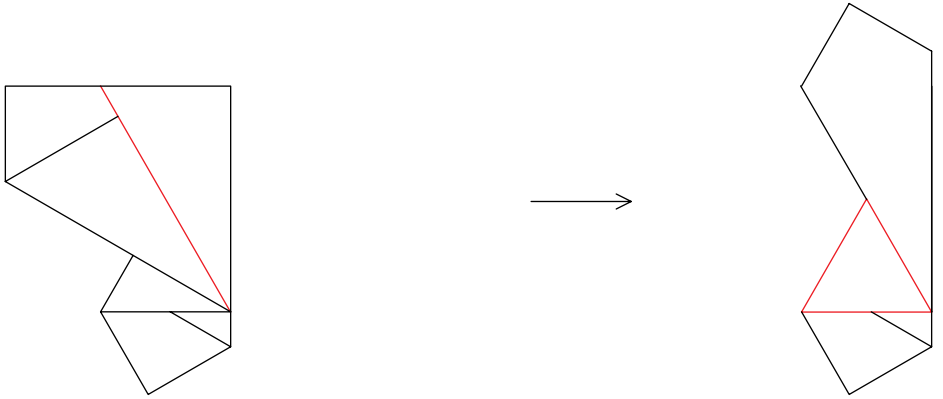
~ Remember to apply pressure across each fold maintaining crisp, sharp edges.



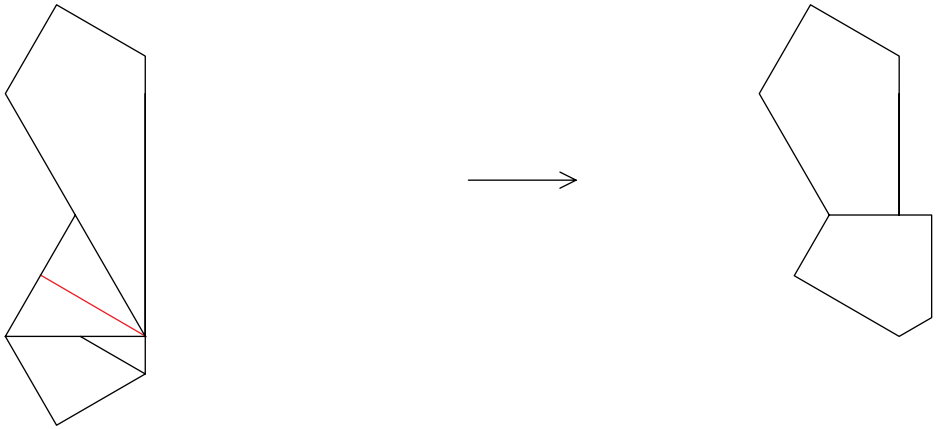
10.

Now repeat step 7, folding the segment in half, so that the edge lines up on the right.

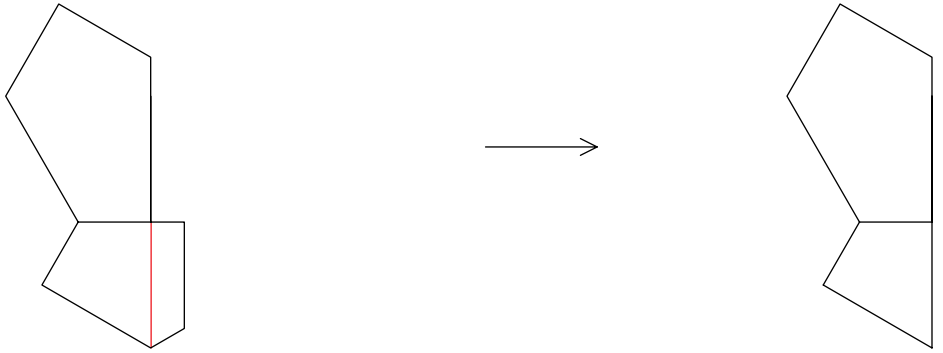
~ The piece should become symmetrical, with an equilateral triangle shape as shown in red.



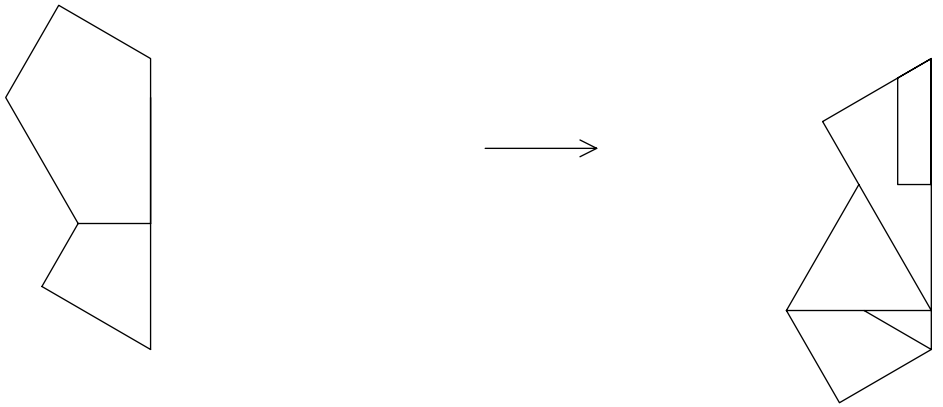
11. Fold the equilateral triangle shape in half.



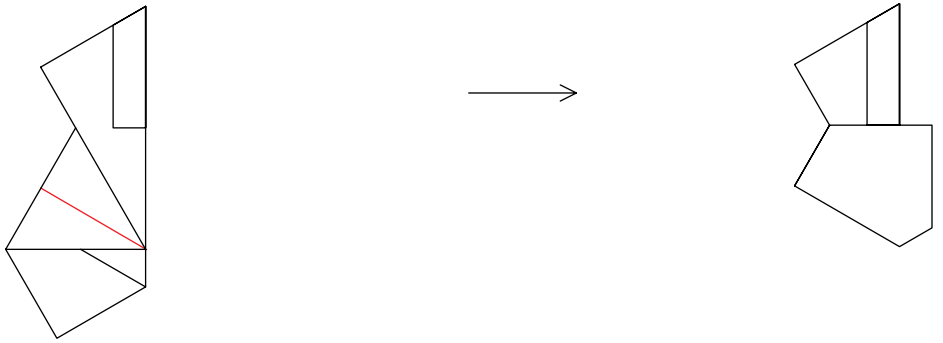
12. Fold the small tab around the back.



13. Flip to repeat the previous two steps.



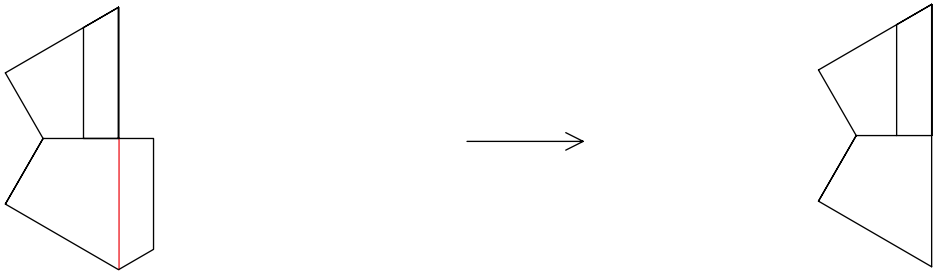
14. Repeat step 11, folding the equilateral triangle in half.



15.

Repeat step 12, folding the tab around the back.

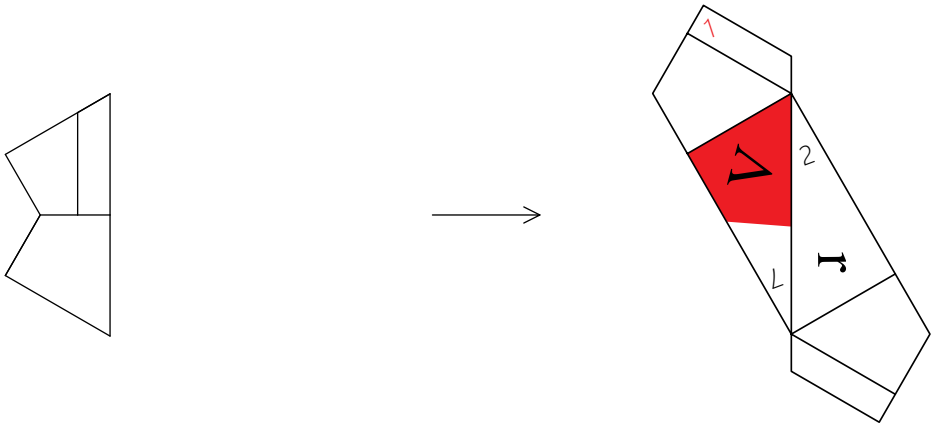
~ Done!



16.

Partially un-wrap the piece so that the symbols are shown on the outside. Repeat the folding process for all 30 pieces.

~ Refer to the beginning of this chapter for a summary of the pictograms.



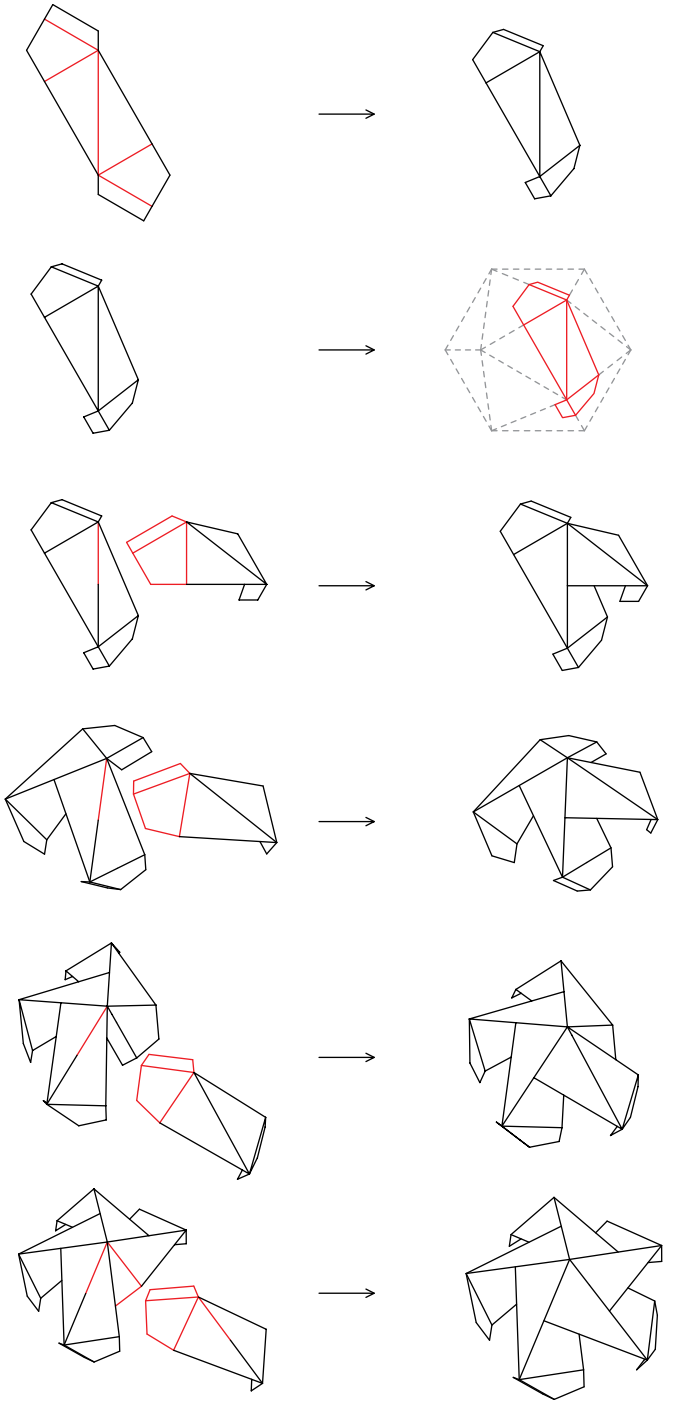
7.

Assembly

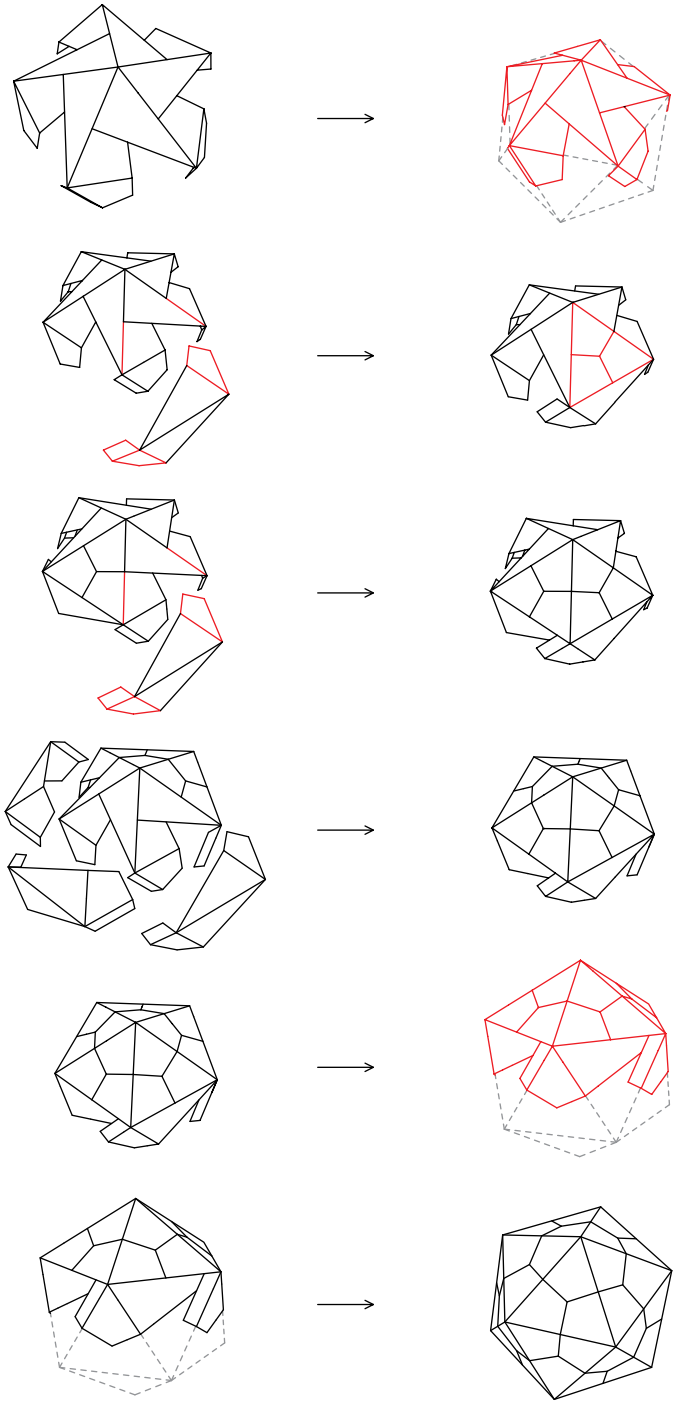
"The connections, the connections, the connections!"

~ Charles Eames

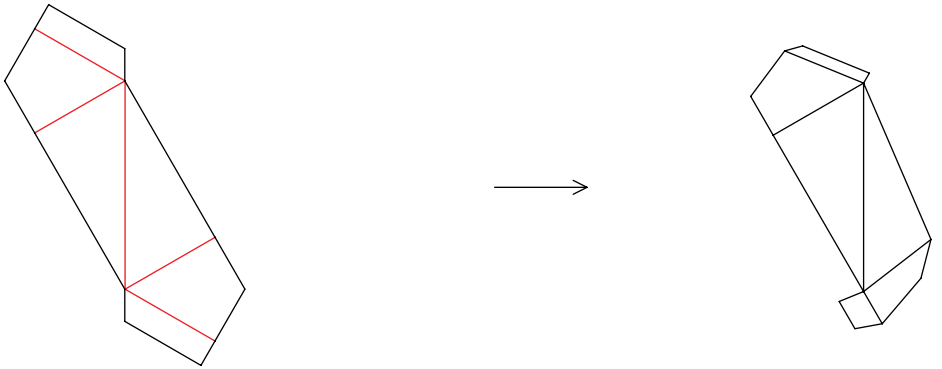
Here is a summary of the steps for...



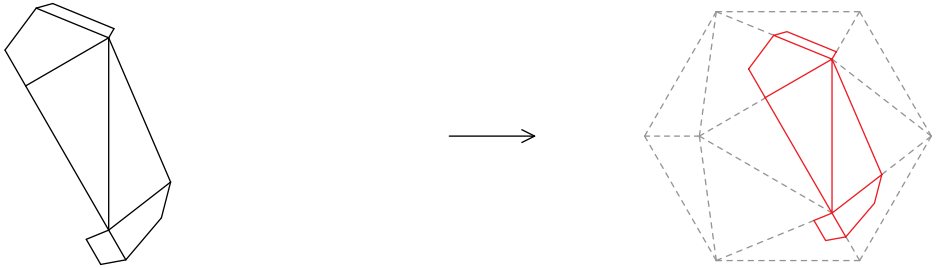
... putting everything together.



1. After folding all 30 pieces, they can be woven together in numerical order to form the final assembly.

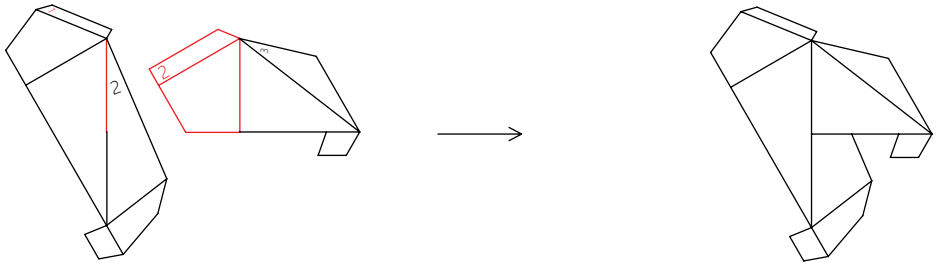


2. Each piece will eventually form a part of two adjacent faces on the die.

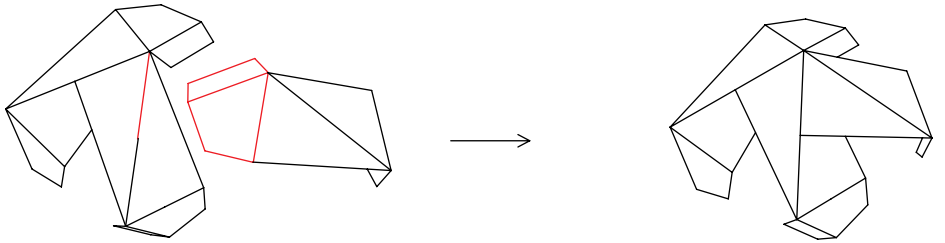


3. Fit the first two pieces together by slotting tab 2 into shoulder 2.

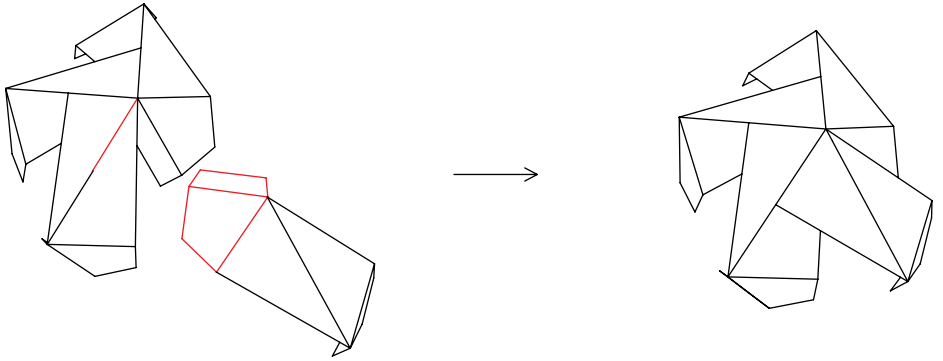
~ Shoulder 2 can be found on piece 1.



4. Find piece 3 and add it to the model at shoulder 3.

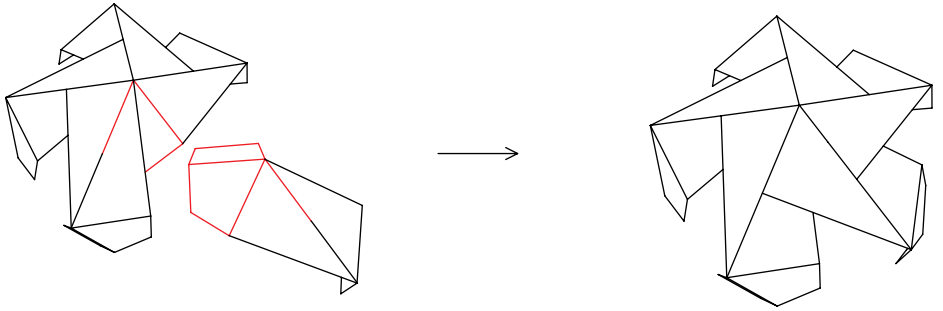


5. Continue with piece 4, building around into a flower shape.

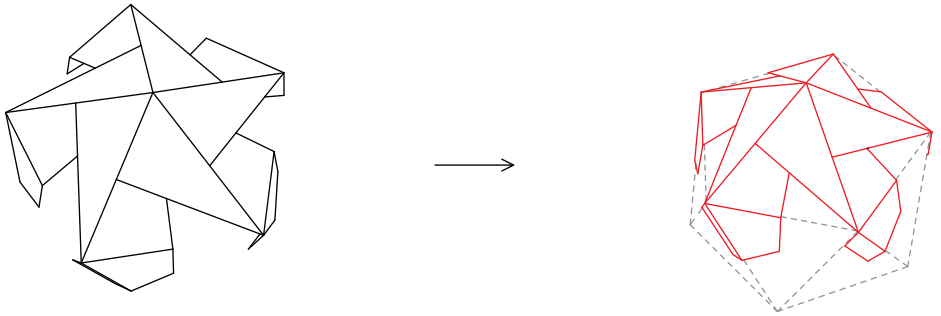


6. Add piece 5 and complete the flower shape by slotting tab 1 from the first piece into shoulder 1 .

~ Shoulder 1 can be found on piece 5.

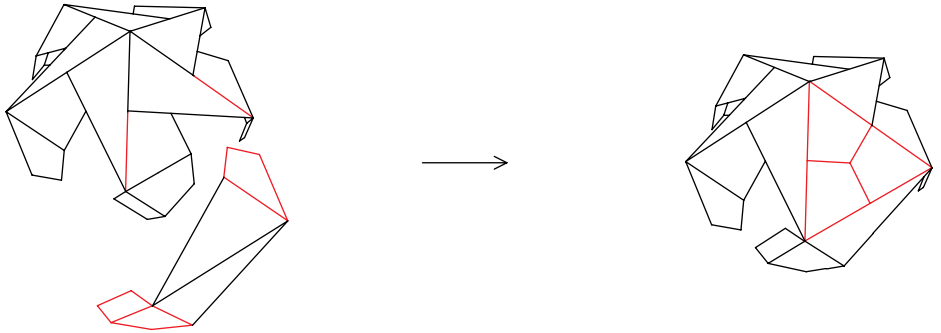


7. These 5 pieces form one vertex (or “point”) on the die.



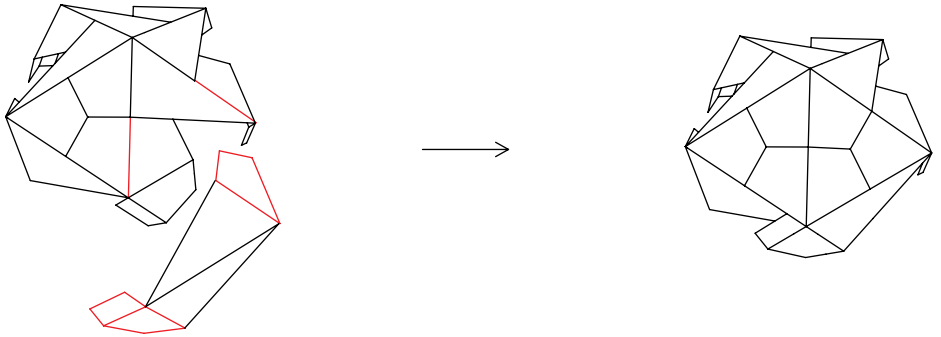
8. Now begin completing each triangular face of the die by adding piece 6.

~ Ensure the other end is also slotted in place, this is not numbered.

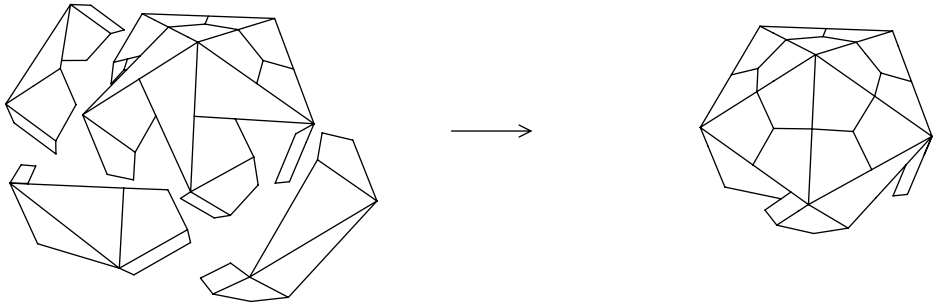


9. Add piece 7 to complete a second triangular face.

~ Each triangular face should be made up of pieces of the same colour.

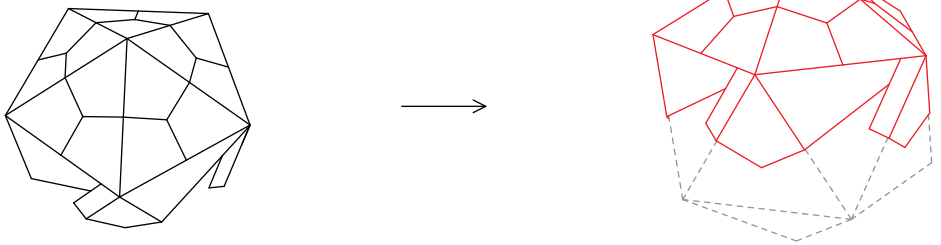


10. Continue around, adding pieces 8, 9 and 10, making sure both ends are slotted into place each time.

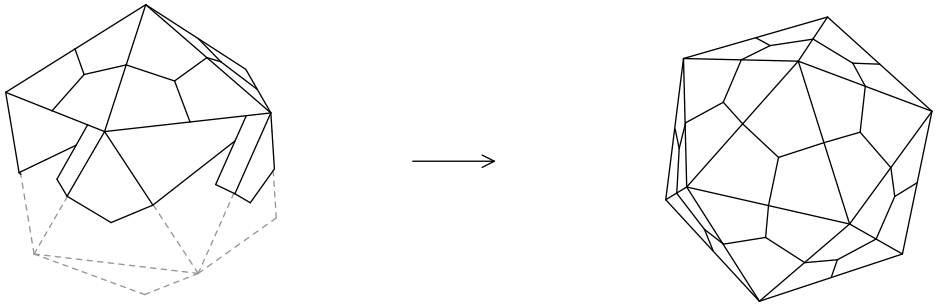


11. The die is starting to take shape. Continue to add pieces in numerical order.

~ Always checking that both ends are slotted into place before adding the next piece.

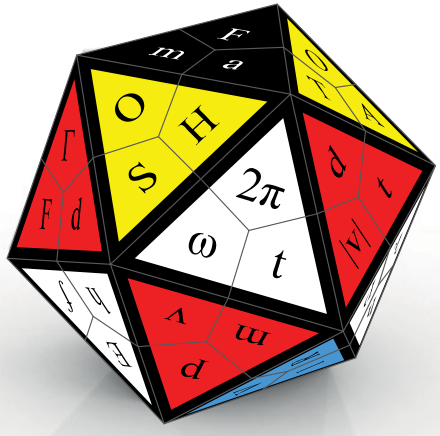


12. When complete, cup the die in your hands and gently massage the paper into place for a snug fit.



And you're ready to roll...

Well done!



Symbol	Quantity	Unit	Category
2π	2π radians = 360 degrees	deg or rad	
c	wavespeed	ms^{-1}	
E	energy	J	
f	frequency	Hz	
h	Planck's constant (6.63×10^{-34})	Js	
p	momentum	kg ms^{-1} or Ns	△ *Waves*
r	radius	m	
t	time	s	
v	velocity	ms^{-1}	
α	centripetal acceleration	ms^{-2}	
λ	de Broglie wavelength (λ=h/p)	m	
λ	wavelength	m	
ω	angular velocity	rad s^{-1}	
I	current	A	
P	power	W	
Q	charge	C	▲ *Electricity*
R	resistance	Ω	
t	time	s	
V (blue)	voltage	V	
a	acceleration	ms^{-2}	
c	speed of light	ms^{-1}	▲ *Iconic*
E	energy	J	
F	force	N	
m	mass	kg	
A (yellow)	adjacent	m	
C	cos θ	deg or rad	
H	hypotenuse	m	▲ *Trigonometry*
O	opposite	m	
S	sin θ	deg or rad	
T	tan θ	deg or rad	
|v|	speed (magnitude of velocity)	ms^{-1}	
a	acceleration	ms^{-2}	
A (red)	area	m^2	
d	distance	m	
F	force	N	
p	momentum	kg ms^{-1} or Ns	
P	power	W	▲ *Mechanics*
t	time	s	
v	velocity	ms^{-1}	
V (red)	volume	m^3	
W	work	J	
Γ	torque (moment)	Nm	
ρ	density	kg m^{-3}	
σ	tensile stress (pressure)	Pa	