

The Egyptian Tangram



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mmaca

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The Egyptian Tangram

The Egyptian Tangram



A square dissection firstly proposed as a tangram in:

Luna-Mota, C. (2019) *"El tangram egipci: diari de disseny"* Nou Biaix, 44

Design process

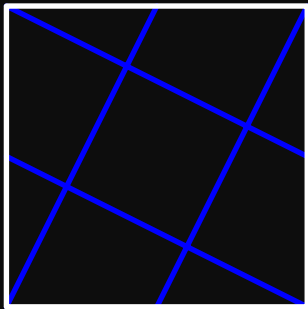
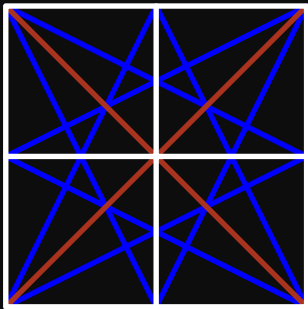
The Egyptian Tangram inspiration comes from the study of two other 5-piece tangrams...



The “Five Triangles” & “Greek-Cross” tangrams

Design process

...and their underlying grids



The “Five Triangles” & “Greek-Cross” underlying grids

Design process

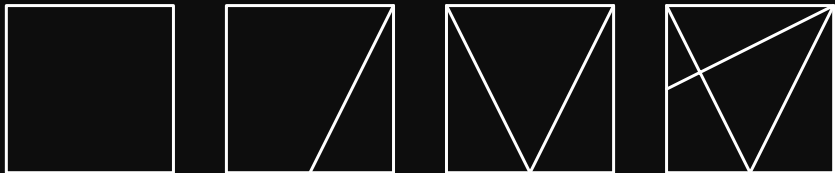


This simple *cut* let us build five interesting figures...



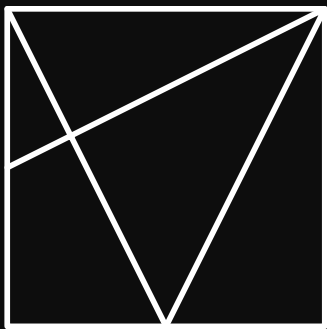
Design process

...so it looked like a good starting point for our heuristic incremental design process:



Take a square and keep adding “the most interesting straight cut” until you have a dissection with five or more pieces.

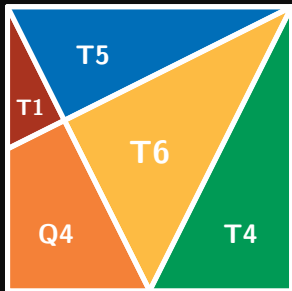
Design process



Straight cuts simplify creating an Egyptian Tangram from a square:

1. Connect the lower midpoint with the upper corners
2. Connect the left midpoint with the top right corner

Promissing features

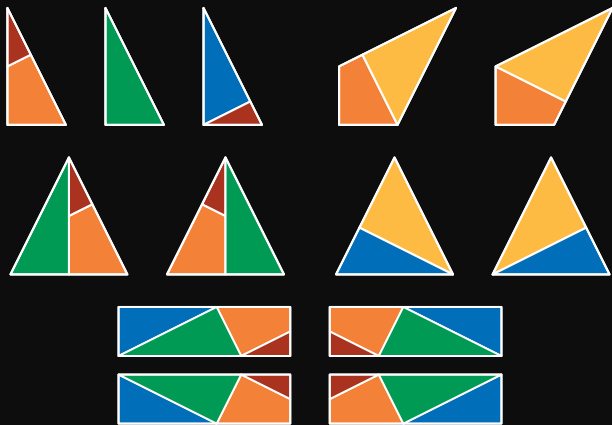


- Just five pieces
- All pieces are different
- All pieces are asymmetric
- Areas are integer and not *too different*
- All sides are multiples of 1 or $\sqrt{5}$
- All angles are linear combinations of 90° and $\alpha = \arctan\left(\frac{1}{2}\right) \approx 26,565^\circ$

| Name | Area | Sides | Angles |
|------|------|-------------------------------|---|
| T1 | 1 | 1, 2, $\sqrt{5}$ | 90° , α , $90^\circ - \alpha$ |
| T4 | 4 | 2, 4, $2\sqrt{5}$ | 90° , α , $90^\circ - \alpha$ |
| T5 | 5 | $\sqrt{5}$, $2\sqrt{5}$, 5 | 90° , α , $90^\circ - \alpha$ |
| T6 | 6 | 3, 4, 5 | 90° , $90^\circ - 2\alpha$, 2α |
| Q4 | 4 | 1, 3, $\sqrt{5}$, $\sqrt{5}$ | 90° , $90^\circ - \alpha$, 90° , $90^\circ + \alpha$ |

Promissing features

Although all pieces are asymmetric and different, they often combine to make symmetric shapes



Promissing features

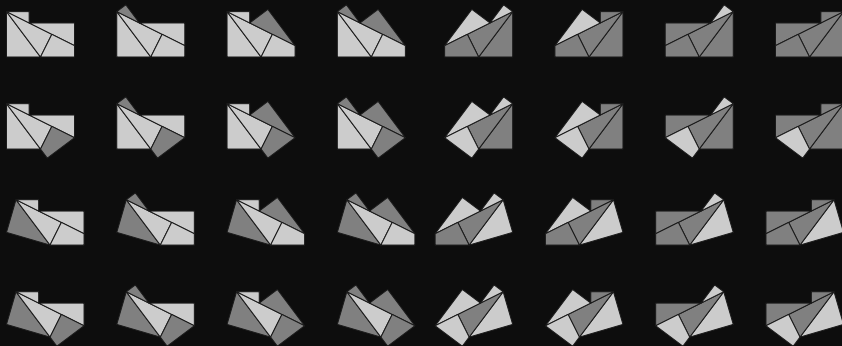
This means that it is rare for an Egyptian Tangram figure to have a unique solution



There are three different solutions for the square and, in all three cases, two corners of the square are built as a sum of acute angles!

Promissing features

The asymmetry of the pieces also implies that each solution belongs to one of these equivalence classes:

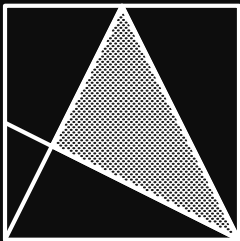


You cannot transform one of these figures into another without flipping a piece

Historical precedents

It turns out that this figure is not new...

Detemple, D. & Harold, S. (1996) *"A Round-Up of Square Problems"*



Problem 3

...but, to the best of our knowledge,
nobody used it before **as a tangram**

Historical precedents

The name is not new either...



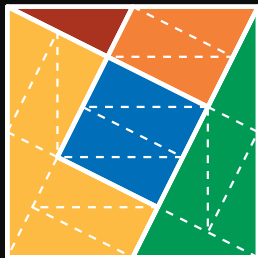
This dissection is often called “Egyptian Puzzle” or “Egyptian Tangram”

...but there is a good reason to consider
our dissection the real “Egyptian Tangram”

(even if it was designed in Catalonia)

Why we called it the *Egyptian* Tangram?

The smallest pieces of the Chinese and Greek-Cross tangrams can be used to build all the other pieces...



...but you cannot do the same with
the Egyptian Tangram because of T6

Why we called it the *Egyptian* Tangram?

Initially, T6 was considered as *the leftover piece* that results from cutting all these $1:2:\sqrt{5}$ triangles from the borders of the square.

But it turned out to be a very well known triangle...



...an **Egyptian** Triangle (3:4:5)
and, hence, the name of this tangram

Puzzles & Activities

Realistic figures

Use all five pieces to make these figures:



Lightning



Sailing ship



Bow tie



Wooden hut



Caltrop



Snowmobile



Candle



Viking hat



Diamond



Moses basket



Erlenmeyer



3D brick



Witch hat



Arrow Sign



Sailboat

Realistic figures

Use all five pieces to make these figures:



Gnome



Handmaid



Mountain range



Fish tail



Teddy bear



Cat



Dromedary



Cow



Snail



Fennec Fox



Penguin



Calf



Sea Turtle



Duck



Crow

Remote control symbols

Use all five pieces to make these symbols:



Rewind



Play/Pause



FFWD



Start



Stop



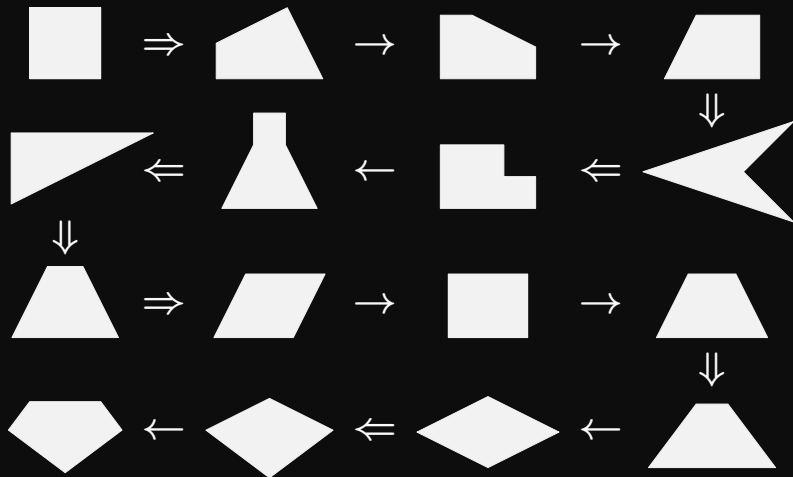
End



Volume

Geometric figures

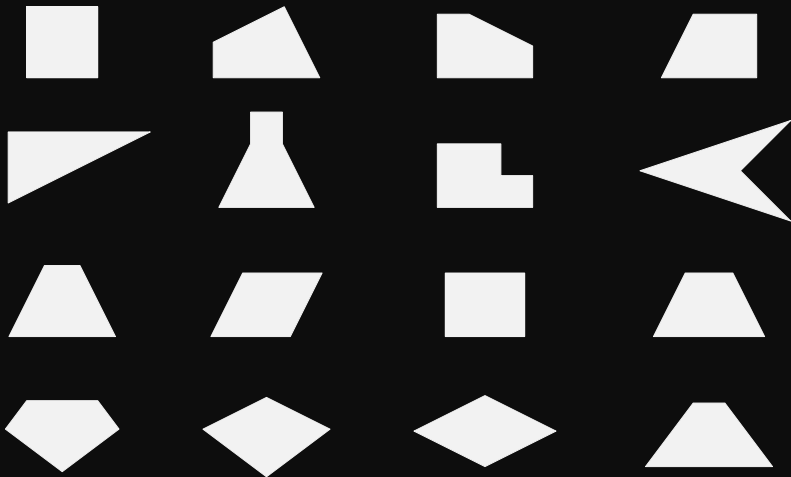
Use all five pieces to make these figures:



Complete the path moving just one or two pieces at a time

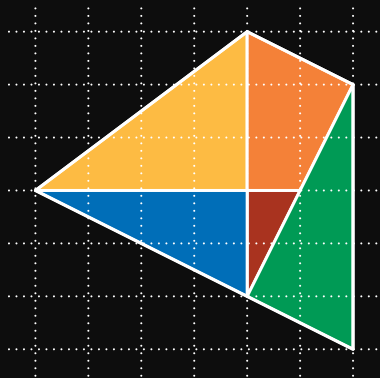
Geometric figures

All of these figures, but one, have multiple solutions:



Could you find which is the only figure with unique solution?

Geometric figures



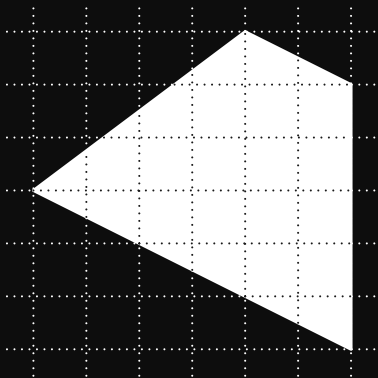
All the figures from the previous page, but one, can be drawn with their vertices lying on this lattice.

Moreover, they can be drawn with the vertices of all 5 pieces lying on the same lattice.

These conditions simplify the task of finding perimeters and areas.

Could you find which is the only figure that requires a finer-grained lattice?

Geometric figures



Pythagorean Theorem:

$$\text{Top} = \sqrt{1^2 + 2^2} = \sqrt{5}$$

$$\text{Left} = \sqrt{3^2 + 4^2} = \sqrt{25} = 5$$

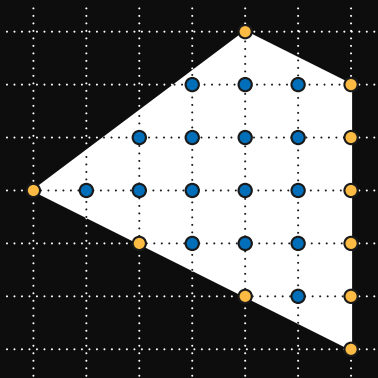
$$\text{Right} = \sqrt{5^2 + 0^2} = \sqrt{25} = 5$$

$$\text{Bottom} = \sqrt{3^2 + 6^2} = \sqrt{45} = 3\sqrt{5}$$

$$\text{Perimeter} = 10 + 4\sqrt{5}$$

Could you use the Pythagorean theorem to compute the perimeter of these figures?

Geometric figures



Pick's Theorem:

lattice points in the interior = 16

lattice points on the boundary = 10

$$\begin{aligned}\text{Area} &= \text{interior} + \frac{\text{boundary}}{2} - 1 \\ &= 16 + \frac{10}{2} - 1 = 20\end{aligned}$$

Could you use Pick's theorem
to compute the area of these figures?

Triangles

Could you prove that there are just 10 triangles you can make with one or more pieces of the Egyptian Tangram?

How many solutions could you find for each figure?

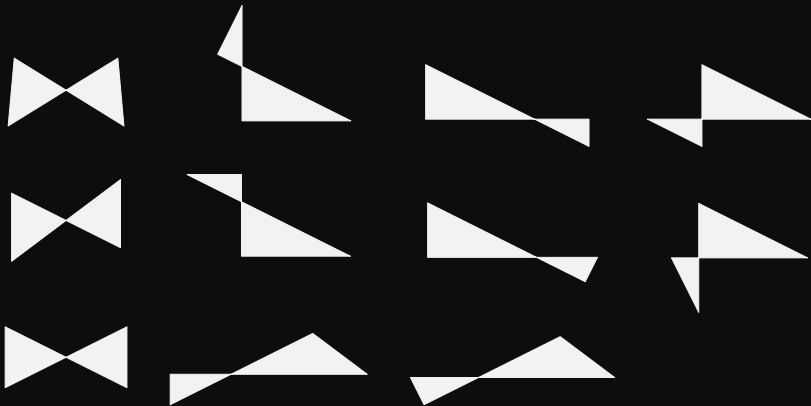


Top row areas: 20, 16, 9, 5, 4, 1

Bottom row areas: 15, 10, 10, 6

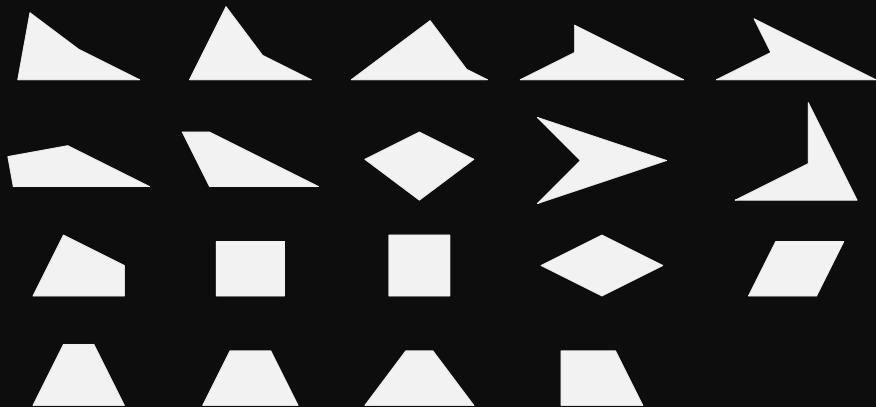
Quadrilaterals

Could you prove that there are just 11 **complex quadrilaterals** you can make with all five pieces of the Egyptian Tangram?



Quadrilaterals

Simple quadrilaterals: Not self-intersecting

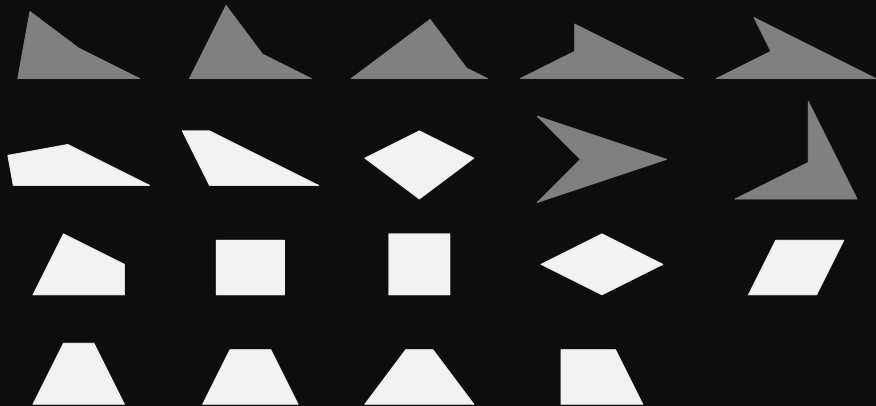


All simple quadrilaterals tile the plane!

$$\alpha + \beta + \gamma + \delta = 2\pi$$

Quadrilaterals

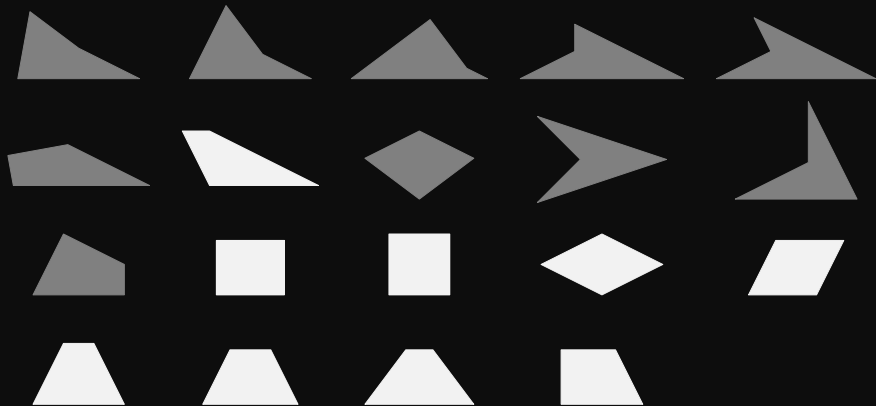
Convex quadrilaterals: All internal angles are smaller than π



Law of Cosines: $p^2q^2 = a^2c^2 + b^2d^2 - 2abcd \cos(\alpha + \gamma)$

Quadrilaterals

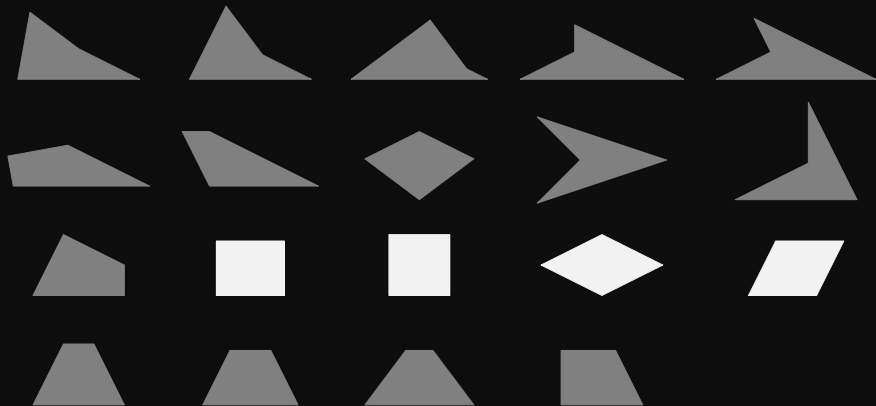
Trapeziums (UK) / Trapezoids (US): One pair of parallel sides



Trapezium/Trapezoid \Leftrightarrow Diagonals cut each other in the same ratio

Quadrilaterals

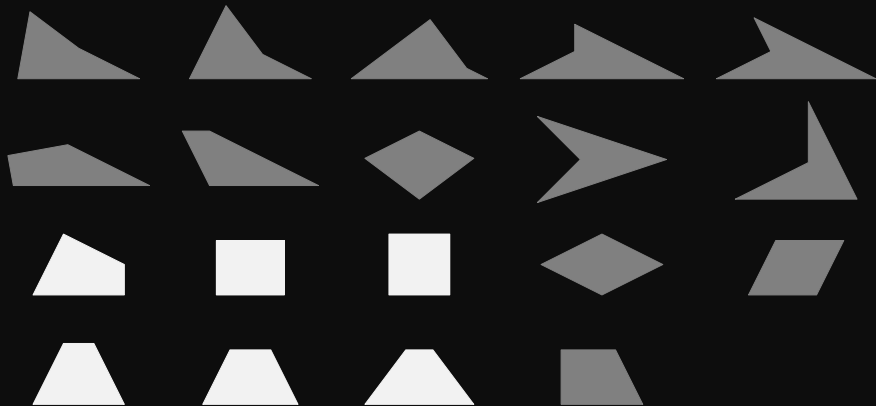
Parallelograms: Two pairs of parallel sides



$$\text{Parallelogram} \Leftrightarrow \text{Diagonals bisect each other} \Leftrightarrow a^2 + b^2 + c^2 + d^2 = p^2 + q^2$$

Quadrilaterals

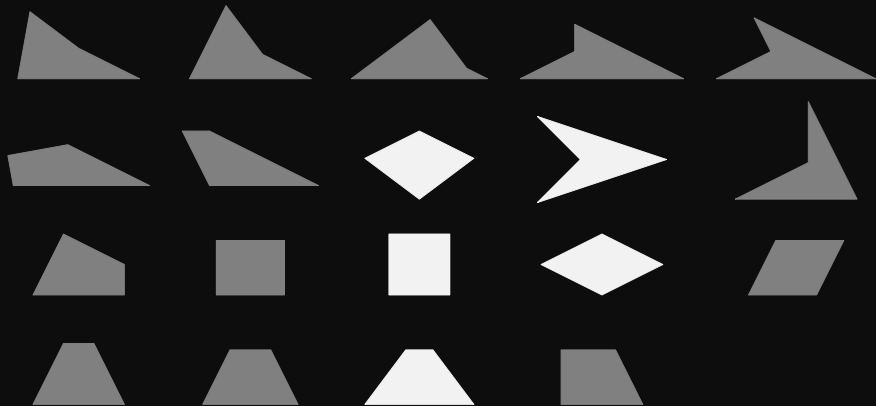
Cyclic quadrilaterals: All vertices lie on a circle



$$\text{Cyclic} \Leftrightarrow \alpha + \gamma = \beta + \delta$$

Quadrilaterals

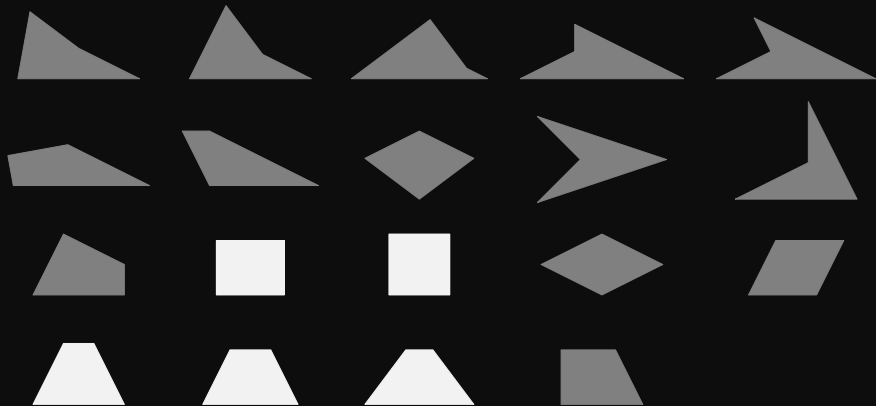
Tangential quadrilaterals: All sides are tangent to a circle



$$\text{Tangential} \iff a + c = b + d$$

Quadrilaterals

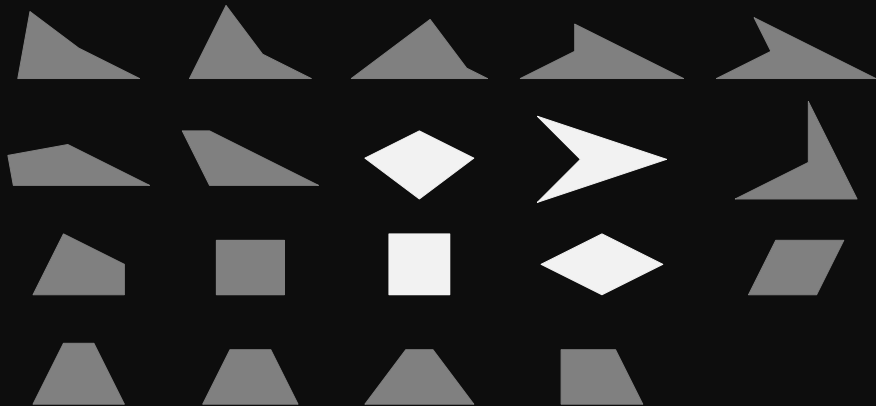
Isosceles Trapezoids: Two pairs of adjacent angles are equal



Isosceles trapezoids \Leftrightarrow Cyclic quadrilaterals with equal diagonals

Quadrilaterals

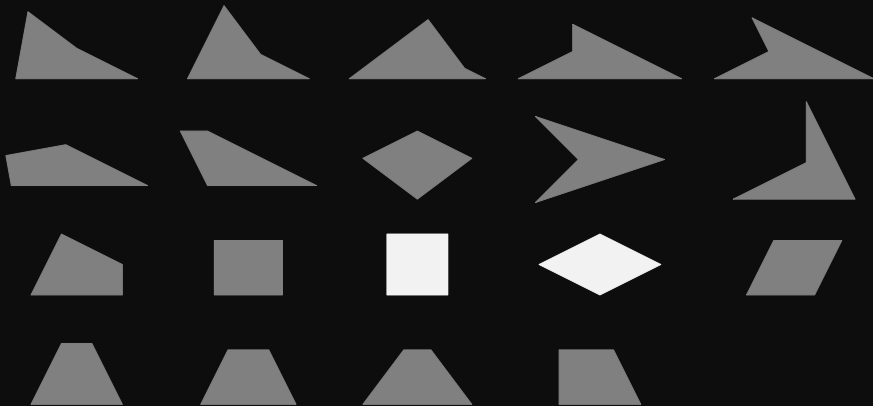
Darts & Kites: Two pairs of adjacent sides are equal



Darts/Kites \Leftrightarrow Tangential quadrilaterals with perpendicular diagonals

Quadrilaterals

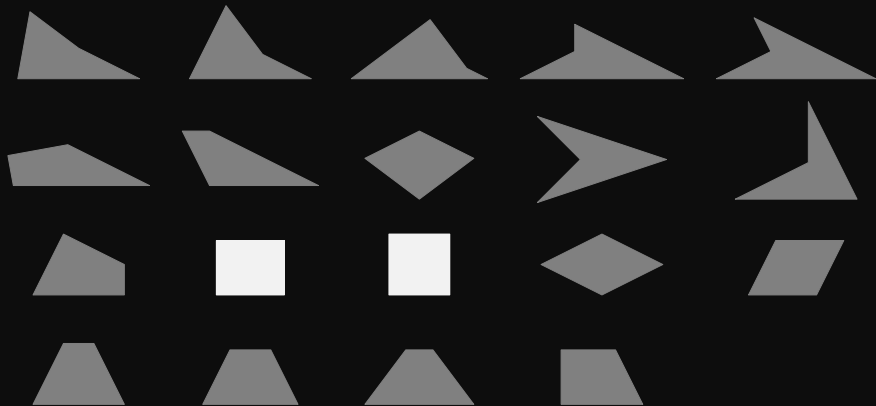
Rhombi: All sides are equal



Rhombi \Leftrightarrow Parallelograms with perpendicular diagonals

Quadrilaterals

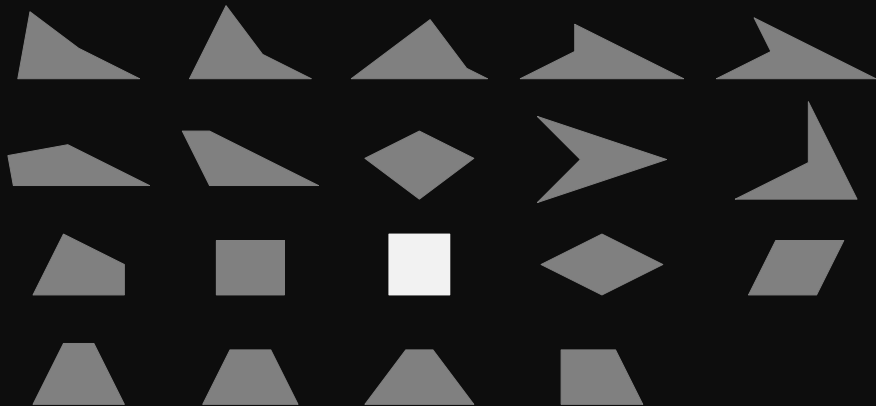
Rectangles: All angles are equal



Rectangles \Leftrightarrow Parallelograms with equal diagonals

Quadrilaterals

Squares: Regular quadrilaterals



Among all quadrilaterals, squares maximize the *Area:Perimeter* ratio

The three solutions of the square

Could you prove that there are just three different solutions for the square?

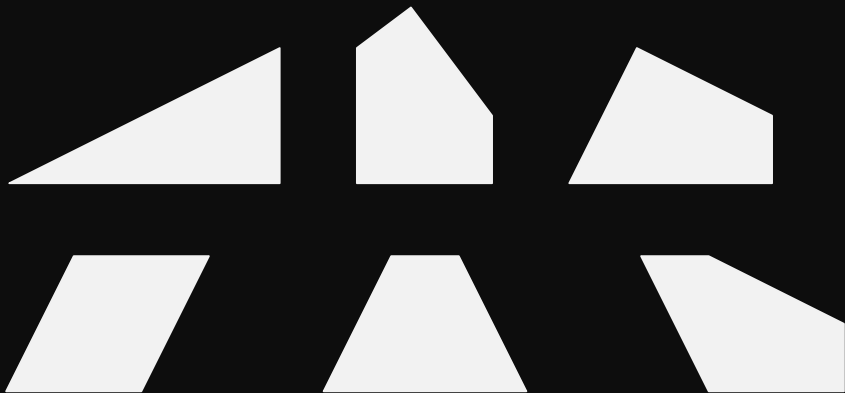


What's the area of this square? What's its perimeter?

How many times do you find $\sqrt{5}$ in the Egyptian Tangram pieces?

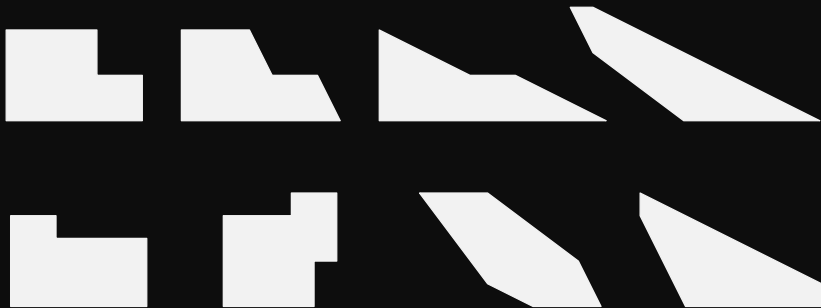
Figures with seven solutions

Could you find seven different solutions for each of these figures?



Figures with unique solutions

Could you prove that there is only one solution for each of these figures?



Missing triangle paradox

Both figures use all 5 pieces...



Where is the missing triangle?

Missing triangle paradox

Both figures use all 5 pieces...



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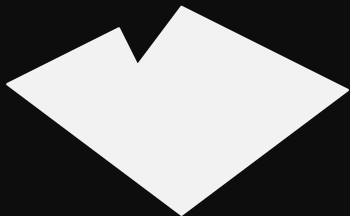
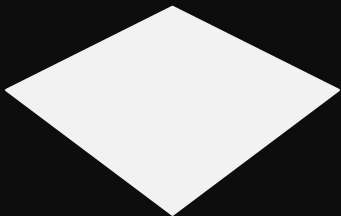
Both figures use all 5 pieces...



Where is the missing triangle?

Missing triangle paradox

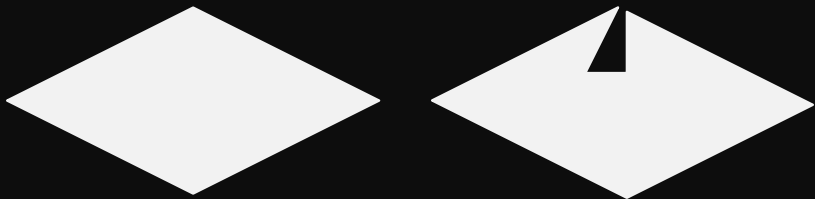
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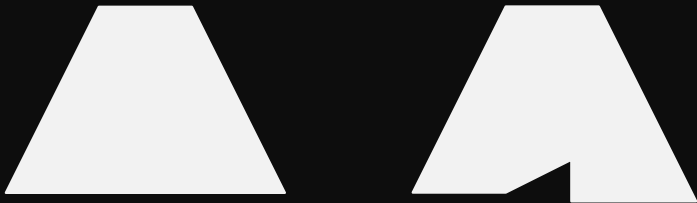
Both figures use all 5 pieces...



Where is the missing triangle?

Missing triangle paradox

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Both figures use all 5 pieces...



Where is the missing triangle?

Missing triangle paradox

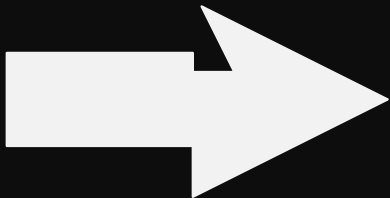
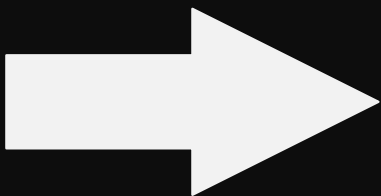
Both figures use all 5 pieces...



Where is the missing triangle?

Missing triangle paradox

Both figures use all 5 pieces...



Where is the missing triangle?

Missing rectangle paradox

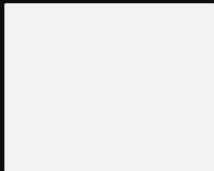
Both figures use all 5 pieces...



Where is the missing rectangle?

Missing rectangle paradox

Both figures use all 5 pieces...



Where is the missing rectangle?

Missing rectangle paradox

Both figures use all 5 pieces...



Where is the missing rectangle?

Missing square paradox

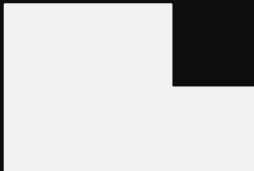
Both figures use all 5 pieces...



Where is the missing square?

Missing square paradox

Both figures use all 5 pieces...



Where is the missing square?

Missing square paradox

Both figures use all 5 pieces...



Where is the missing square?

Sum of similar figures

Use all 5 pieces to make the single figure in the LHS,
then use them to make the two figures on the RHS



In both equations, the figures are similar and areas are in ratio 5 : 4 : 1

Golden Rectangles

The dashed rectangle proportions are $1:\varphi$



where $\varphi = \frac{1+\sqrt{5}}{2}$ is the golden ratio

Golden Rectangles

The dashed rectangle proportions are $1:\varphi$



where $\varphi = \frac{1+\sqrt{5}}{2}$ is the golden ratio

Golden Rectangles

The dashed rectangle proportions are $1:\varphi$



where $\varphi = \frac{1+\sqrt{5}}{2}$ is the golden ratio

Golden Rectangles

The dashed rectangles proportions are $1:\varphi$



where $\varphi = \frac{1+\sqrt{5}}{2}$ is the golden ratio

Golden Rectangles

There are 4 golden rectangles hidden in this figure



Could you spot them?

Golden Rectangles

There are 4 golden rectangles hidden in this figure



Could you spot them?

Golden Rectangles

There are 4 golden rectangles hidden in this figure



Could you spot them?

Golden Rectangles

There are 5 golden rectangles hidden in this figure



Could you spot them?

Golden Rectangles

You can find golden rectangles of 14 different types

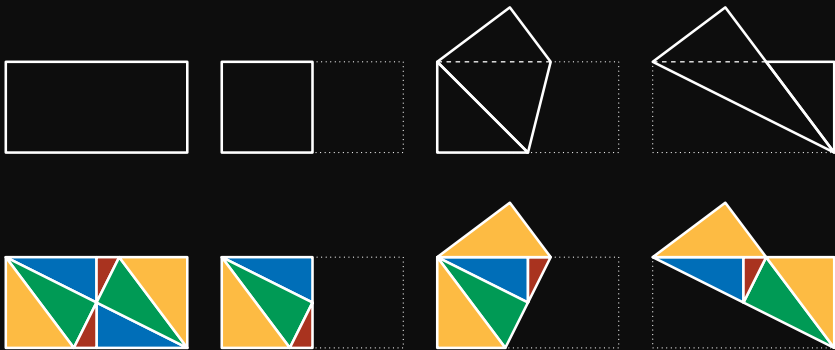
| Type | Proportions | Type | Proportions |
|----------|---------------------------------|----------|--------------------------------|
| A | $3 - \sqrt{5} : 2\sqrt{5} - 4$ | H | $2\sqrt{5} : 5 - \sqrt{5}$ |
| B | $\sqrt{5} - 1 : 3 - \sqrt{5}$ | I | $3 + \sqrt{5} : 1 + \sqrt{5}$ |
| C | $2 : \sqrt{5} - 1$ | J | $6 : 3\sqrt{5} - 3$ |
| D | $2\sqrt{5} - 2 : 6 - 2\sqrt{5}$ | K | $2 + 2\sqrt{5} : 4$ |
| E | $5 - \sqrt{5} : 3\sqrt{5} - 5$ | L | $5 + \sqrt{5} : 2\sqrt{5}$ |
| F | $1 + \sqrt{5} : 2$ | M | $1 + 3\sqrt{5} : 7 - \sqrt{5}$ |
| G | $4 : 2\sqrt{5} - 2$ | N | $4 + 2\sqrt{5} : 3 + \sqrt{5}$ |

Could you build an example of each type?

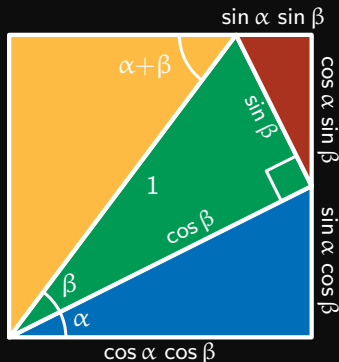
Simplified Tangrams

The Egyptian Four-Triangle-Tangram

T1, T4, T5 & T6 appear naturally
when you fold a 2:1 rectangle



The Egyptian Four-Triangle-Tangram

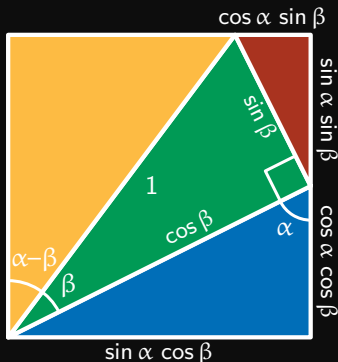


You can use this figure to prove these identities:

$$\sin(\alpha + \beta) = \sin \alpha \cos \beta + \cos \alpha \sin \beta$$

$$\cos(\alpha + \beta) = \cos \alpha \cos \beta - \sin \alpha \sin \beta$$

The Egyptian Four-Triangle-Tangram

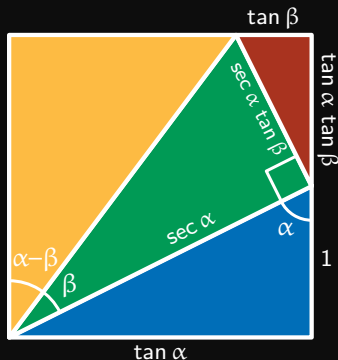
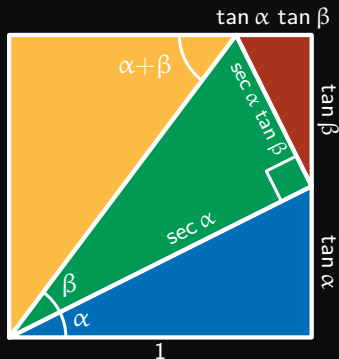


You can use this figure to prove these identities:

$$\sin(\alpha - \beta) = \sin \alpha \cos \beta - \cos \alpha \sin \beta$$

$$\cos(\alpha - \beta) = \cos \alpha \cos \beta + \sin \alpha \sin \beta$$

The Egyptian Four-Triangle-Tangram



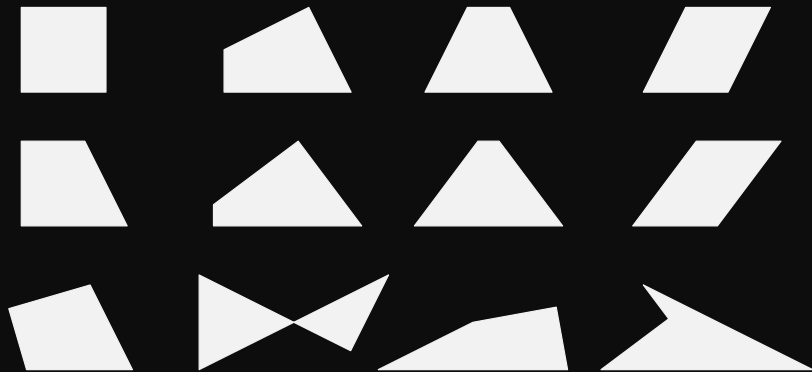
You can use these figures to prove these identities:

$$\tan(\alpha + \beta) = \frac{\tan \alpha + \tan \beta}{1 - \tan \alpha \tan \beta}$$

$$\tan(\alpha - \beta) = \frac{\tan \alpha - \tan \beta}{1 + \tan \alpha \tan \beta}$$

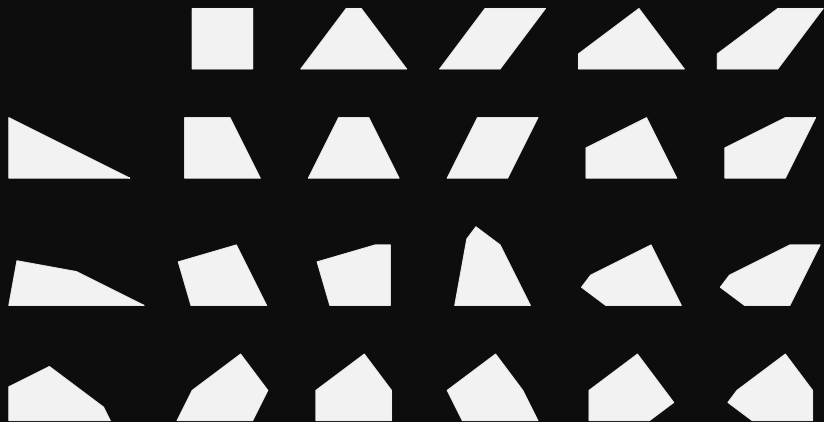
The Egyptian Four-Triangle-Tangram

You can make 12 quadrilaterals using T1, T4, T5 & T6



The Egyptian Four-Triangle-Tangram

You can make 23 convex figures using T1, T4, T5 & T6



The Egyptian Four-Triangle-Tangram

You can find golden rectangles of 7 different types using just T1, T4, T5 & T6

| Type | Proportions |
|----------|--------------------------------|
| A | $3 - \sqrt{5} : 2\sqrt{5} - 4$ |
| C | $2 : \sqrt{5} - 1$ |
| F | $1 + \sqrt{5} : 2$ |
| G | $4 : 2\sqrt{5} - 2$ |
| H | $2\sqrt{5} : 5 - \sqrt{5}$ |
| K | $2 + 2\sqrt{5} : 4$ |
| L | $5 + \sqrt{5} : 2\sqrt{5}$ |

Could you build an example of each type?

The Egyptian Three–Triangle–Tangram

Given any right triangle with sides: $a \leq b \leq c$



you can draw three similar triangles: (a, b, c) , (x, h, a) & (h, y, b)

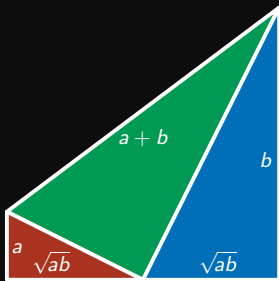
and use them to prove the **Altitude Theorem**: $h^2 = x \cdot y$

and the **Leg Theorems**: $a^2 = x \cdot c$ & $b^2 = y \cdot c$

(T1, T4 & T5 verify this relationship for: $a = \sqrt{5}$, $b = 2\sqrt{5}$ & $c = 5$)

The Egyptian Three-Triangle-Tangram

Since $\frac{a}{\sqrt{ab}} = \frac{\sqrt{ab}}{b}$, these three right triangles are similar...



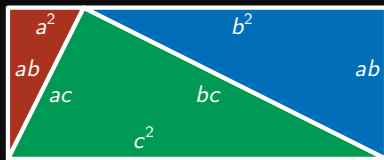
...and you can use this figure to prove the **AM-GM Inequality**:

$$\frac{a + b}{2} \geq \sqrt{ab}$$

(T1, T4 & T5 verify this relationship for: $a = 1$ & $b = 4$)

The Egyptian Three–Triangle–Tangram

Given any right triangle with sides: $a \leq b \leq c$



you can make a rectangle with three similar triangles:

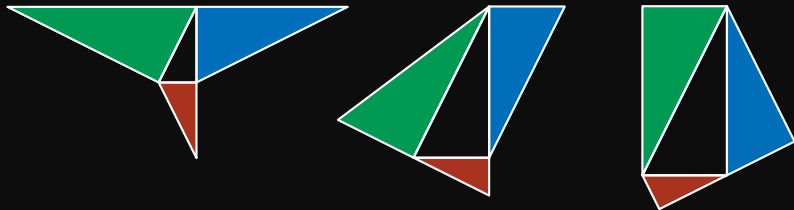
$$(a^2, ab, ac), (ab, b^2, bc) \text{ \& } (ac, bc, c^2)$$

and compare the top ($a^2 + b^2$) and the bottom (c^2) sides of the rectangle to prove the **Pythagorean Theorem**

(T1, T4 & T5 verify this relationship for: $a = 1$, $b = 2$ & $c = \sqrt{5}$)

The Egyptian Three-Triangle-Tangram

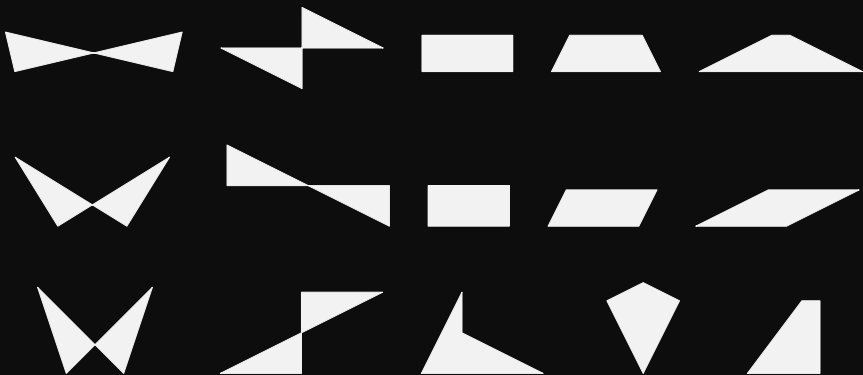
Since $\text{area}(T1) + \text{area}(T4) = \text{area}(T5) \dots$



...you can verify 3 cases of the **Pythagorean Theorem**
(and these particular cases turn out to be the T1, T4 & T5 right triangles!)

The Egyptian Three-Triangle-Tangram

You can make 15 quadrilaterals using just T1, T4 & T5



See also: Brügger, G. (1984) *"Three-Triangle-Tangram"*, Bit, 24

The Egyptian Three-Triangle-Tangram

You can make 11 convex figures using just T1, T4 & T5



See also: Brügger, G. (1984) *"Three-Triangle-Tangram"*, Bit, 24

The Egyptian Three-Triangle-Tangram

You can find golden rectangles of 5 different types using just T1, T4 & T5

| Type | Proportions |
|------|--------------------------|
| C | $2 : \sqrt{5}-1$ |
| F | $1+\sqrt{5} : 2$ |
| G | $4 : 2\sqrt{5}-2$ |
| H | $2\sqrt{5} : 5-\sqrt{5}$ |
| K | $2+2\sqrt{5} : 4$ |

Could you build an example of each type?

Mathematical Properties

φ and $\sqrt{5}$ are irrational



This is a golden rectangle, which means that $\frac{\text{base}}{\text{height}} = \varphi$, the golden ratio.

If we remove a square, what remains is also a golden rectangle: $\frac{\text{height}}{\text{base}-\text{height}} = \varphi$

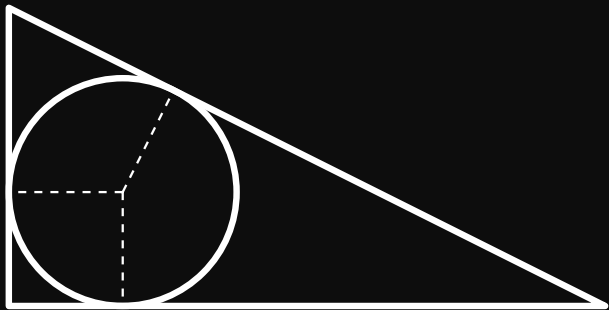
If we assume that $\varphi = \frac{b}{h}$, with b and h coprime integers, then $\varphi = \frac{h}{b-h}$ is an equivalent fraction, with a smaller integer numerator and a smaller integer denominator, which is absurd. Therefore, our initial assumption must be false.

And, since $\varphi = \frac{1+\sqrt{5}}{2}$ is irrational, $2\varphi - 1 = \sqrt{5}$ must be irrational too.



The $1:2:\sqrt{5}$ incenter

If the inradius of a $1:2:\sqrt{5}$ triangle is 1...



...its shorter leg measures $\varphi + 1 = \varphi^2 = \frac{3+\sqrt{5}}{2}$

The 3:4:5 incenter

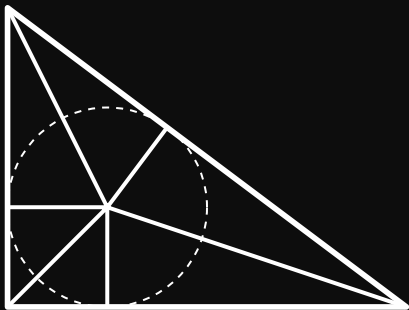
If we overlay T6 and T1 as shown in the figure...



...a T1 vertex lies on the incenter of T6

Dissecting 3:4:5

You can use this dissection of T6 to prove that...

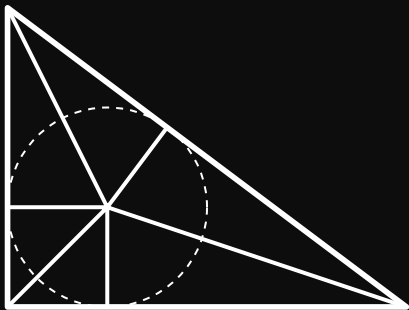


$$\pi = \arctan(1) + \arctan(2) + \arctan(3)$$

(consider the sum of the angles touching the incenter of T6 and divide by 2)

Dissecting 3:4:5

You can use this dissection of T6 to prove that...

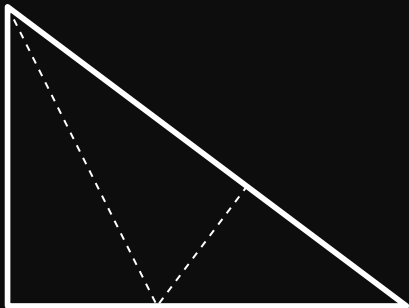


$$\frac{\pi}{2} = \arctan\left(\frac{1}{1}\right) + \arctan\left(\frac{1}{2}\right) + \arctan\left(\frac{1}{3}\right)$$

(consider the sum of the angles touching the vertices of T6 and divide by 2)

Dissecting 3:4:5

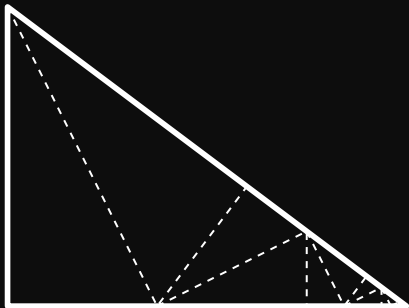
You can dissect a 3:4:5 triangle into...



...a 3:4:5 triangle and
two congruent $1:2:\sqrt{5}$ triangles

Dissecting 3:4:5

Iterating this dissection of T6 you can prove that...



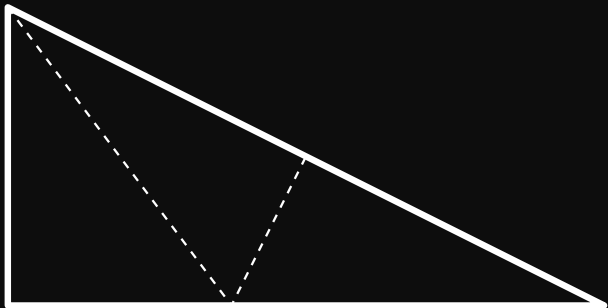
$$\sum_{n=1}^{\infty} \frac{18}{4^n} = 6$$

or, equivalently,

$$\sum_{n=1}^{\infty} \frac{1}{4^n} = \frac{1}{3}$$

Dissecting $1:2:\sqrt{5}$

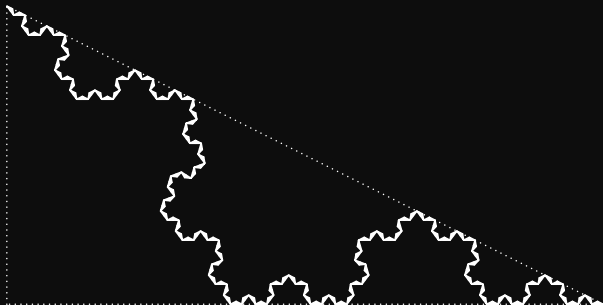
You can dissect a $1:2:\sqrt{5}$ triangle into...



...a $3:4:5$ triangle and
two congruent $1:2:\sqrt{5}$ triangles

Dissecting $1:2:\sqrt{5}$

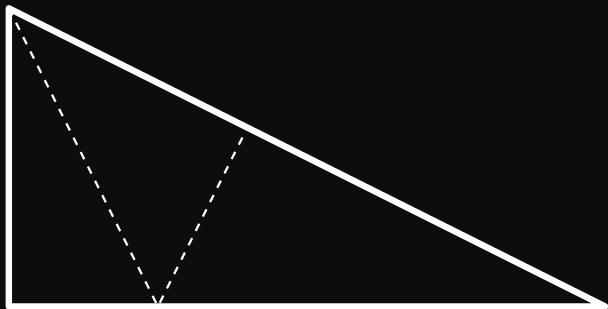
Removing the 3:4:5 triangle and iterating this dissection...



...produces a variant of the **Koch curve** fractal

Dissecting $1:2:\sqrt{5}$

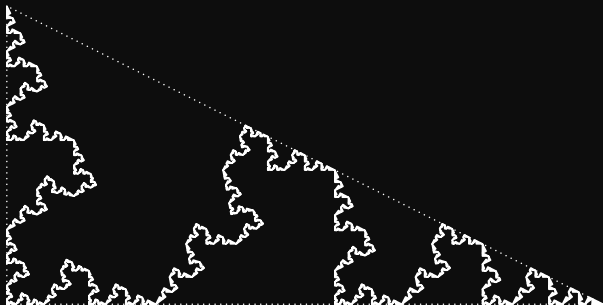
You can dissect a $1:2:\sqrt{5}$ triangle into...



...a $3:4:5$ triangle and
two different $1:2:\sqrt{5}$ triangles

Dissecting $1:2:\sqrt{5}$

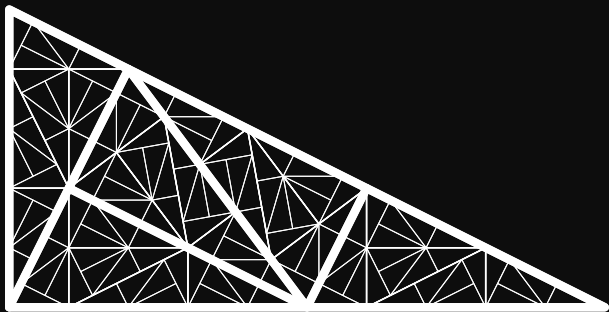
Removing the 3:4:5 triangle and iterating this dissection...



...produces a variant of the **Minkowski sausage** fractal

Dissecting $1:2:\sqrt{5}$

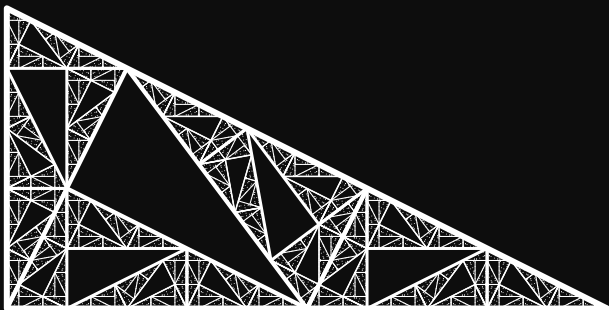
You can dissect a $1:2:\sqrt{5}$ triangle into...



...five congruent $1:2:\sqrt{5}$ triangles
and iterate to get the **Pinwheel tiling** of the plane

Dissecting $1:2:\sqrt{5}$

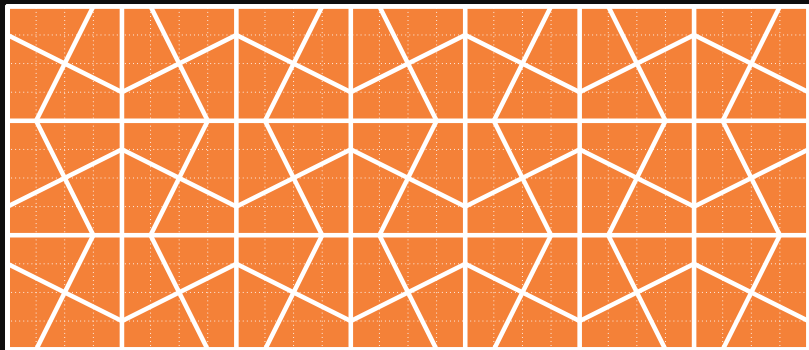
You can dissect a $1:2:\sqrt{5}$ triangle into...



...five congruent $1:2:\sqrt{5}$ triangles, remove the central one
and iterate to get the **Pinwheel fractal**

Q4 tilings

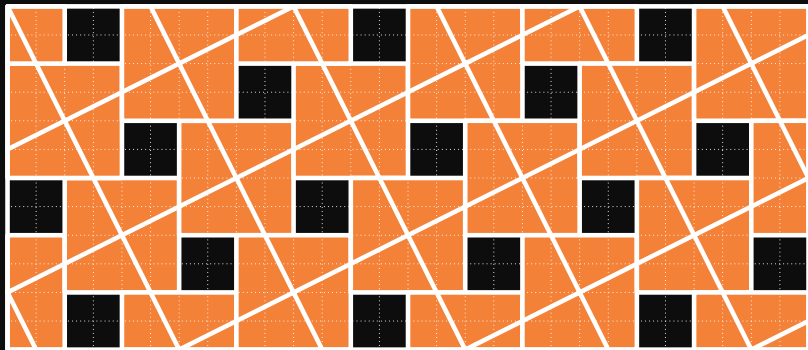
Two copies of Q4 form a pentagon that can be used...



...to make this variant of the **Cairo Tiling** of the plane

Q4 tilings

You can use this **Pythagorean Tiling** to verify...

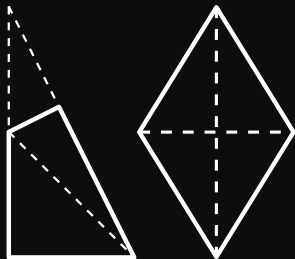


...that T4 satisfies the **Pythagorean Theorem**

The angles of Q4

The angles $90 - \alpha$ and $90 + \alpha$ that appear in Q4
also appear in the Golden Rhombus

(a rhombus whose diagonals are in proportion $1 : \varphi$, with $\varphi = \frac{1+\sqrt{5}}{2}$)



$$90 + \alpha = 2 \cdot \arctan(\varphi) = \arctan(1) + \arctan(3)$$

$$90 - \alpha = 2 \cdot \arctan\left(\frac{1}{\varphi}\right) = \arctan(2)$$

The faces of the rhombic triacontahedron and
the rhombic hexecontahedron are Golden Rhombi

The angles of Q4

Even though they are NOT similar figures...



...the same angles appear in Q4 and $T5 \cup T6$

The perimeter of Q4

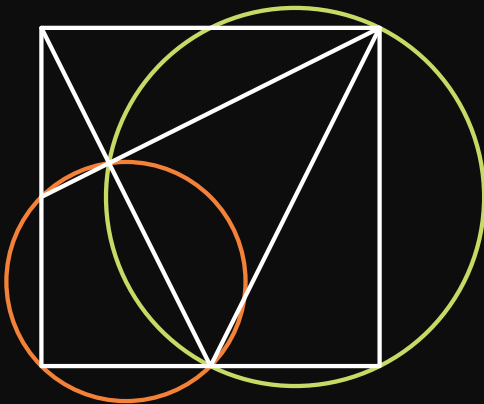
These three perimeters are in a geometric progression...



$$\frac{2\sqrt{5} + 4}{\sqrt{5} + 3} = \frac{3\sqrt{5} + 7}{2\sqrt{5} + 4} = \varphi = \frac{1 + \sqrt{5}}{2}$$

The circumcircles

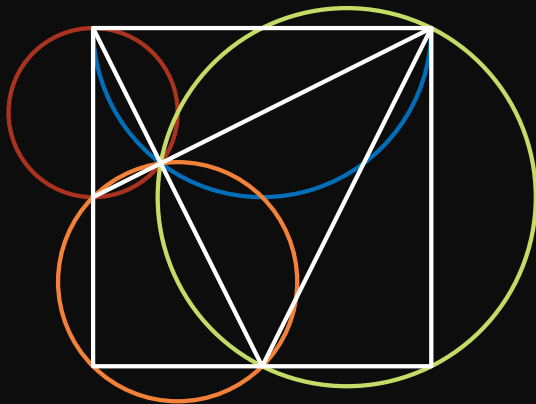
Since opposite angles add to π ...



...Q4 and $T5 \cup T6$ are cyclic quadrilaterals

The circumcircles

All circumcircles pass through a common point...



...and $C(T5 \cup T6)$ passes through the center of $C(Q4)$ and $C(T4)$

The circumcircles

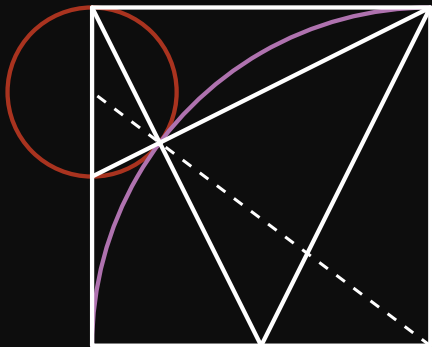
These circumcircles intersect at the square's center...



...which happens to be T6's incenter

Tangent circles

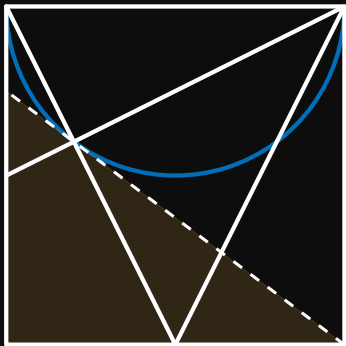
These three points are aligned...



...and these two circles are tangent

Tangent circles

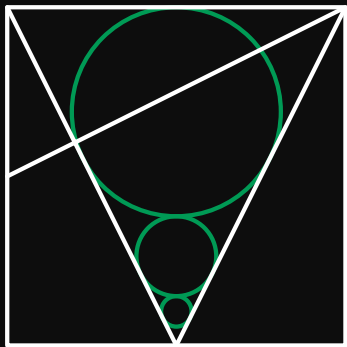
The line is tangent to this circle...



...and the right triangle below is an Egyptian Triangle

Tangent circles

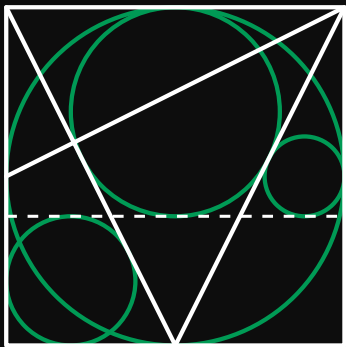
The radius of these three circles are in ratio $1:\varphi^2:\varphi^4$



where $\varphi = \frac{1+\sqrt{5}}{2}$ is the golden ratio

Tangent circles

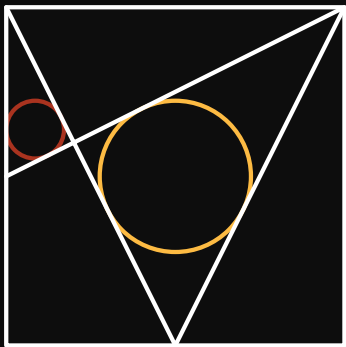
The radius of these four circles are in ratio $1:\varphi:\varphi^2:\varphi^3$



where $\varphi = \frac{1+\sqrt{5}}{2}$ is the golden ratio

Tangent circles

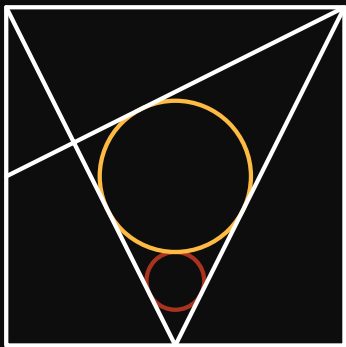
The radius of these two circles are in ratio $1:\varphi^2$



where $\varphi = \frac{1+\sqrt{5}}{2}$ is the golden ratio

Tangent circles

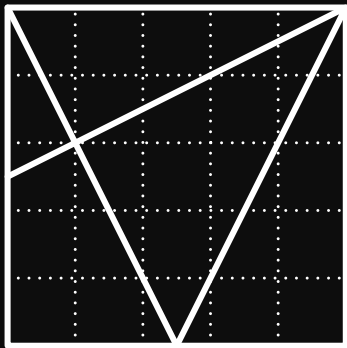
The radius of these two circles are in ratio $1:\varphi^2$



where $\varphi = \frac{1+\sqrt{5}}{2}$ is the golden ratio

The underlying grid

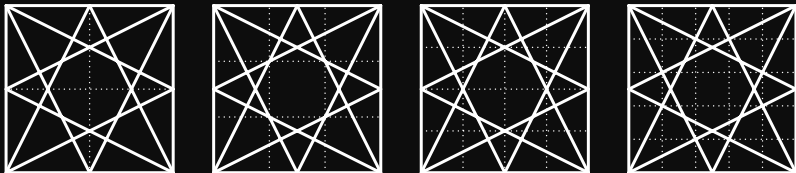
Using the intersection point of the Egyptian Tangram...



...you can divide the square into 5×5 smaller squares!

The underlying grid

Using the intersection points of this figure...

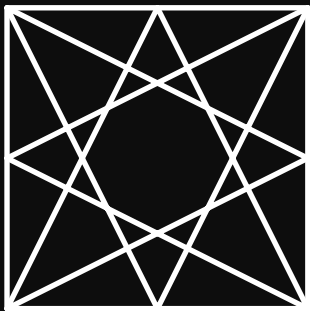


...you can divide the square into:

2×2 , 3×3 , 4×4 or 5×5 smaller squares!

The underlying grid

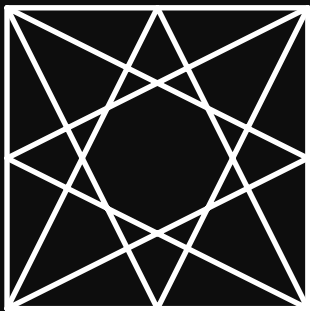
There are 32 egyptian triangles in this figure...



...they come in 4 sizes and there are 8 of each kind

The underlying grid

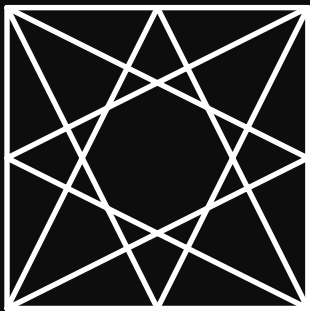
There are 24 $1:2:\sqrt{5}$ triangles in this figure...



...they come in 3 sizes and there are 8 of each kind

The underlying grid

There are 24 other triangles in this figure...



...of 3 different kinds (one of them comes in 2 sizes)

The underlying grid

The relative sizes of these polygons are...



Small Triangles: 1

Small Kites: 3

Whole Square: 120

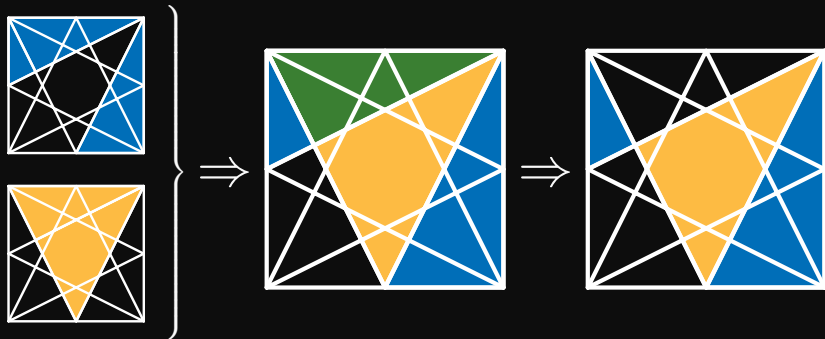
Big Triangles: 6

Big Kites: 8

Octagon: 20

The carpets theorem

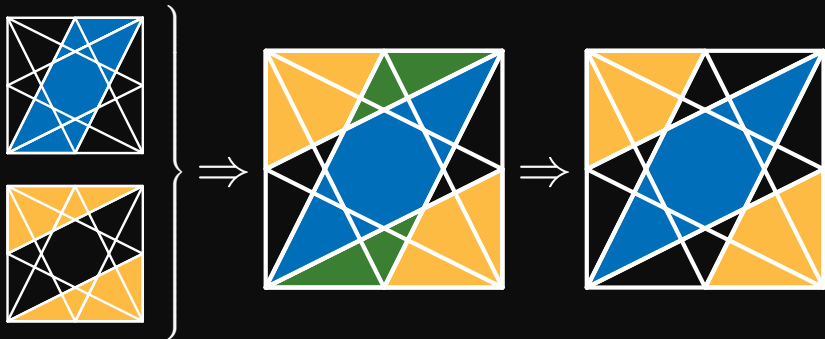
Since $\text{Area}(\text{BLUE}) = \text{Area}(\text{YELLOW})...$



... $\text{Area}(\text{BLUE}-\text{GREEN}) = \text{Area}(\text{YELLOW}-\text{GREEN})$

The carpets theorem

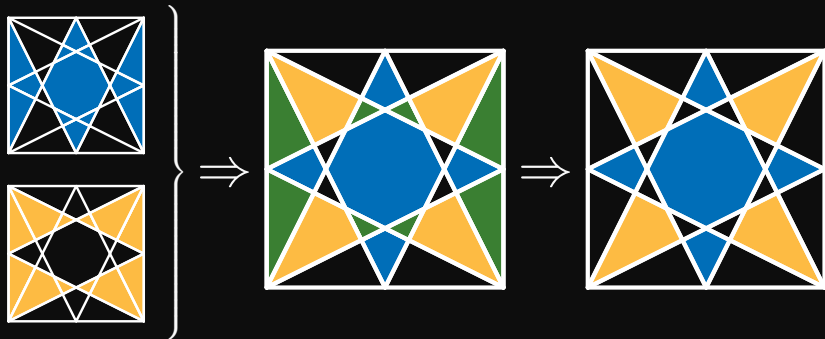
Since $\text{Area}(\text{BLUE}) = \text{Area}(\text{YELLOW})...$



... $\text{Area}(\text{BLUE}-\text{GREEN}) = \text{Area}(\text{YELLOW}-\text{GREEN})$

The carpets theorem

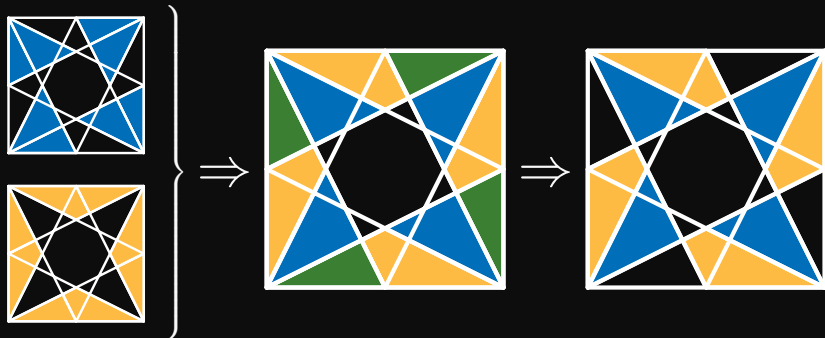
Since $\text{Area}(\text{BLUE}) = \text{Area}(\text{YELLOW})...$



... $\text{Area}(\text{BLUE} - \text{GREEN}) = \text{Area}(\text{YELLOW} - \text{GREEN})$

The carpets theorem

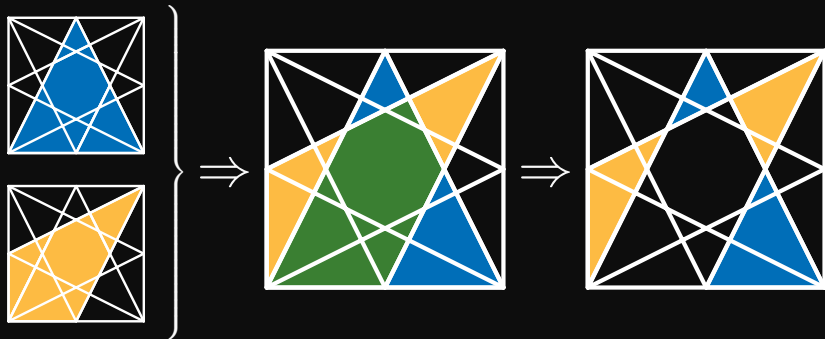
Since $\text{Area}(\text{BLUE}) = \text{Area}(\text{YELLOW})...$



... $\text{Area}(\text{BLUE}-\text{GREEN}) = \text{Area}(\text{YELLOW}-\text{GREEN})$

The carpets theorem

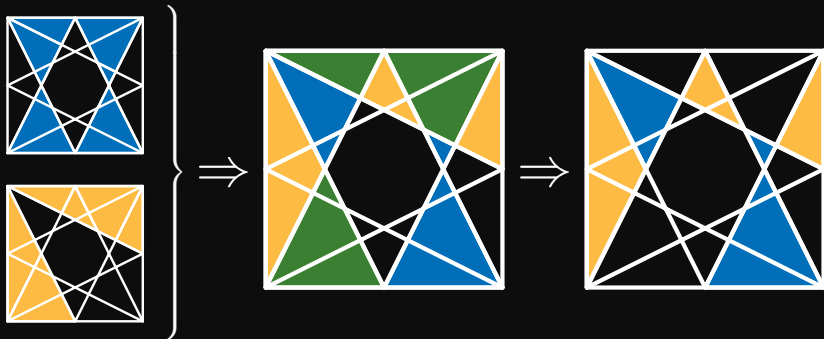
Since $\text{Area}(\text{BLUE}) = \text{Area}(\text{YELLOW})...$



... $\text{Area}(\text{BLUE} - \text{GREEN}) = \text{Area}(\text{YELLOW} - \text{GREEN})$

The carpets theorem

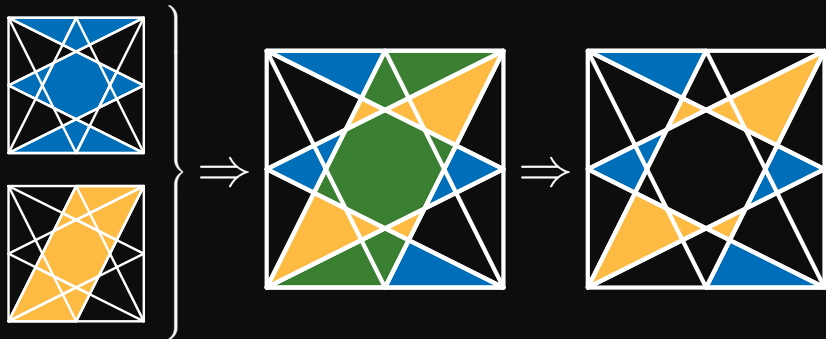
Since $\text{Area}(\text{BLUE}) = \text{Area}(\text{YELLOW})...$



... $\text{Area}(\text{BLUE} - \text{GREEN}) = \text{Area}(\text{YELLOW} - \text{GREEN})$

The carpets theorem

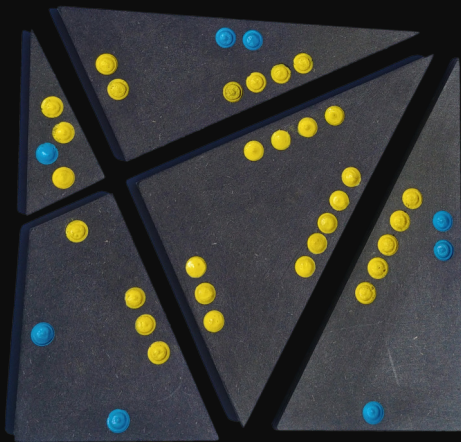
Since $\text{Area}(\text{BLUE}) = \text{Area}(\text{YELLOW})...$



... $\text{Area}(\text{BLUE} - \text{GREEN}) = \text{Area}(\text{YELLOW} - \text{GREEN})$

Divuligation of the Egyptian Tangram

Divulgence of the Egyptian Tangram



Wooden prototype for MMACA's exhibitions (2019)

Divulagation of the Egyptian Tangram

Design diary at Nou Biaix
magazine 44 (2019)

190 • noubiaix 44

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el racó del mmaca

El tangram egipci: diari de disseny

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carlos.luna@mmaca.cat

Què és un tangram?

El tangram que tots coneixem és un trencaclosques d'origen xinès format per set peces planes, cinc triangles i dos quadrilàters, amb les quals es poden crear un gran nombre de figures [Gardner, 1968].



Figura 1. Tangram xinès.

En la seva vessant més lúdica, el tangram s'acompanya d'un llibret on apareixen les siluetes de diverses figures, i el repte consisteix a recobrir completament cadascuna de les siluetes fent servir les set peces sense que sobresurtin de la figura o s'encavalquin entre elles. Sovint, les figures representen objectes o persones amb gran realisme, cosa sorprenent si tenim en compte la simplicitat geomètrica de les peces del tangram [Lloyd, 2007].



Figura 2. Tangram xinès: silueta realista i solució.

Divulagation of the Egyptian Tangram

Parlem de tangrams!

De la Xina a Egipte passant per Cornellà...

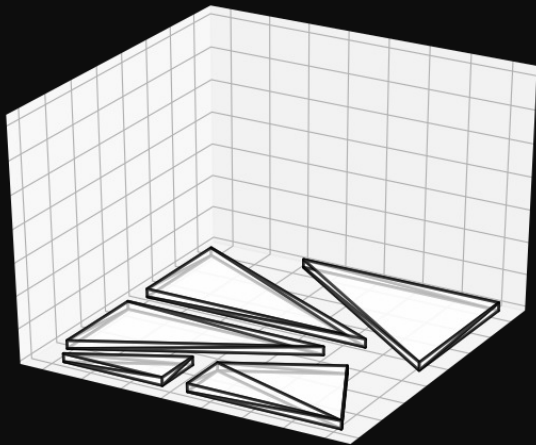


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29 de gener de 2020

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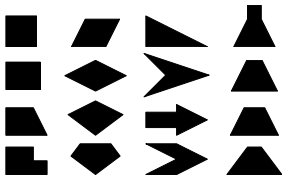
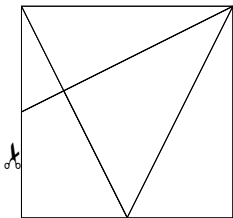
Talk at MMACA (2020)

Divulgence of the Egyptian Tangram



3D printer prototype (2020)

Divulcation of the Egyptian Tangram



Print-&-play flyer for families
affected by CoVID-19 (2020)

Divulagation of the Egyptian Tangram

The Egyptian Tangram as a highschool learning activity (2020)

Matemàtiques

El tangram egipci

Amb les normes sanitàries d'aquest curs resulta gairebé impossible fer excursions i viatges a museus. Altitudinàriament, els companys del MNMCA (Museu de Matemàtiques de Catalunya) pensen en tot i han inventat un nou material didàctic, el **tangram egipci**, que és molt fàcil de reproduir amb cartó i tisores. Així, en comptes d'anar trobant-se al museu, hem dissenyat que el nostre viatge les sales de di d'ESO mentre treballaven la geometria i les àrees quadrades.

En aquesta imatge podeu veure les 5 peces del tangram egipci dibuixades sobre una quadrícula.

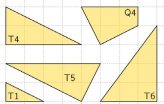


Figure 1. Les peces del tangram egipci

Us permeten fer qualsevol d'aquestes figures geomètriques:

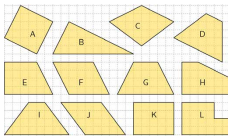


Figure 2. Figures geomètriques

I quan hàgiu acabat de fer-les totes, podeu intentar fer figures de core realitzant com aquestes:



Figure 3. Core, d'Anna Escart



Figure 4. Core, de Anna Escart



Figure 5. Core, de Anna Escart

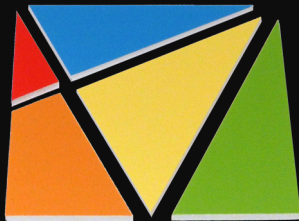


Figure 6. Core, de Anna Escart



Figure 7. Core, de Anna Escart

Divulcation of the Egyptian Tangram

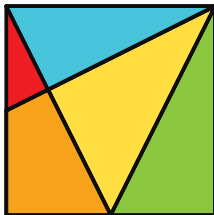


First commercial edition (2021)

Divulagation of the Egyptian Tangram



El Tangram Egipcio



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On-line talks for FUNDAPROMAT and
MMACA's 7th anniversary (2021)

Ideas? Suggestions?
Use examples?

`carlos.luna@mmaca.cat`

References

- Brunés, T. – *“The Secrets of Ancient Geometry”* (1967)
- Barr, S. – *“Mathematical Brain Benders”* (1969)
- Bankoff, L. & Trigg, C. W. – *“The Ubiquitous 3:4:5 Triangle”* (1974)
- Brügger, G. – *“Three-Triangle-Tangram”* (1984)
- Detemple, D. & Harold, S. – *“A Round-Up of Square Problems”* (1996)
- Nelsen, R. B. & Alsina, C. – *“Icons of Mathematics”* (2011)
- Bogomolny, A. – *“Cut The Knot”* (1996–2018)
- Luna-Mota, C. – *“El tangram egipci: diari de disseny”* (2019)
- Rajput, C. – *“A Classical Geometric Relationship That Reveals The Golden Link in Nature”* (2019)