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Traditional Craft Heritage Training , Design & Marketing in Jordan and Syria
(HANDS)
Project Number: 610238-EPP-1-2019-1-JO-EPPKA2-CBHE-JP

Proportions and Geometry in Architecture

Course Offered By: : ZUJ

Module 1

Responsible partner(s):

Training and Technical Group (TTG)

Scientific and Supervising Committee (SC)

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Hand's project

GEOMETRIC PROPORTIONS AS A TOOL OF DESIGN:

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GEOMETRIC PROPORTIONS AS A TOOL OF DESIGN: STUDY MODEL

The system of geometric design starts from the circle (the basic unit), from which the pattern starts to unfold, creating harmonious divisions of the circle in four stages:

1. The planning stage: starting by determining the proportional systems based on the unit pattern structure within the circle of Unity. The decision is based on the symbolic meanings underlying the geometric pattern and its relation to micro–macro cosmos.
2. The division phase: construction of the basic geometric pattern.
3. Pattern order and structure: initiating the crossing lines to create the artistic shape of the pattern on natural junctions formed by those lines. This gives rise to a series of points that can be used in the development of patterns. This type of framework forms the driving geometry for the relatively simple Islamic patterns with which we are familiar.
4. Desired pattern revealing: establishing the geometric variations of the pattern and defining its boarder lines. It is derived from all the vital proportion systems based on a single unit. The process can be repeated indefinitely, presenting the same center everywhere and nowhere. It is ratio, rather than measurement, that determines the relative lengths of crucial dimensions

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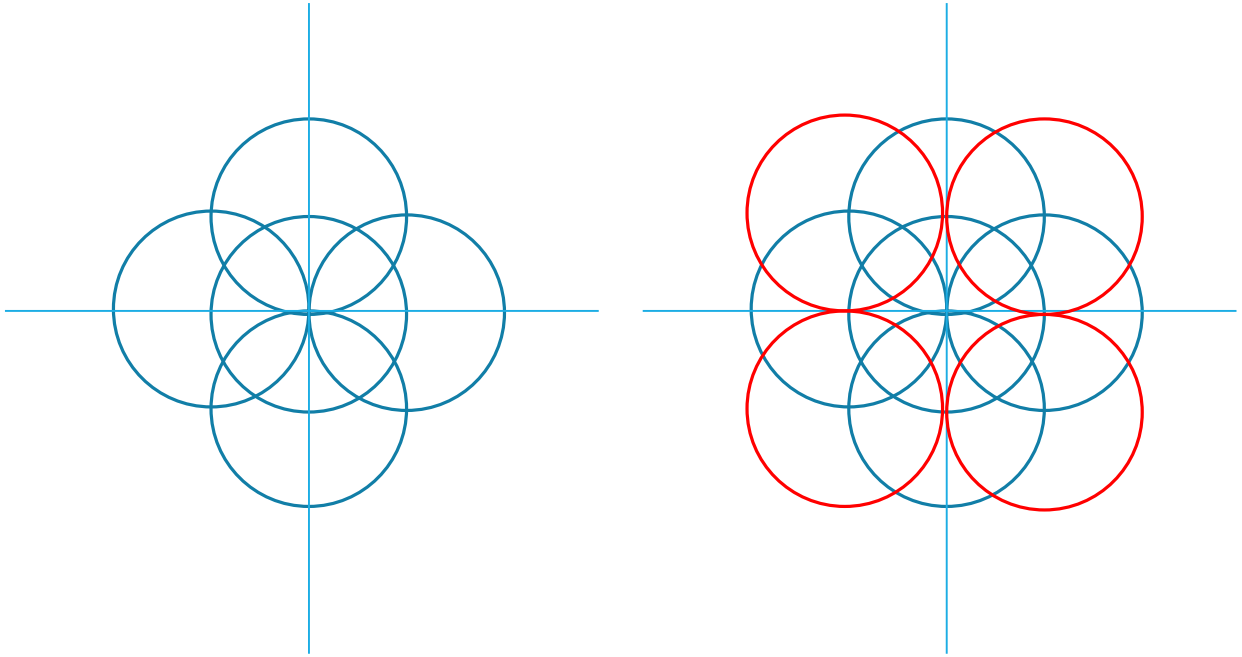
FOURFOLD TO EIGHTFOLD PATTERN

CONSTRUCTION STAGES OF FOUR POINTED PATTERNS

Hand's project

PLANNING STAGE

- The two simplest geometric constructions which form the basis for many of the patterns to be found in Islamic decorations are the constructions of four and eight pointed geometries respectively.
- By illustrating how small changes can affect the overall pattern according to the types of pattern and how they are achieved by simple changes, it is possible to see how a very small differentiation can produce a dramatically different overall pattern



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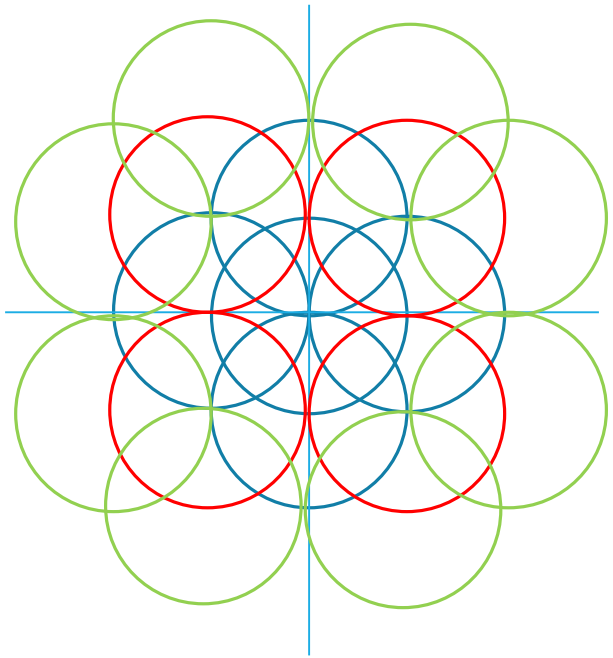
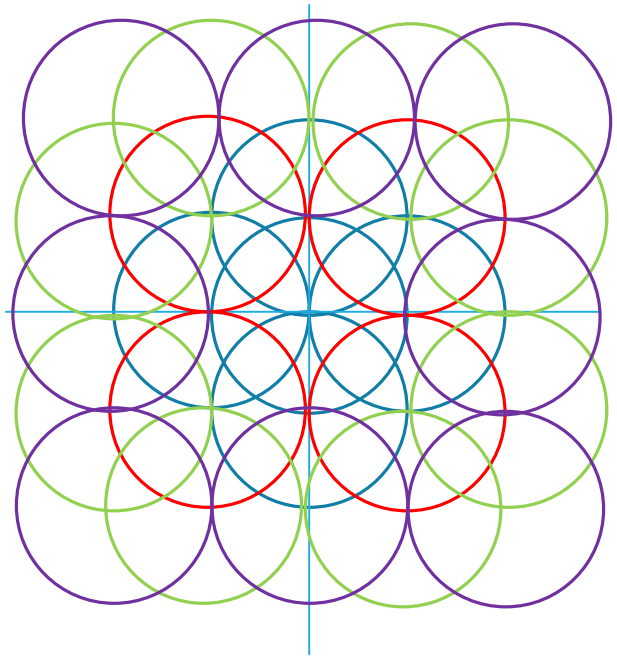
THE DIVISION STAGE





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ORDER AND STRUCTURE STAGE

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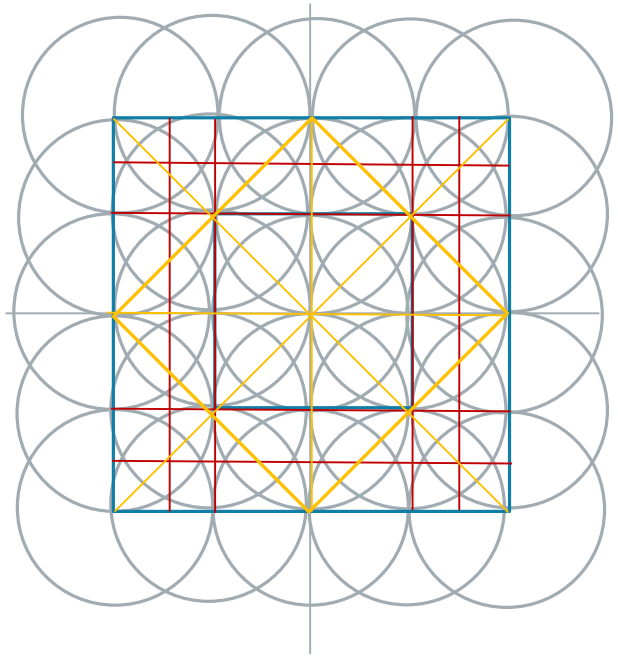

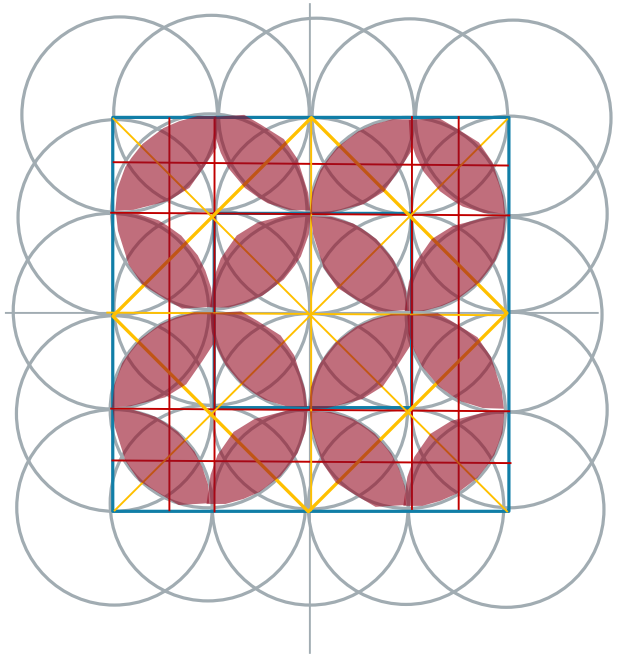

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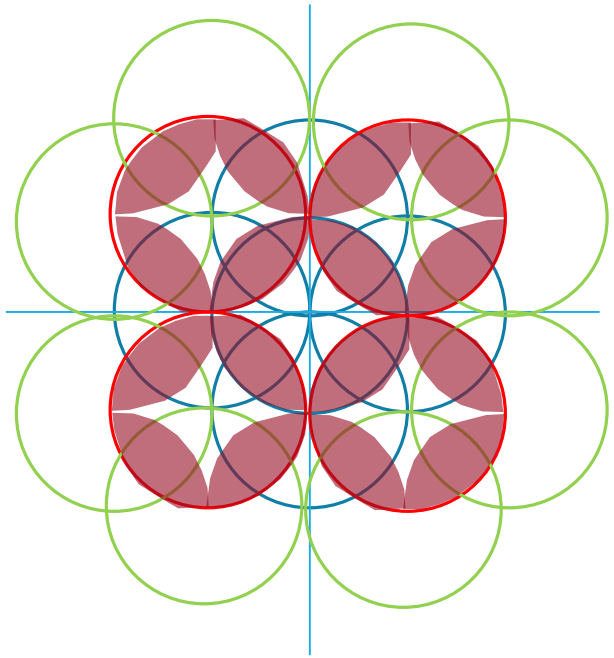
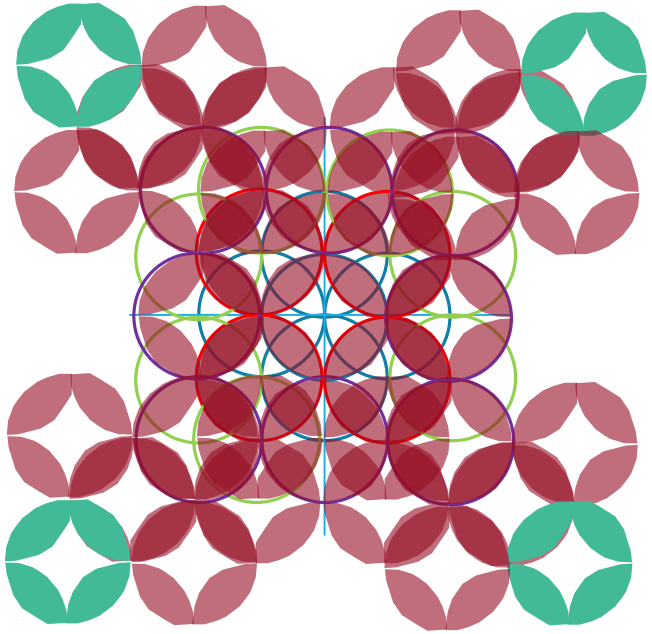
PATTERN REVEALING STAGE

Hand's project





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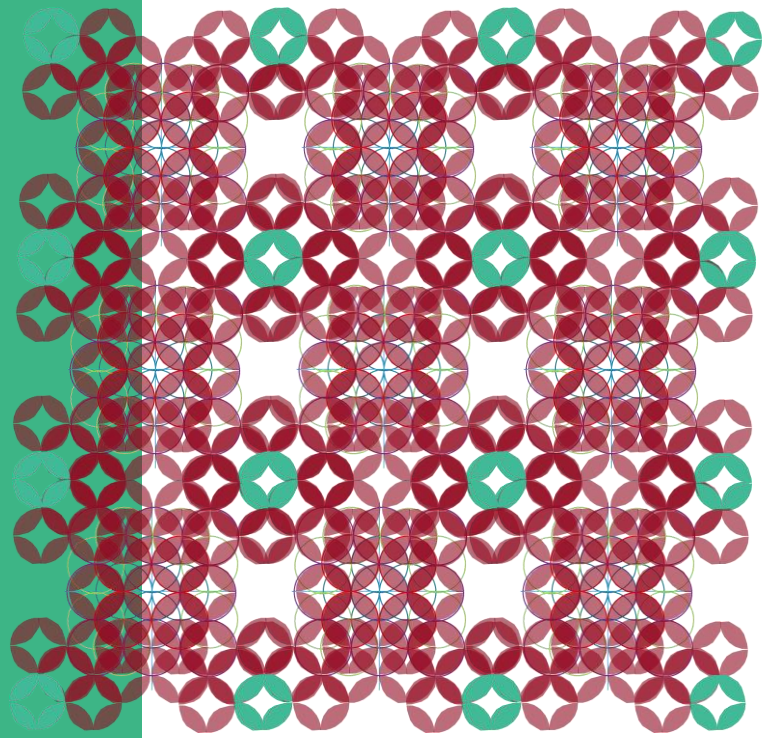
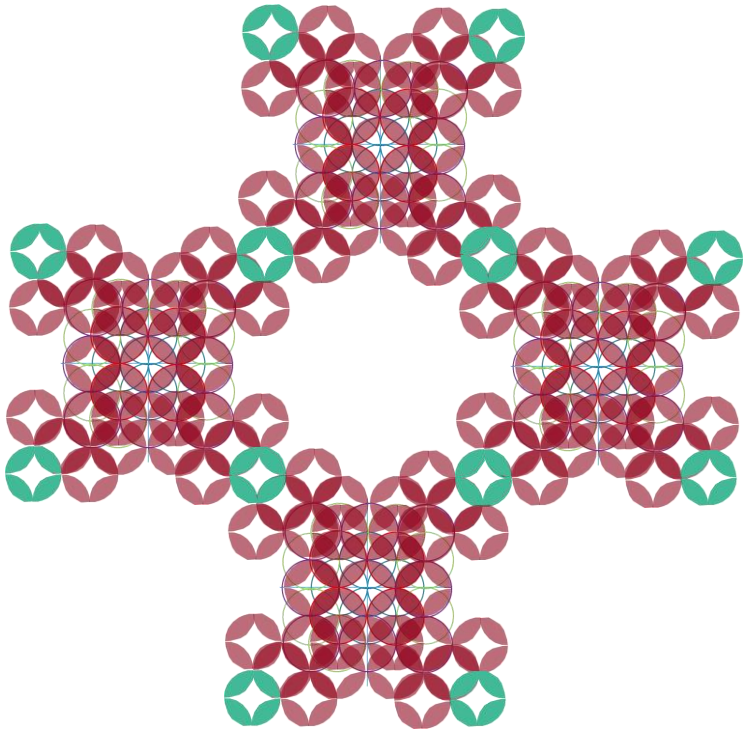
PATTERN REVEALING STAGE

Hand's project





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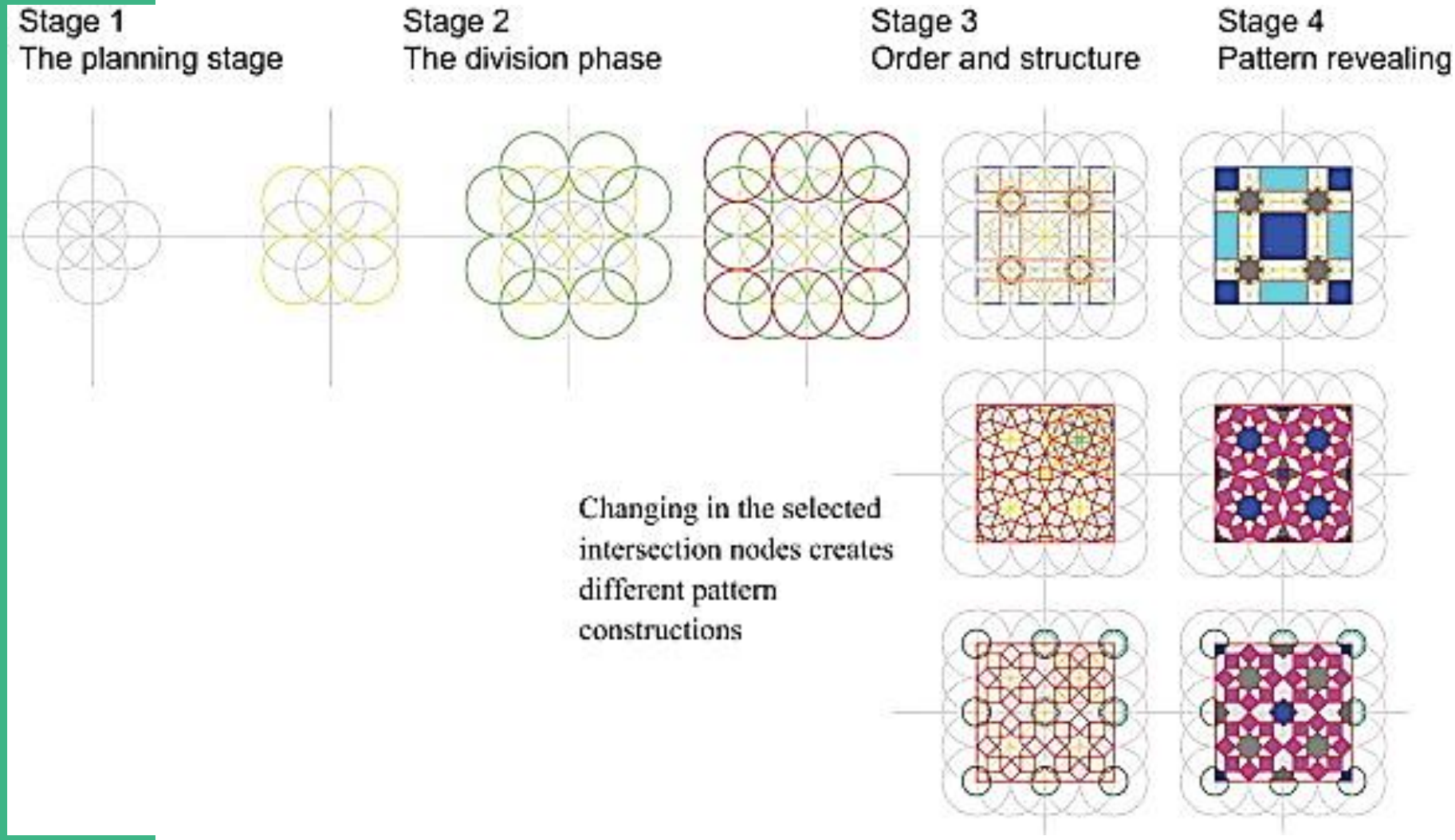
Hand's project

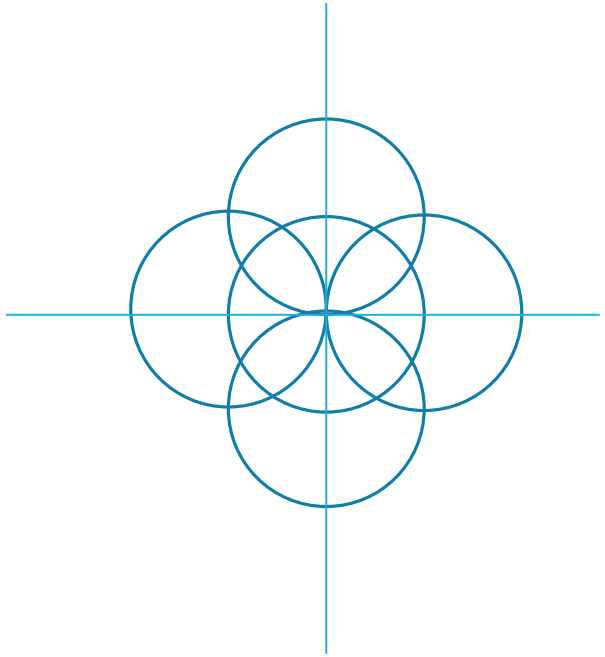
Construction stages of four pointed patterns

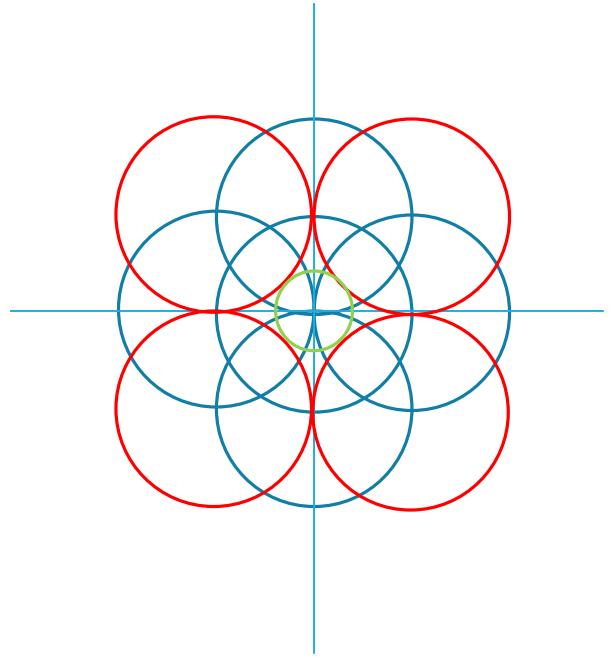


Planning stage

Hand's project

CONSTRUCTION STAGES OF EIGHT POINTED PATTERNS





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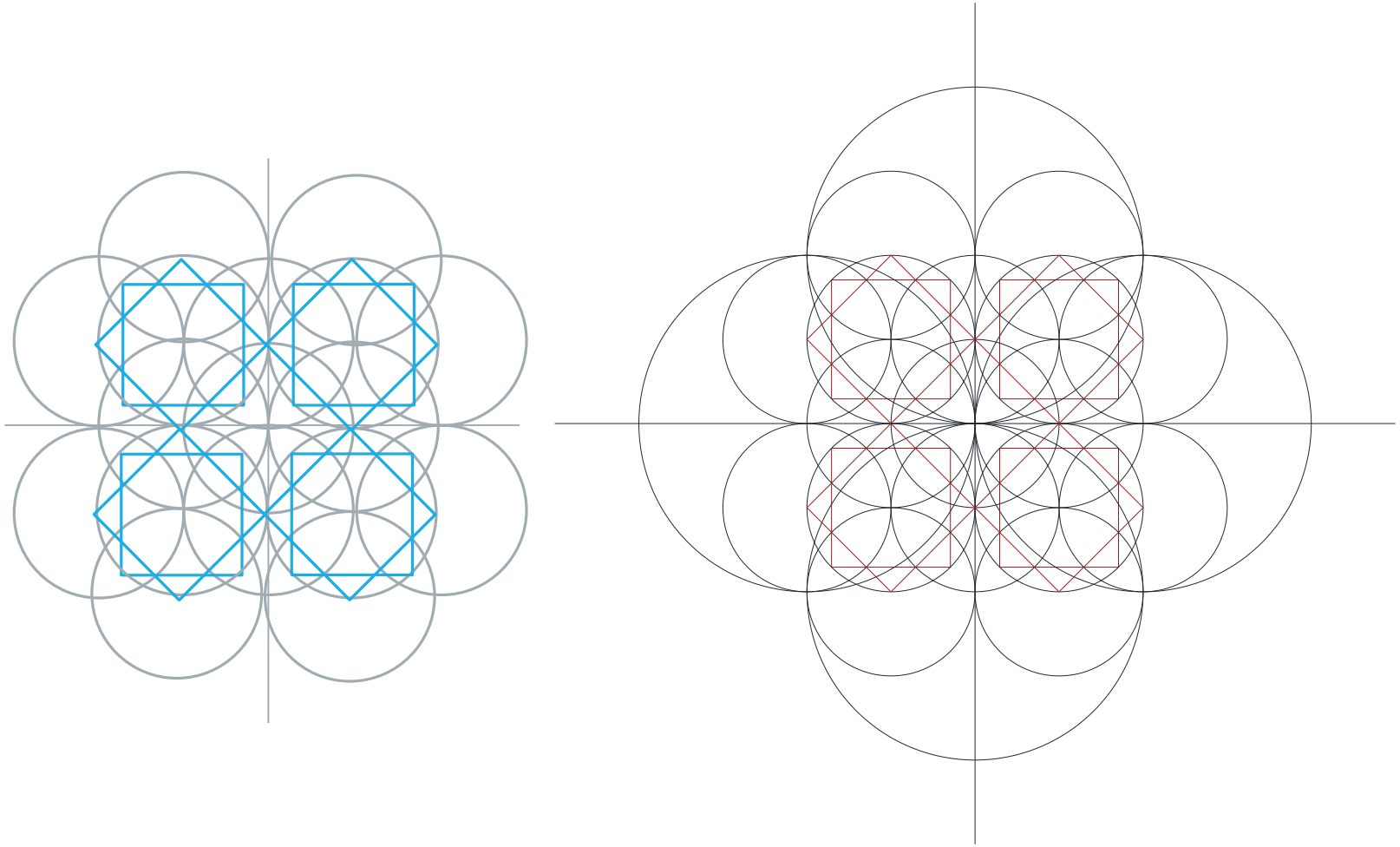
THE DIVISION STAGE

Hand's project



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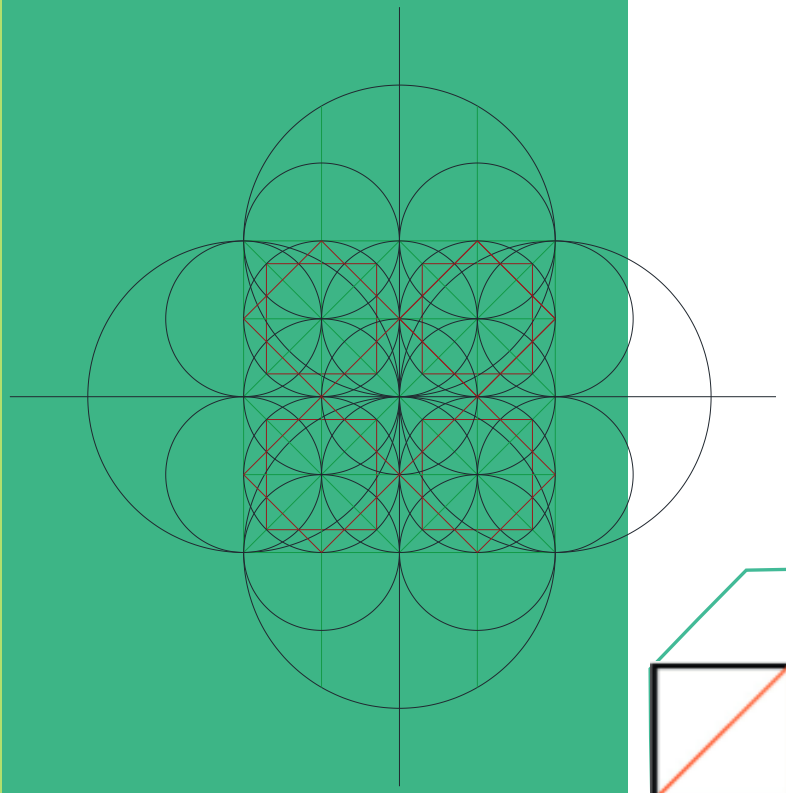
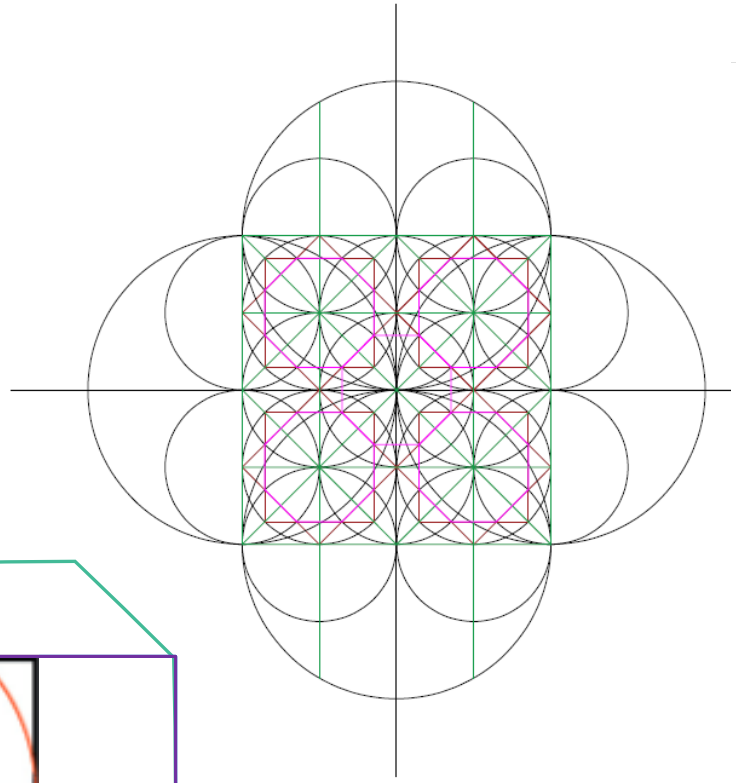
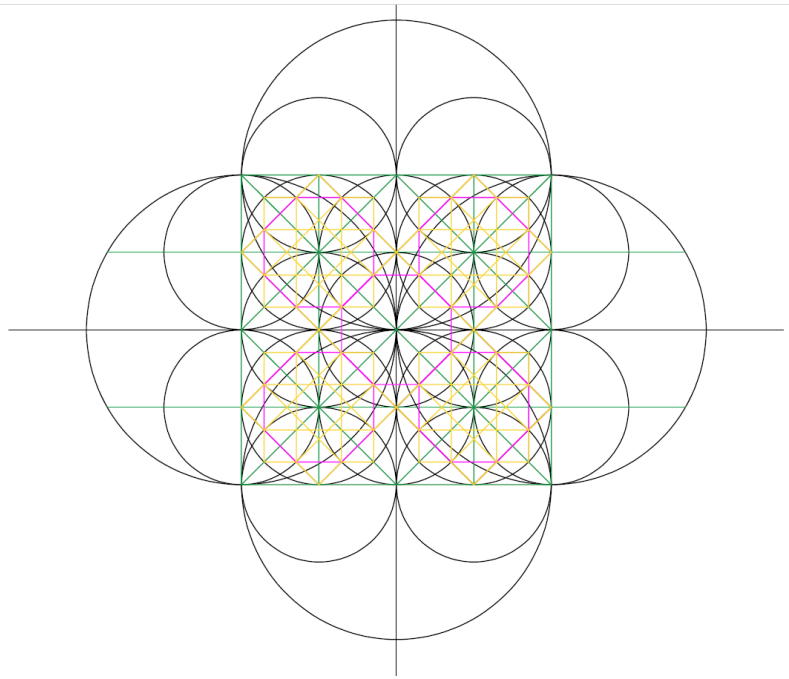
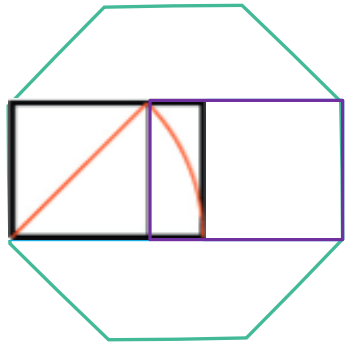
ORDER AND STRUCTURE STAGE

Hand's project









$\sqrt{2}$

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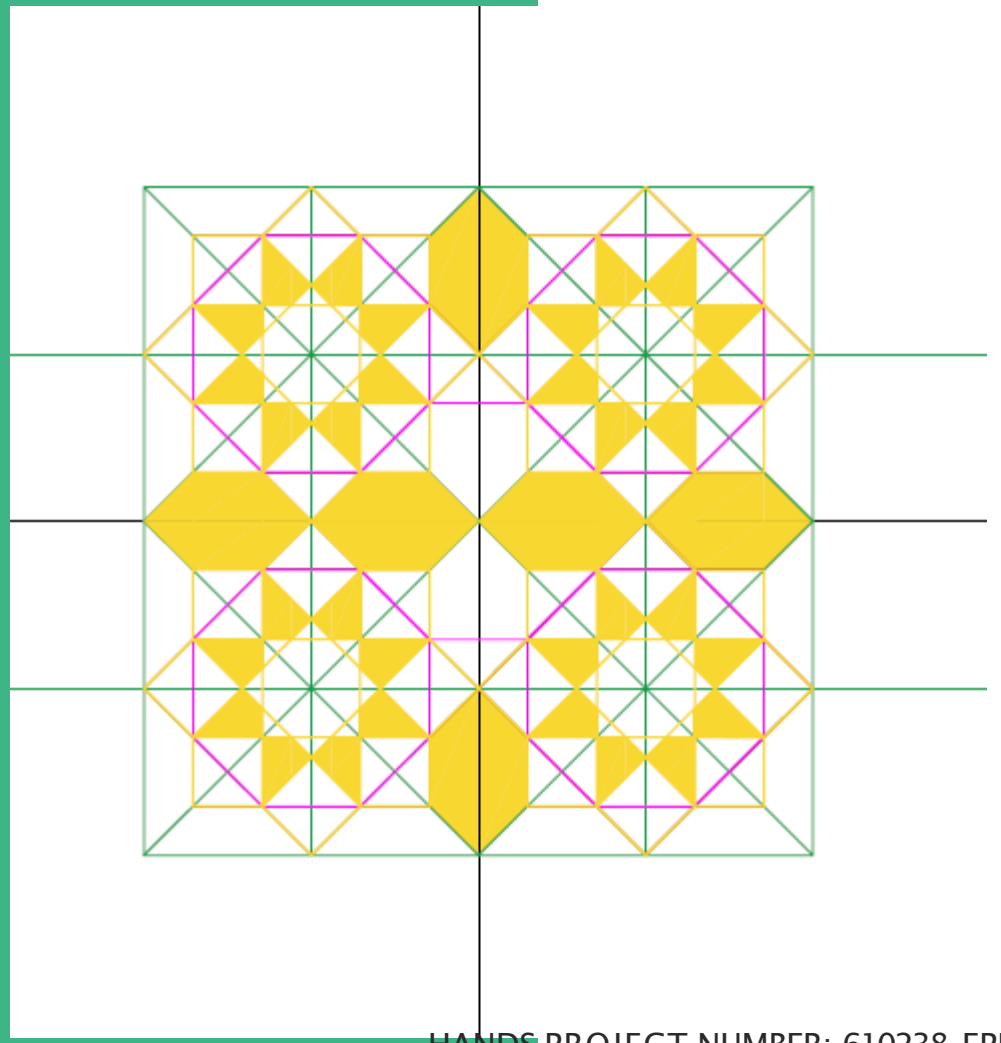
PATTERN REVEALING STAGE

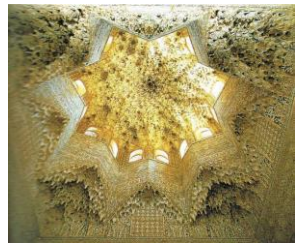


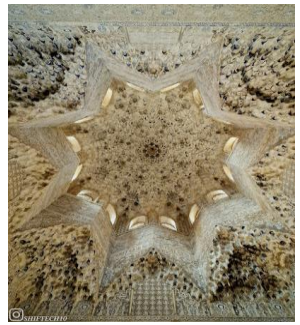
Hand's project

EXAMPLES ON PREVIOUS PATTERNS

Applications of the octagon based on eight pointed patterns in architecture "And the angels will be on its sides, and eight will, that Day, bear the throne of thy Lord above them"

- Its application within architecture is reflected in a Moroccan ceramic (Zilij) panel
- In the harmonic diminishing of the eight-fold star in the Alhambra Palace
- The Hall of The Abencerrajes
- The Hall of the Two Sisters.

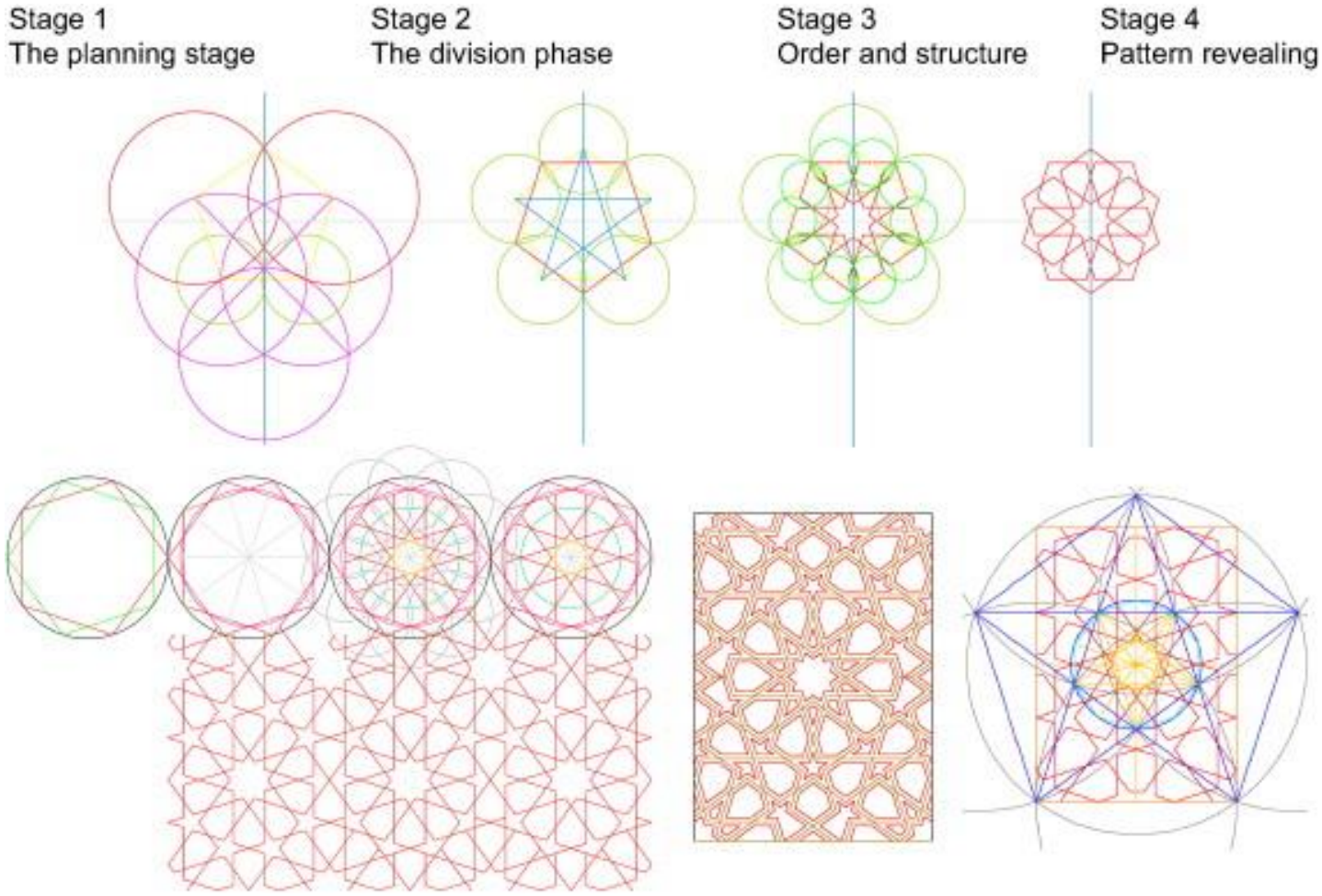




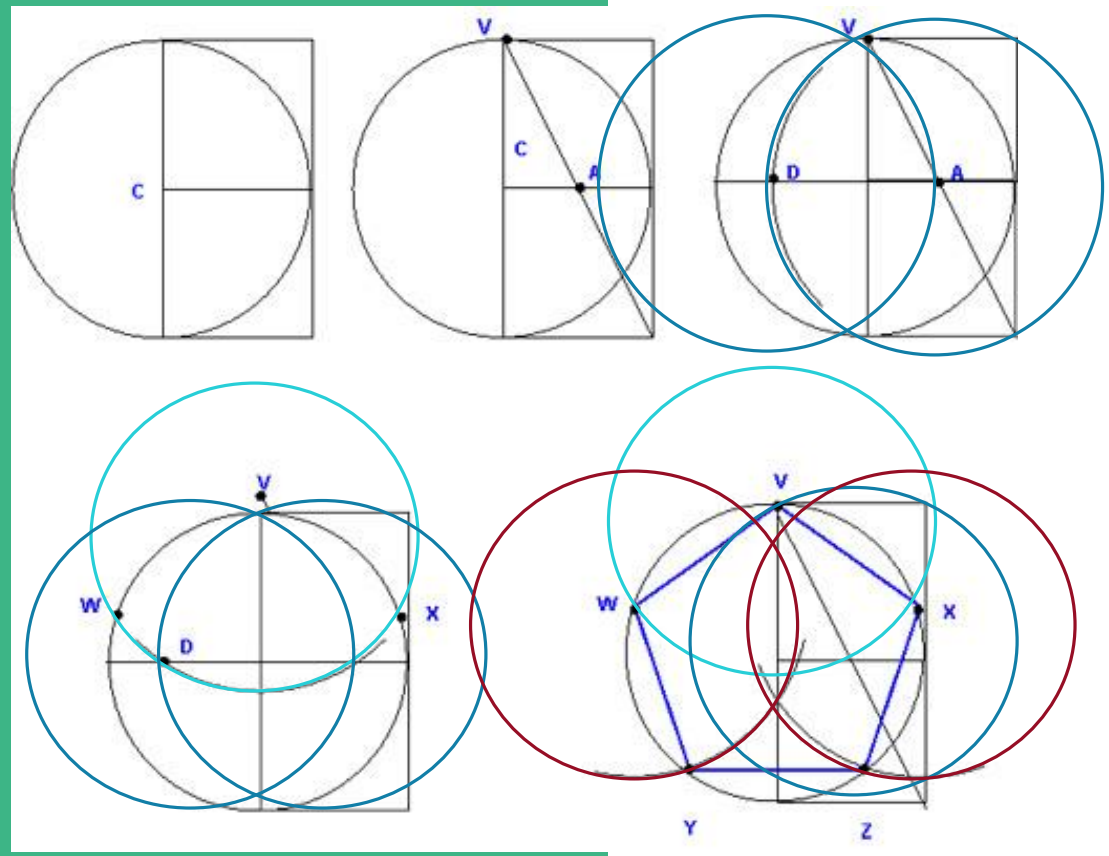
CONSTRUCTION STAGES OF FIVE FOLD TO TEN FOLD PATTERNS

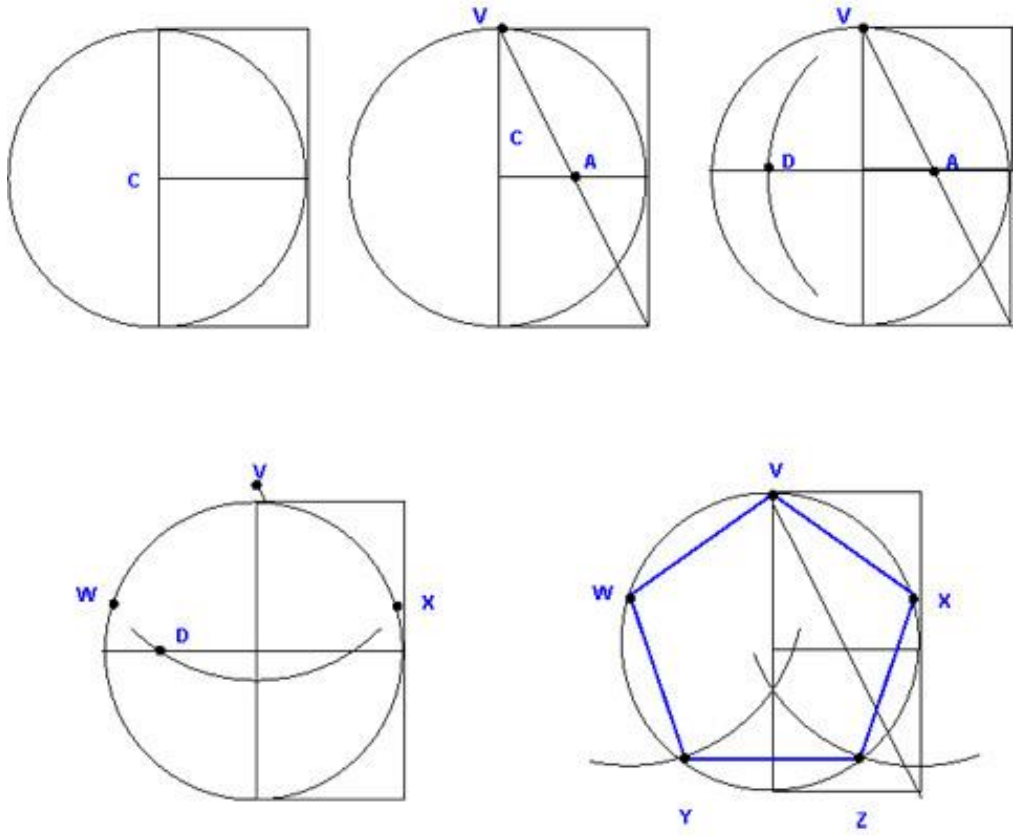
Hand's project

- its esthetic advantage is related to the golden section, showing one of the many ways to apply the geometry to form different patterns.



PLANNING STAGE





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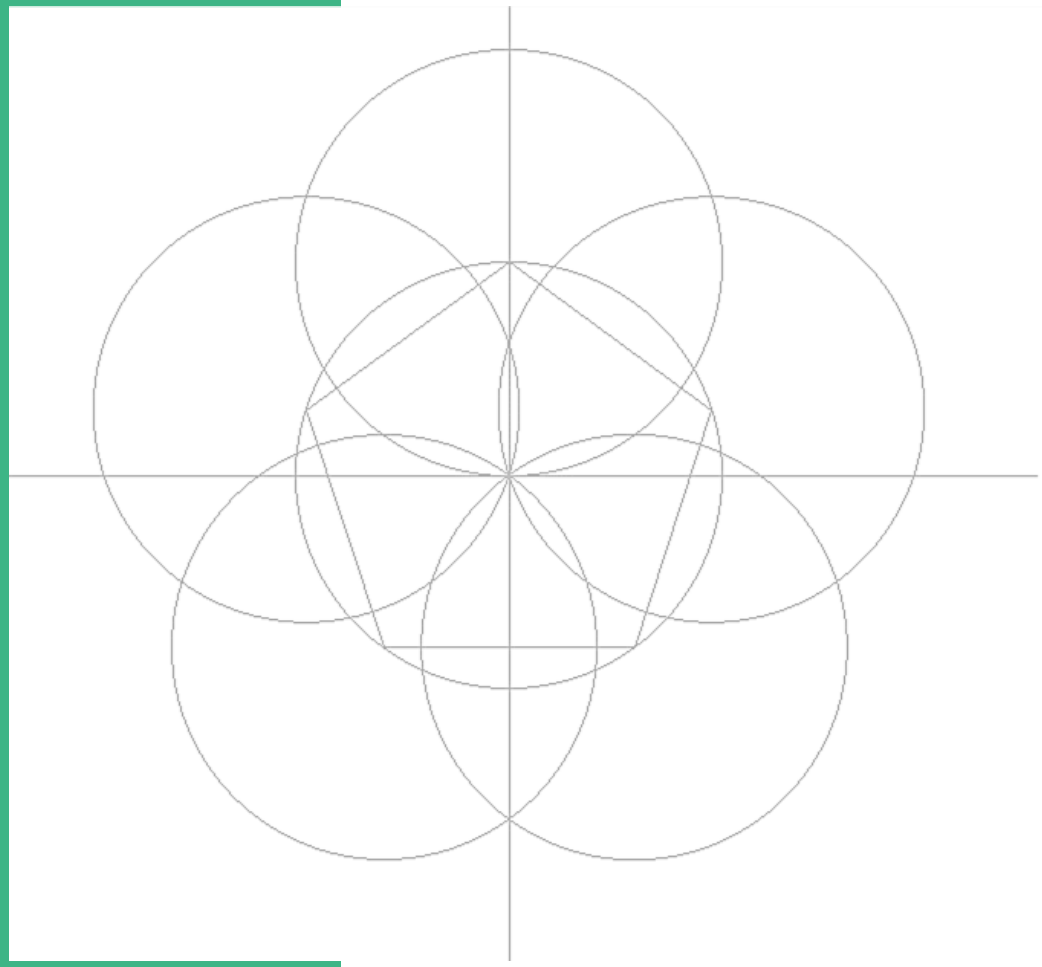
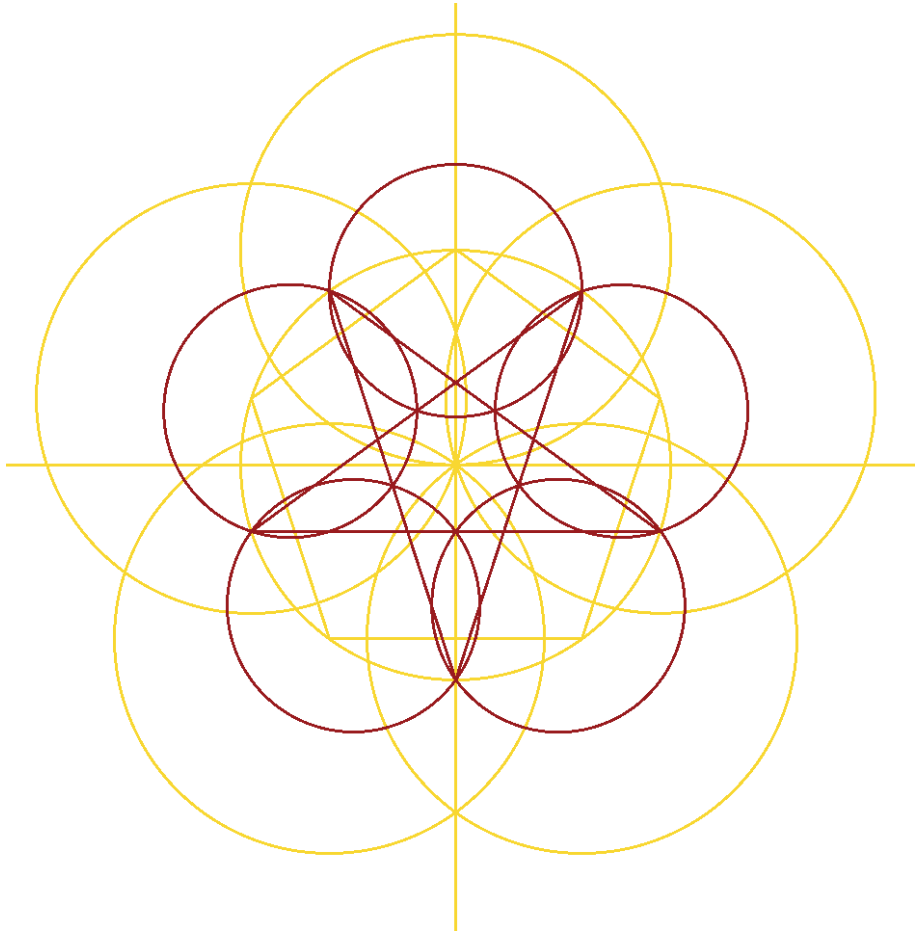
PLANNING STAGE





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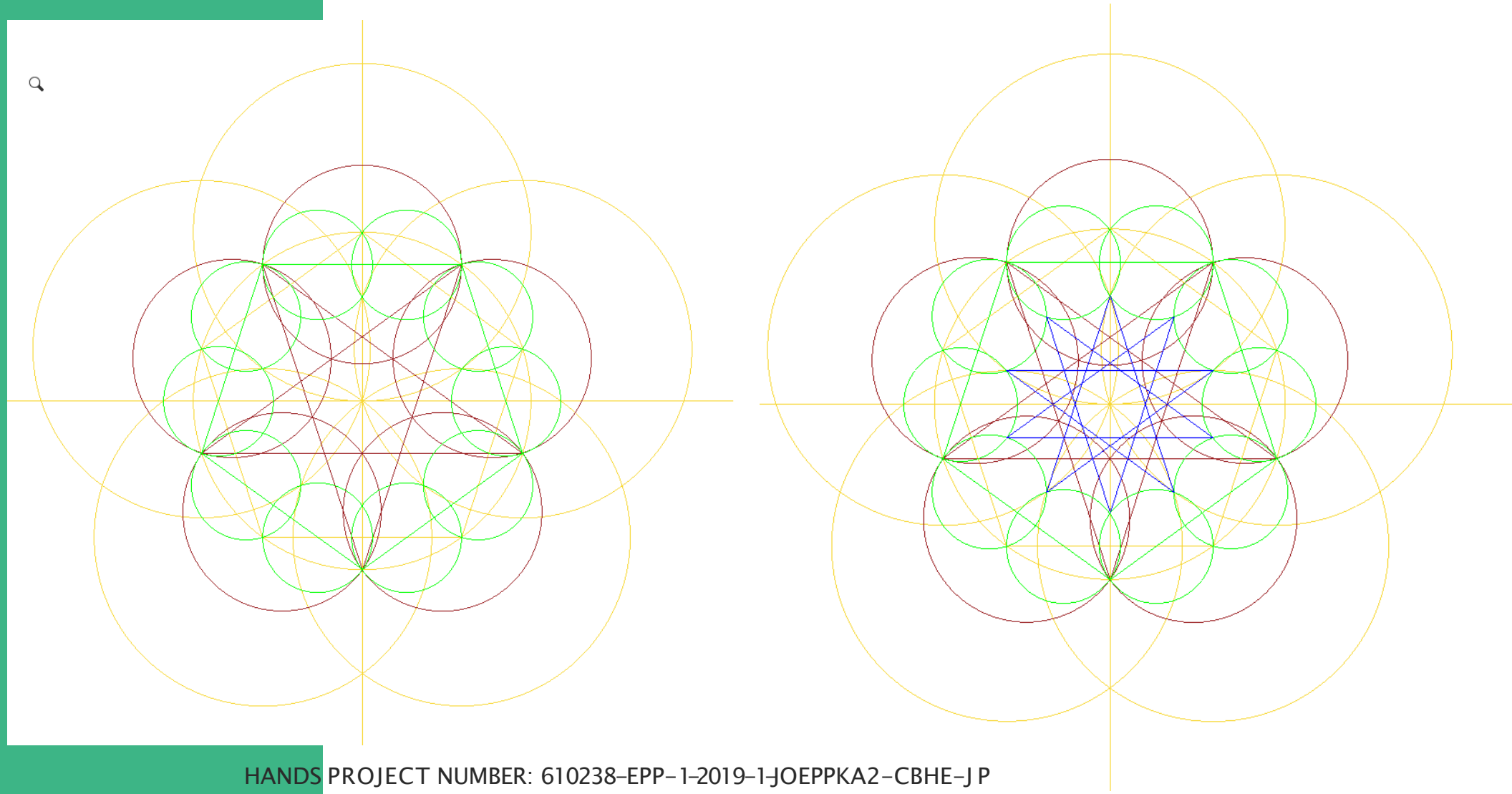
THE DIVISION STAGE



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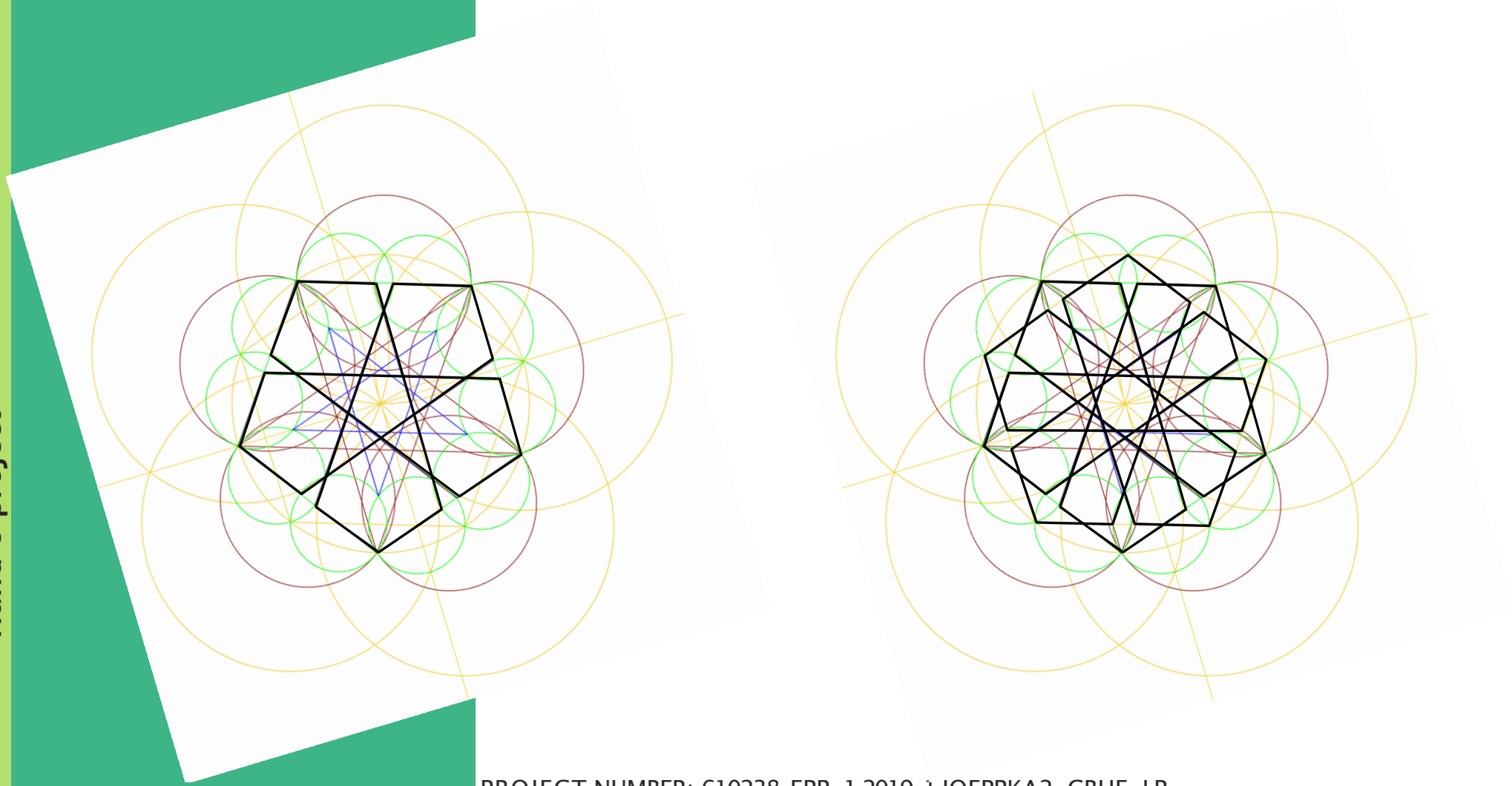
ORDER AND STRUCTURE STAGE

Hand's project



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HANDS

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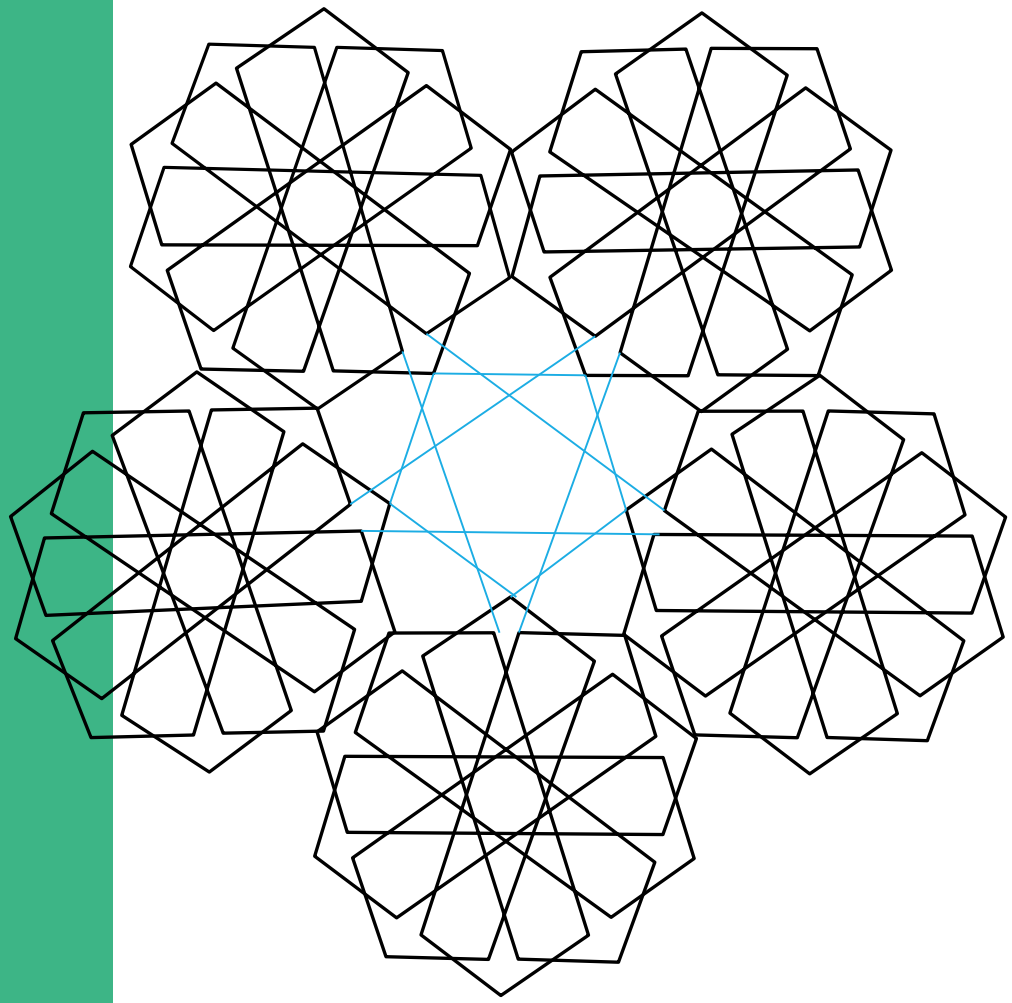
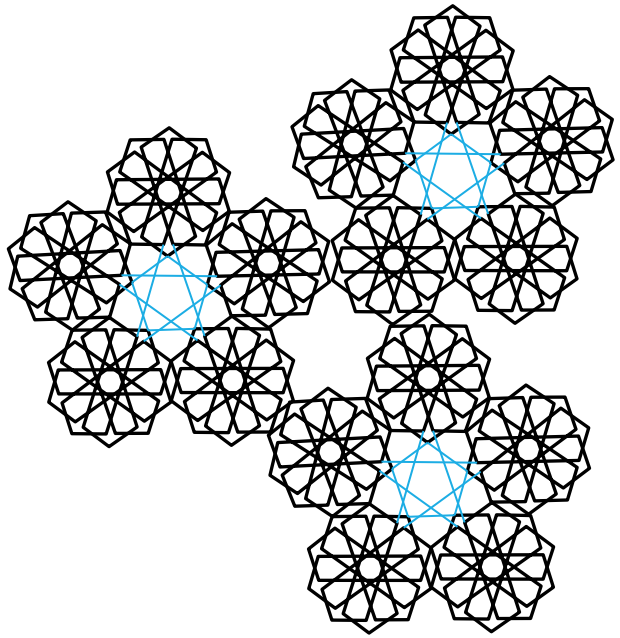
PATTERN REVEALING STAGE

ONLY ARRANGE BASED ON PENTAGON





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EXAMPLES ON PREVIOUS PATTERNS

- Salah Al-Din wooden Minbar (Pulpit) at Al-Aqsa mosque (Jerusalem), on a wooden door from Mumluk period (Cairo) and on a frontispiece at a Mamluk Quran.
- Ten pointed geometry lends itself to a wide variety of design possibilities through relatively small variations in the underlying relationships and to the creation of different patterns at different scales as a unified design.

Wooden panel at a Minbar at a book art (Quran)

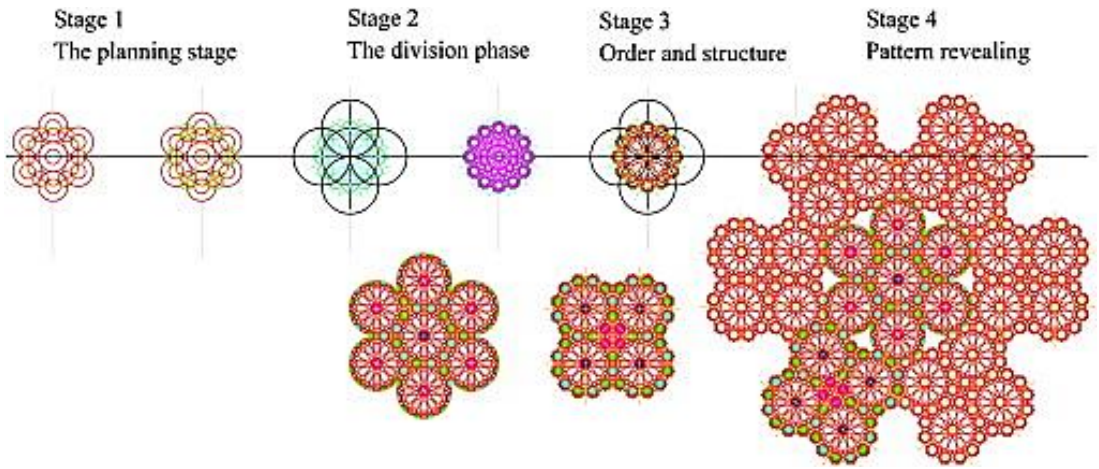
Wooden panel on a door

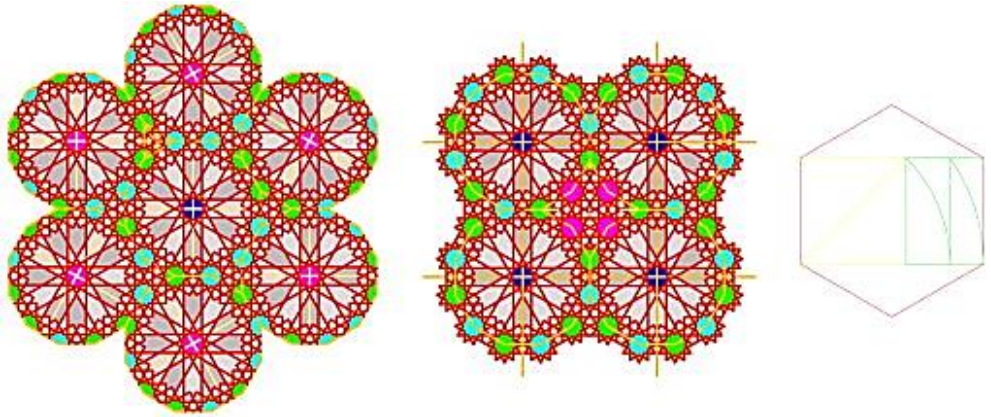
Two frontispieces

CONSTRUCTION STAGES OF SIX FOLD TO TWELVE FOLD PATTERNS

Hand's project

- Twelve pointed geometry can be constructed from six pointed geometry. The hexagon is one of the most important forms in Islamic geometry.
- It is simple to construct, it has the capability of producing, by means of repetition, an overall coverage of a surface, it contains the important relationship of √3 proportions, and it bears a strong similarity to the circle, a symbol of the Creation in Islam.
- The complexity is introduced on a relatively simple basis by applying colors and doubling of the structure lines while employing the technique of cutting the tiles in such a way as to imply the interweaving of the running lines.
- The pattern is both logical and rhythmical, i.e., both mathematical and melodious, which is the most significant characteristics of the spirit of Islam, showing its balancing—"unity in multiplicity" or "multiplicity in unity" within a series of regular geometrical figures contained within a circle, or a series of regular polyhedral contained within a sphere





Potential variations of 6–12 pointed patterns based on the same structure as in Figure above based on √3 proportions.

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GEOMETRIC PROPORTION SYSTEMS AND TERMS

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GEOMETRIC PROPORTION SYSTEMS AND TERMS

The proportions of the golden mean

- Circle of Unity
- HUMAN PROPORTION (Vitruvian Man)
- The primary three proportional roots $\sqrt{2}$, $\sqrt{3}$ and $\sqrt{5}$

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THE PROPORTIONS OF THE GOLDEN MEAN

The golden mean proportion is a proportional system whereby two elements are related to each other by a set proportion.

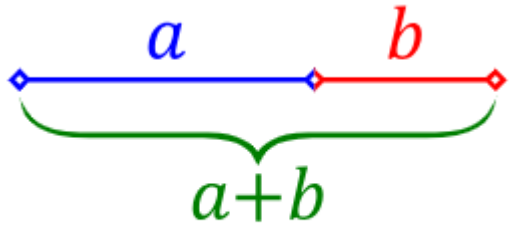
Two segments of a line not equal to each other are related in a proportion: a/b=(a+b)/a

In mathematics and the arts, two quantities are in the golden ratio if the ratio of the sum of the quantities to the larger quantity is equal to the ratio of the larger quantity to the smaller one.

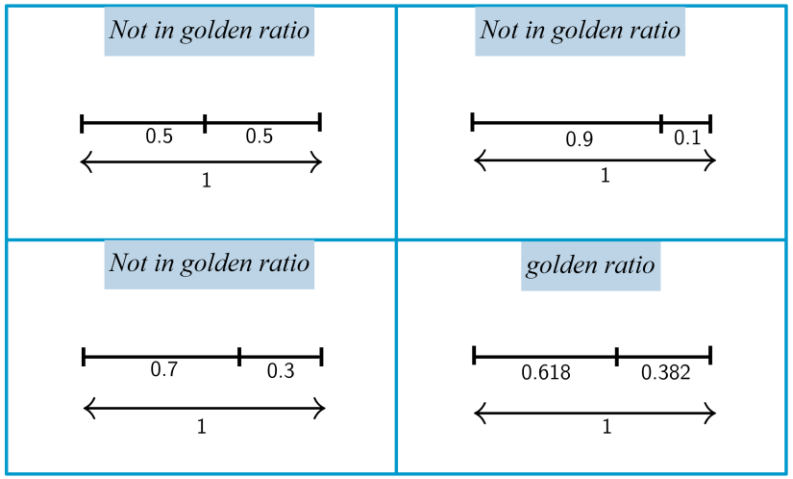
The golden ratio is an irrational mathematical constant = approximately 1.618 and usually denoted by the Greek letter Phi (Φ).

1:1.618

To get the larger dimension multiply by 1.618 and divide by 1.618 to get the smaller dimension.



$a+b$ is to a as a is to b



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GOLDEN RATIO APPLICATIONS IN LAYOUT

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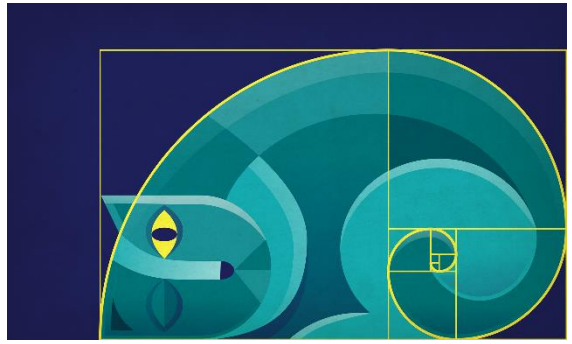

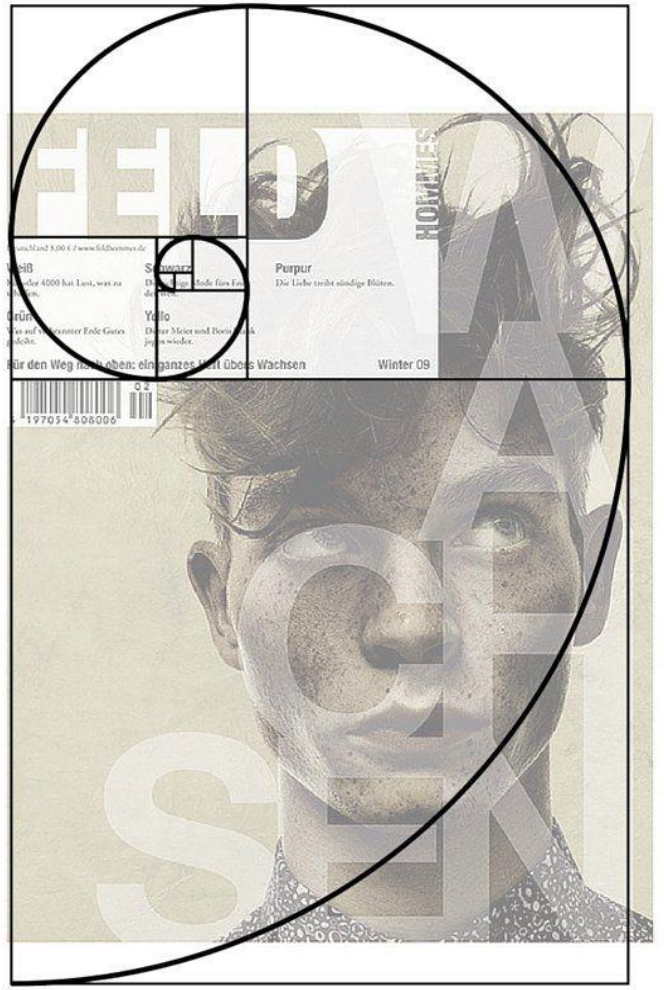

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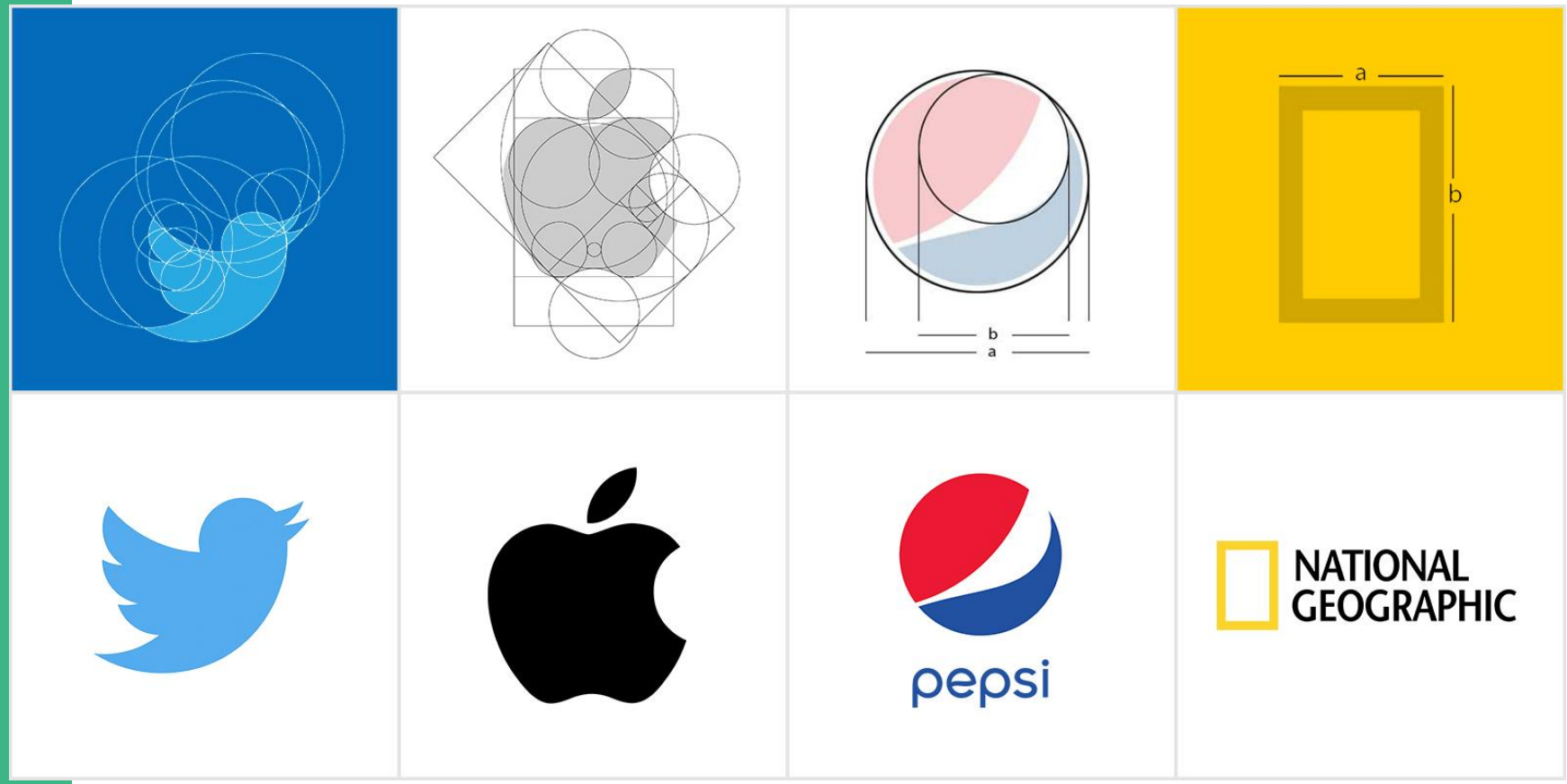
GOLDEN RATIO IN LOGO DESIGN



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GOLDEN RATIO APPLICATIONS IN ARCHITECTURE

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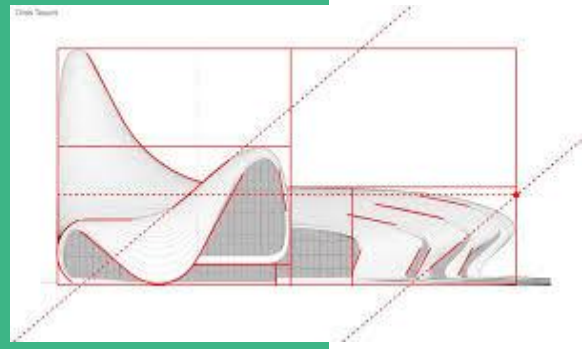

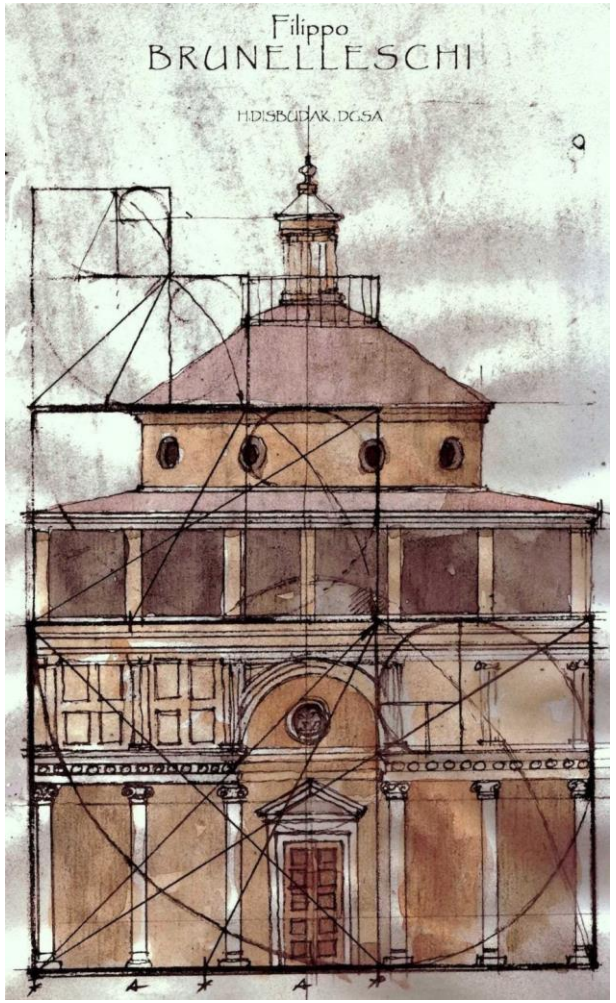

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Hand's project

HOW TO CREATE GOLDEN RATIO SPIRAL

STEP 1

Create a rectangle with Golden Ratio proportions.

STEP 2

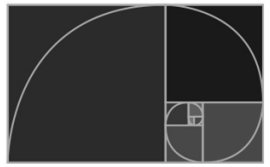
Lay the square over the newly formed rectangle.

STEP 3

Repeat the process unitl we obtain the series 0,1,1, 2,3,5,8.

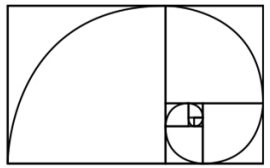
STEP 4

Draw an arch starting from one corner and ending in the opposite in all squares.



RESULT

We have form the Golden Spiral.



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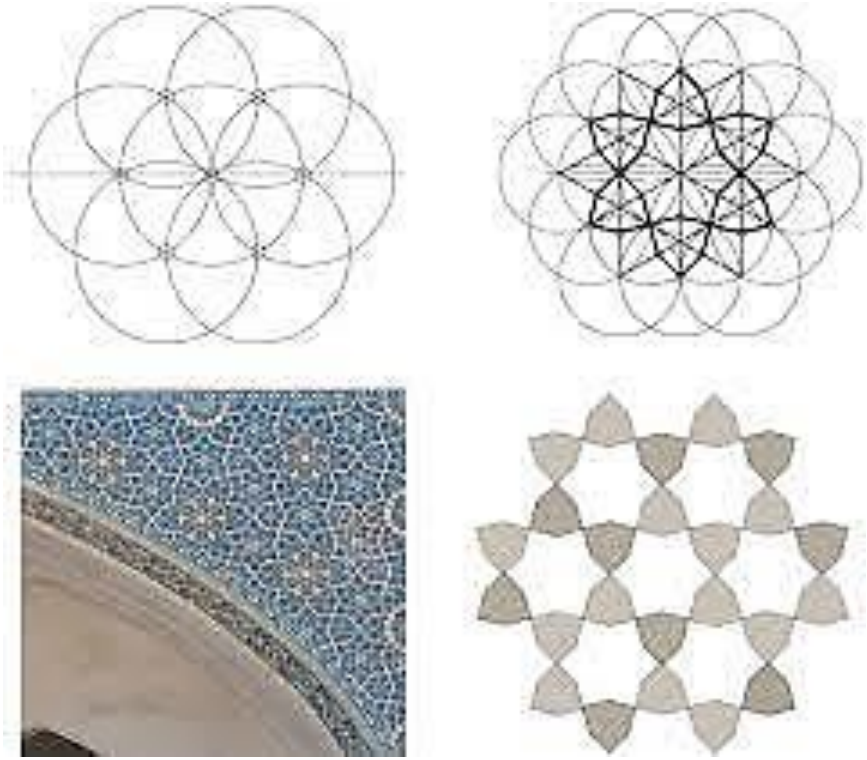
CIRCLE OF UNITY

The Muslim artists created the geometric proportions from the circle of Unity.

The circle of Unity is the most significant form, for it contains a circumference revolving around a fixed center.

It is therefore extremely important to understand that all other geometric shapes can be determined from a circle, from which come the full polygons, including series of roots and proportions.

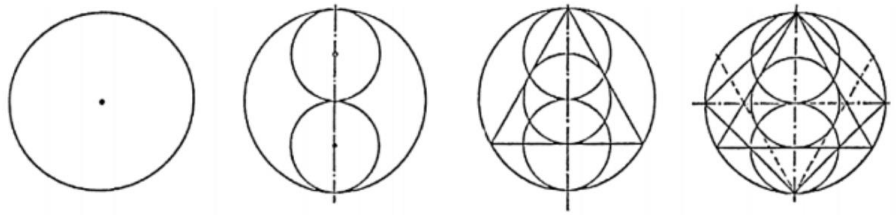


CIRCLE OF UNITY

Hand's project

Using a straight edge and compass, drew the four stages of geometrical creation:

from a point (monad) representing unity, to a line (dyad) expressing division, a plane (triad) denoting structure, and finally a solid (tetrad) representing



The four stages of the Geometrical Creation Story

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EVOLUTION OF GEOMETRY IN ARCHITECTURE

Hand's project

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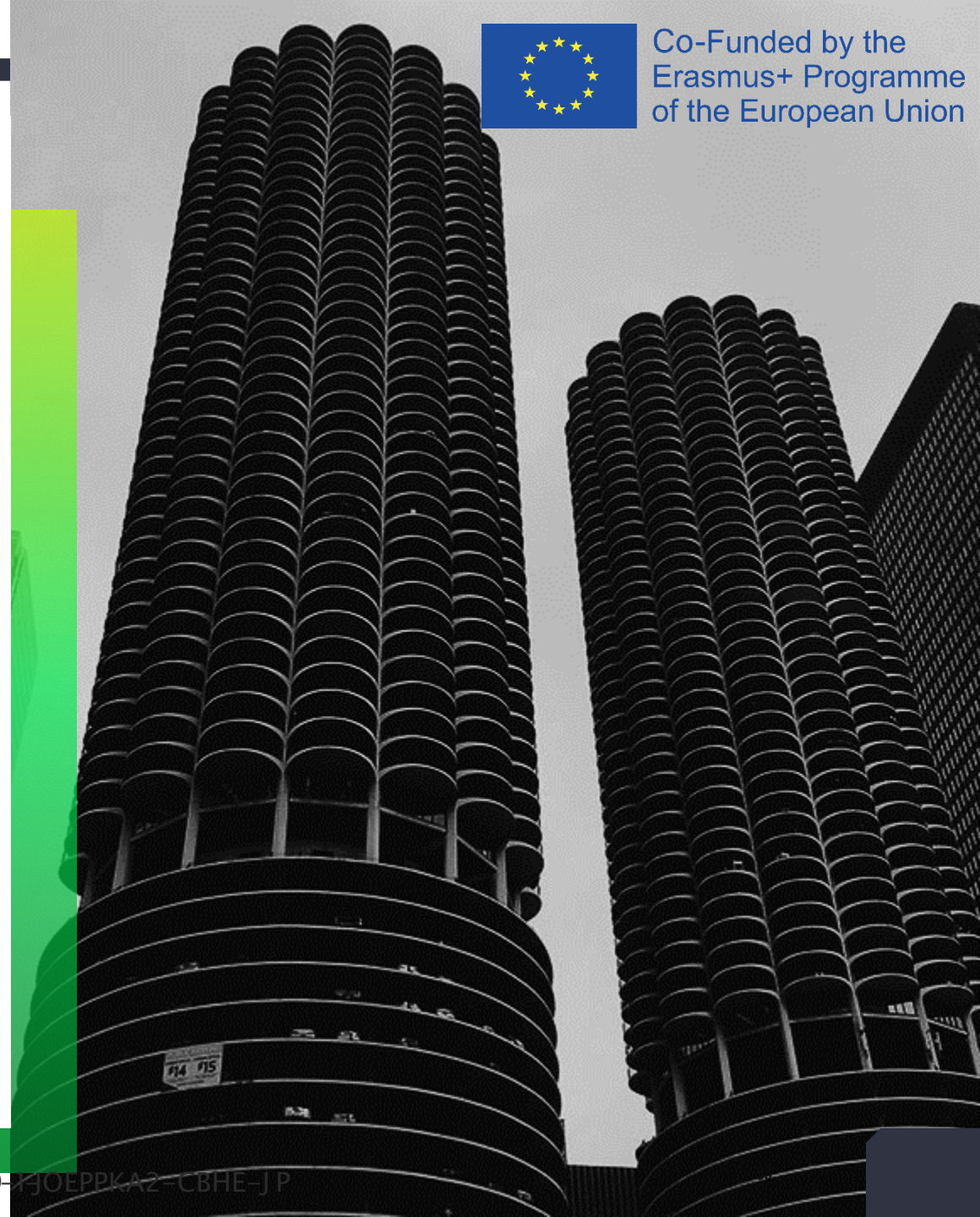
INTRODUCTION

- Throughout history the link between geometry and architecture has been strong
- while architects have used mathematics to construct their buildings, geometry has always been the essential tool allowing them to choose spatial shapes which are aesthetically appropriate.
- Sometimes it is geometry which drives architectural choices, but at other times it is architectural innovation which facilitates the emergence of new ideas in geometry.
- Among the best known types of geometry (Euclidean, projective, analytical, Topology, descriptive, fractal, etc…) those most frequently employed in architectural design are:

1. Euclidean Geometry
2. Projective Geometry
3. The non-Euclidean geometries



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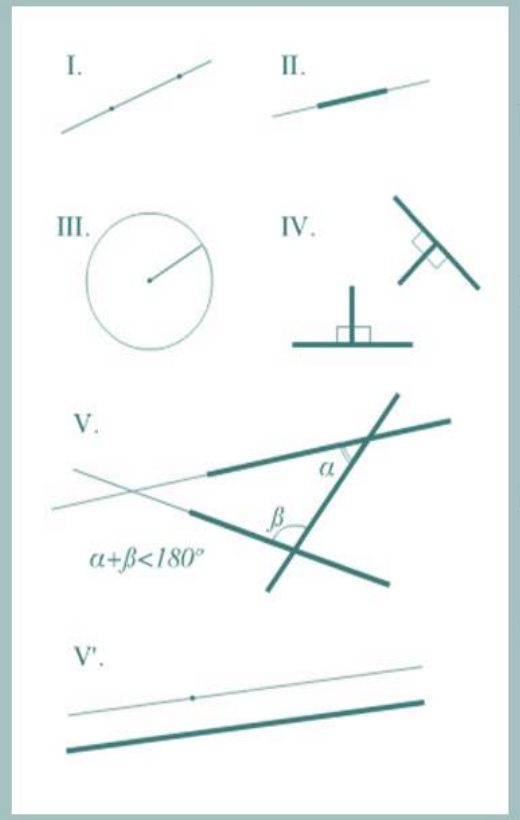
Euclidean Geometry

- For centuries geometry was effectively Euclidean Geometry: it was thought to be the one real geometry, representing space in a realistic way and, thus, no other geometry was believed possible.
- Euclidean geometry is the study of points, lines, planes, and other geometric figures, using a modified version of the assumptions of Euclid.
- The development of Euclidean geometry extends at least from 10,000 Be to the 20th century.
- Set of proportions in geometry that can be derived by rigorous logical steps from the five postulates stated by Euclid in his elements. The five postulates are:



Euclid's Five Postulates

I. Any two points can be joined by a straight line segment.

II. A straight line segment can be extended infinitely in either direction.

III. A straight line segment of any length can be used as a circle's radius, with one endpoint serving as the circle's center.

IV. All right angles are congruent.

V. If two lines intersect a third line in away that their inner angles add up to less than 180 degrees, those two lines will intersect on that same side, forming a triangle with the third line.

Euclidean Geometry in architecture

1. Flooding of the Nile symbolized the annual return of chaos, geometry, used to restore the boundaries, was perhaps seen as restoring order on earth: geometry acquired a kind of sacredness.

- A golden ratio pyramid is based on a triangle whose three sides represent the mathematical relationship that defines the golden ratio.
- This triangle is known as a Kepler triangle, where ϕ is 1.618 as shown on figure 1

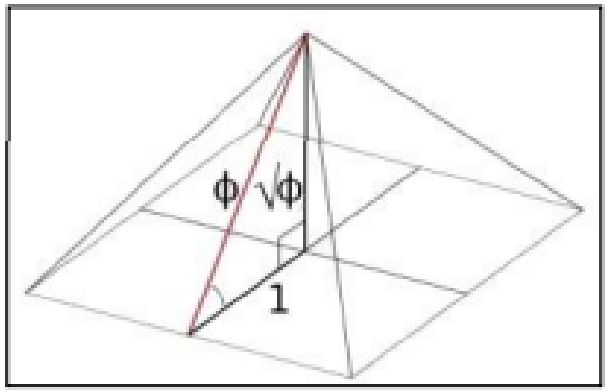


Fig. 1 The Kepler triangle

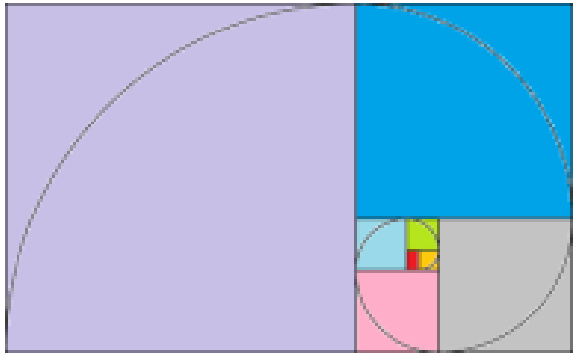


Fig.2 The golden spiral

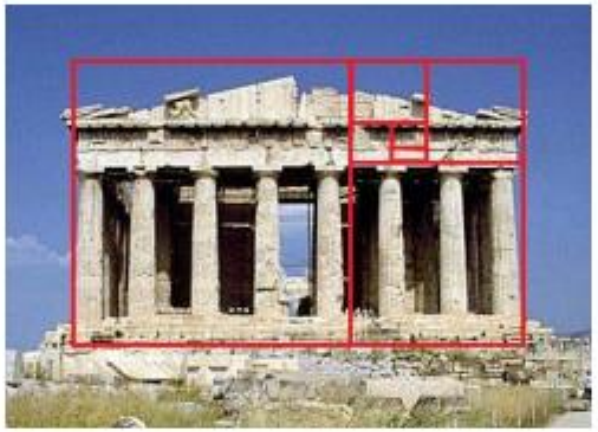


Fig. 3 The Parthenon (Athens, V century b.C.)

2. Fibonacci series :1,1,2,3,5,8 etc. figure 2 and 3.

- Temples represent the quintessence of Greek architecture, and Euclidean geometry was the canon defining the proportions of the component parts of these buildings
- The dimensions of an object of beauty are determined by the relationships between its component parts.

3. Euclidean geometry informed architectural styles up to the Romanesque period (the Malatestian Temple at Rimini (L.B. Alberti, 1450-1468)

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PERSPECTIVE AND PROJECTIVE GEOMETRY

Perspective conceives of the world from the viewpoint of a “seeing eye”.

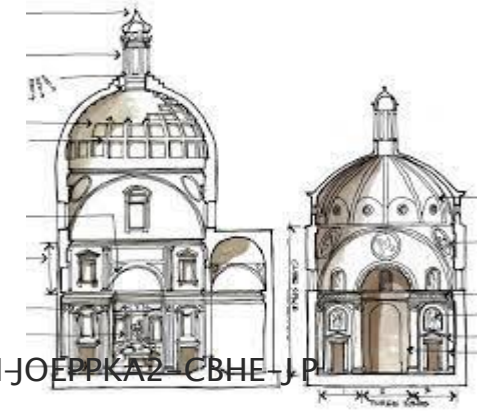
In architecture, a solid perspective gives the beholder the illusion of a greater depth than is real (Saint Mary by Saint Satyrus Church in Milan)

- In the convent of Trinità dei Monti, images of saints which are clearly visible from a precise, lateral viewpoint dissolve as one comes closer to the center of painting.

https://youtu.be/4aGWQOzH0JY?si=fd0hlZRk7tgeRSUy

- Projective geometry is concerned with the study of the properties of figures, with respect to a series of transformations, defined as projective, obtained by operations of projection and section that can alter the metric properties, but not the projective ones.
- understanding of how images are formed depends on an analysis of the process by which a (three-dimensional) scene is projected onto a (two-dimensional) plane, examples:

  - (plans, elevations, sections)
  - Change in geometry as we move vertically (San Lorenzo Church)



PERSPECTIVE ARCHITECTURE AND OPTICAL ILLUSION

all images by maxim loskutov

Hand's project

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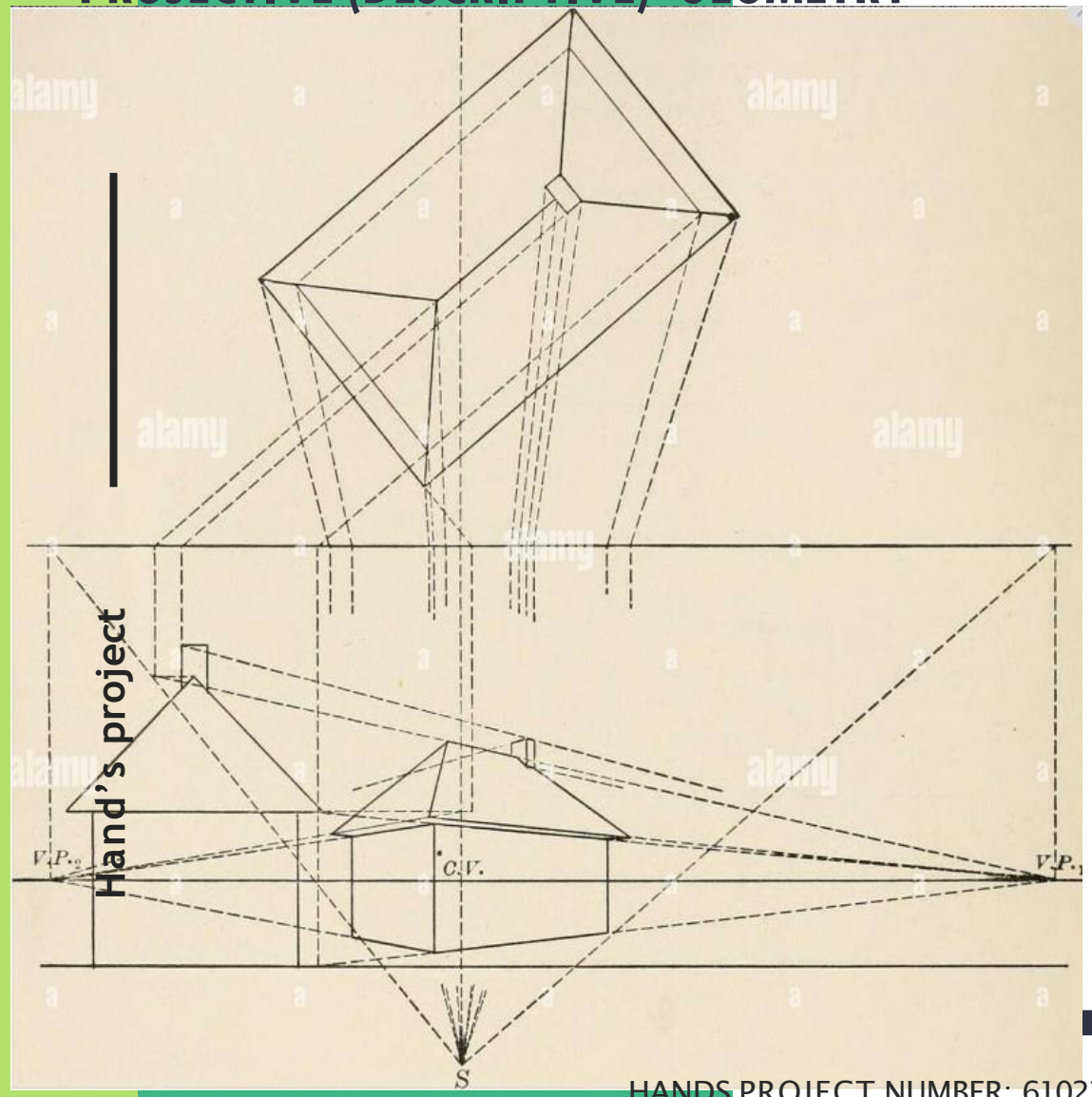
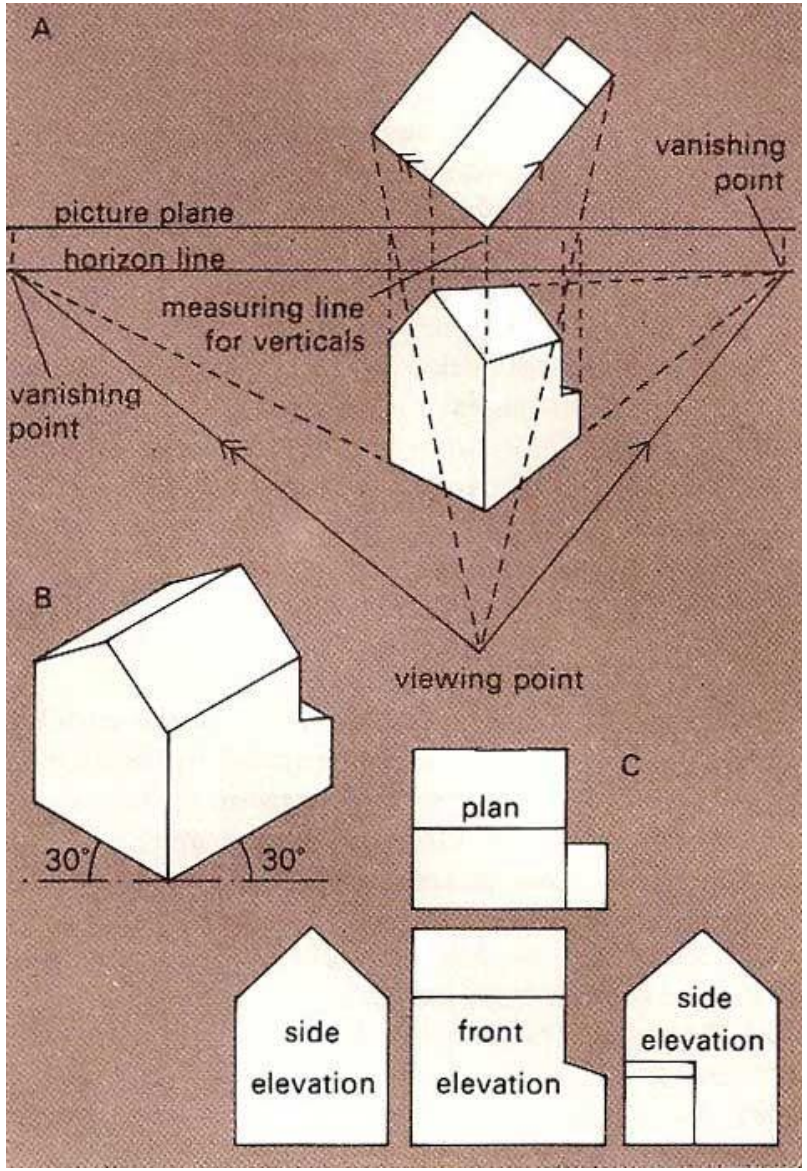
PROJECTIVE (DESCRIPTIVE) GEOMETRY





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Non-Euclidian geometry

- Non-Euclidean geometry is obtained by replacing Euclid's parallel postulate by one of its contradictory forms.
- The use of non-Euclidean geometry in architecture is currently an important route to developing the optimum structural forms and in the search for effective engineering solutions .

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Picasso

Malevich

Hand's project

- The idea of watching an object from all viewpoints has to do with going beyond the third dimension, objects are broken and re-assembled as well as being displayed in a broader context.

  Non-euclidean geometries are present in the work of artists like picasso and malevich and in architectural constructivism and deconstructivism.

  The hyperboloid tower built by shukhov for the nizhny novgorod exhibition (1896) was the prototype for many industrial buildings, and perhaps it was thanks to this that he had some influence on russian constructivism.

  Indeed, constructivism encouraged the use of industrial materials and of shapes derived from technical processes.

  In deconstructivism walls of buildings slope and open out, and the buildings themselves are out of place in their locations:

  cuts, fragmentations and asymmetry are their main characteristics. One important representation is the guggenheim museum in bilbao, by frank gehry (1997)

The Shukhov Tower (1920-1922)

Guggenheim Museum (Bilbao, 1997)

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Application of non-Euclidean geometry in modeling of architectural forms based on selected examples

1 Elliptic geometry

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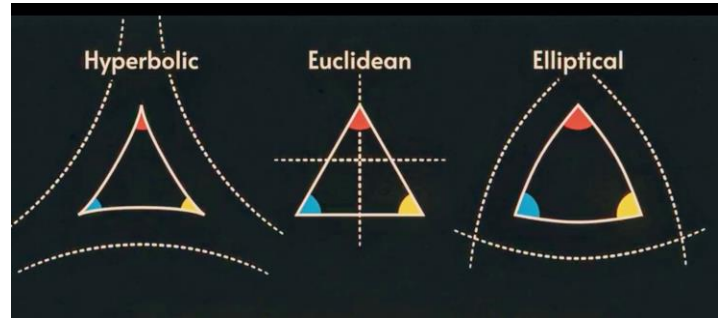

- Elliptic geometry :the sum of internal angles of any triangle is greater than 180°.
- Moreover, in elliptic geometry, all the straight lines are closed lines with a finite length .

30 St Mary Axe Tower, design by Foster & Partners, London;

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2 Hyperbolic geometry

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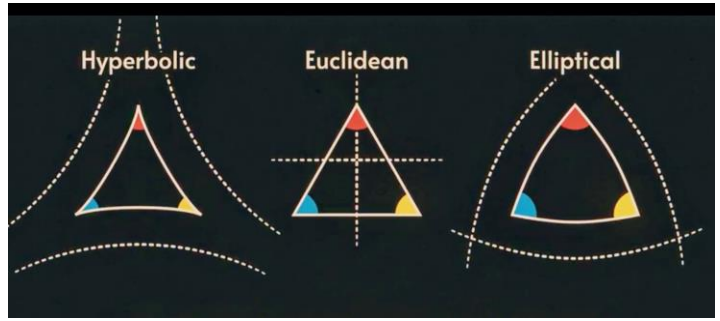
St. Maria Cathedral in San Francisco



hyperbolic geometry: a plane is the surface of a saddle, geodesic lines are inflated and the sum of internal angles of any triangle is less than 180°

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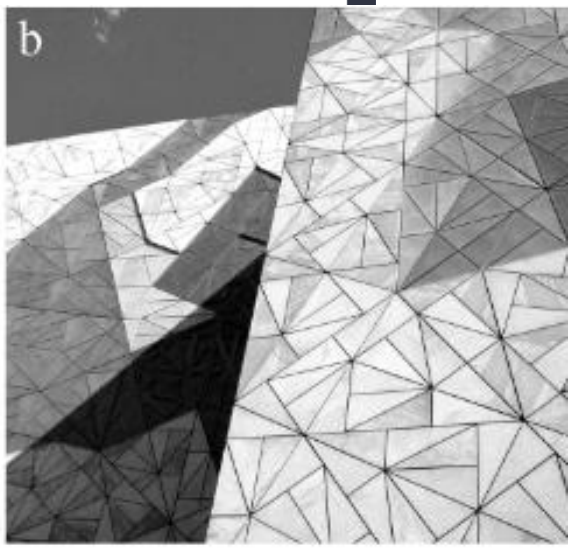
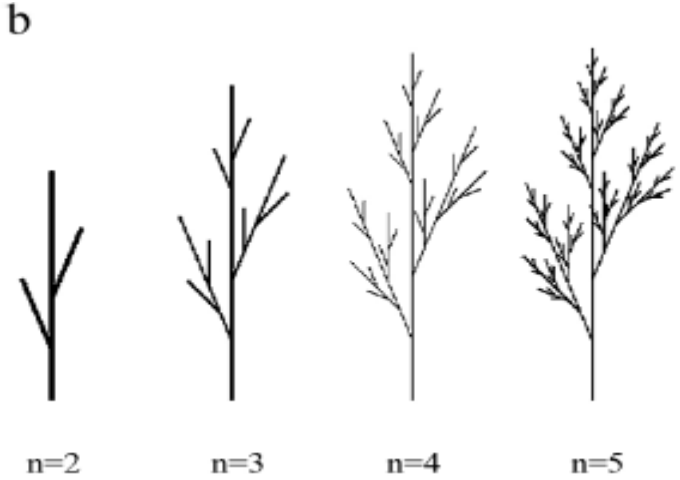


Federation Square, Melbourne



Fractal geometry (mathematicsused to describe and analyze the irregularities found in natural structures)

- describes fractals, self-similar objects forming small structures in a wide range of magnification levels. The characteristic features of fractal geometry elements include:
- self similarity (every fractal part, no matter how low the structural level, bears similarity to the entire structure),
- fractal dimension (describing the complexity of a fractal)
- Iterative structure (the same procedure being repeated for an infinite number of times).

GEOMETRY AND PROPORTION IN ARCHITECTURE

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Hand's project

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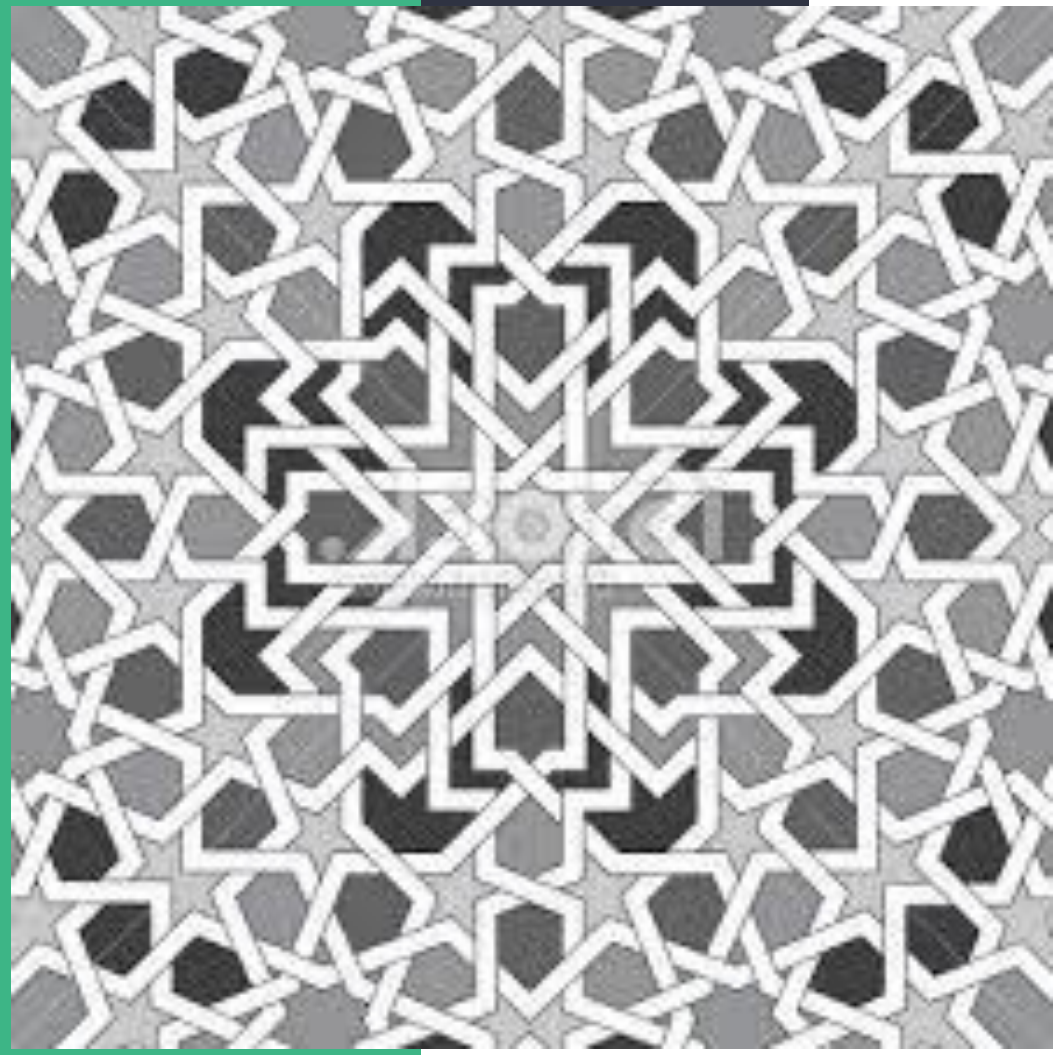

OUTCOMES

What is Geometry and proportion?

Geometry and proportion in architecture?

What are the geometry systems?

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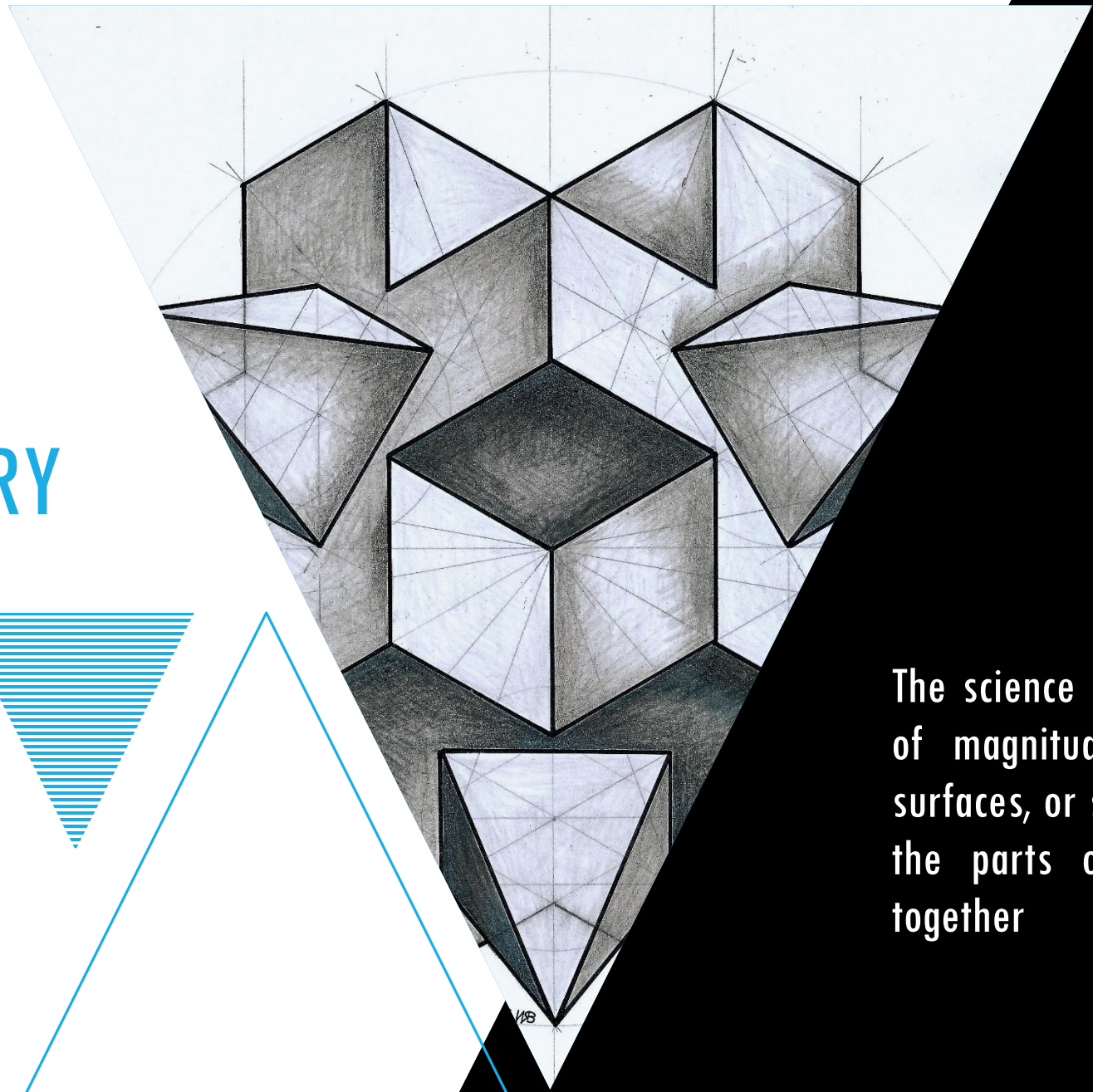
GEOMETRY



Hand's project

The science of properties and relations of magnitudes such as points, lines, surfaces, or solids in space and the way the parts of a particular object fit together

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GEOMETRY AND PROPORTION SCIENCE

It is the science that deals with numbers in space on four basic levels:

1. Arithmetic (pure numbers), i.e., Any measurement or proportion is a geometrical measurement.
2. Numbers in space which represent proportional geometry. They reflect the meanings and “Ideas”.
3. The third level is numbers in time, which is the foundation of music.
4. The fourth level is numbers in space and time which represent the cosmology of the universe.

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GEOMETRIC PROPORTIONS IN ARCHITECTURAL PATTERNS

Hand's project

- Geometric proportions in architectural patterns represent a design language, as words do in a spoken language.
- They determine the frameworks within which elements may be arranged into a pattern, a relation between one element and another, and a proportional relation within one element.
- They reflect the natural laws that govern the basic harmonies of nature, being describable by means of mathematics and geometry.

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HISTORY OF GEOMETRY IN ARCHITECTURE

Geometry has existed in many buildings and design forms across centuries.

- The earliest form was found in Prehistoric carved stones found in Scotland.

Geometric ratios and proportions existed and were employed in the design of ancient sacred and ceremonial sites in all traditional civilizations.

- They were built with dimensions that incorporate mathematical numbers, constants and ratios such as the “golden/sacred mean”, and the use of geometries based on proportional rectangles and Pythagorean triangle.

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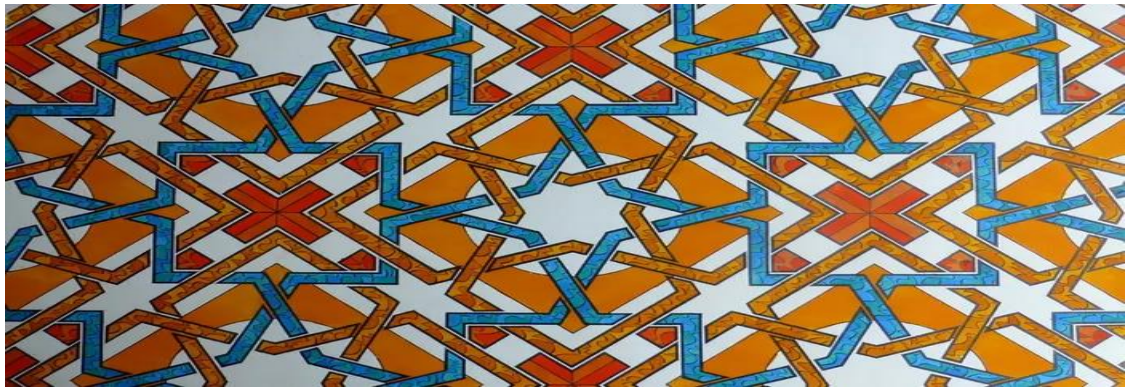
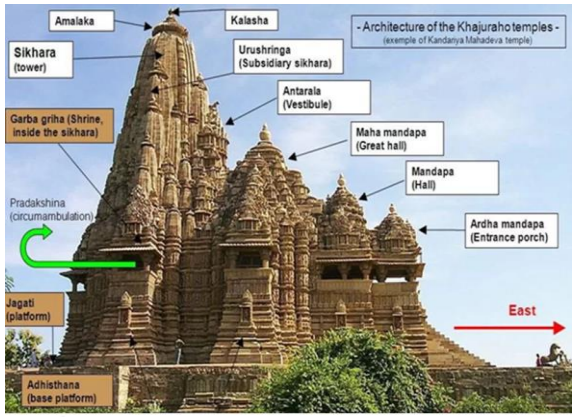
Hand's project

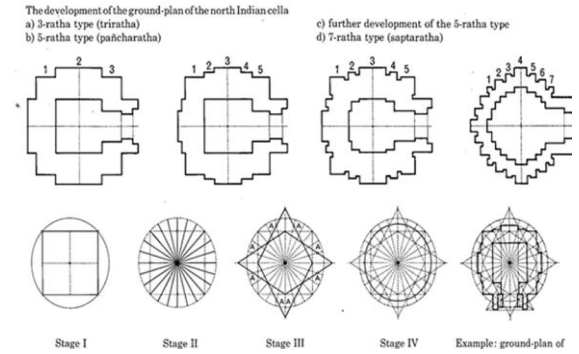
-CHRISTIAN CATHEDRALS INCORPORATED SYMBOLIC GEOMETRY.

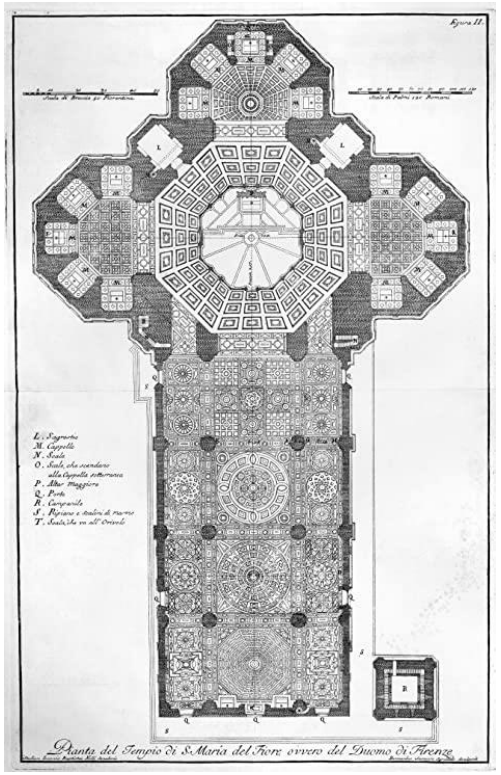
-THE DESIGN OF HINDU AND BUDDHA TEMPLES WAS BASED ON SACRED GEOMETRY.

-IN ISLAMIC ART, GEOMETRIC ELEMENTS USED TO CREATE UNIQUE GEOMETRIC FORMATIONS, SERVING AS THE UNDERLYING STRUCTURE OF ISLAMIC DESIGN PROCESS.









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GEOMETRY AS CODES

Geometry explores and explains the patterns that unify the structure of the Creation within all natural patterns of growth or movement and their conformity with geometric shapes.

All life forms emerge out of timeless geometric codes.

Viewing these codes allow us to understand the universe in order to fully comprehend and appreciate its beauty based on the concept of proportions.

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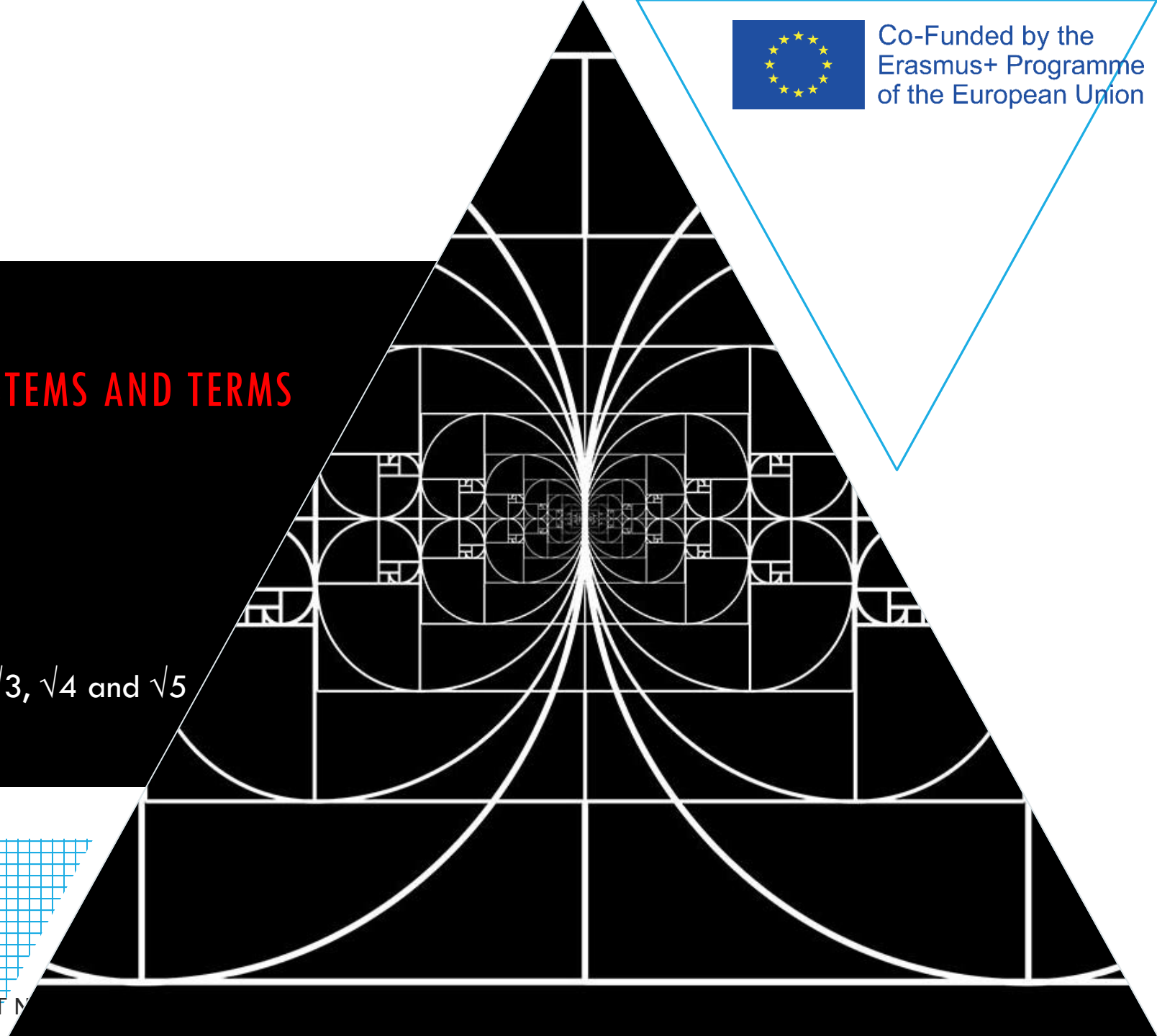
GEOMETRIC PROPORTIONAL SYSTEMS AND TERMS

- The golden mean proportion.
- Circle of Unity
- HUMAN PROPORTION (Vitruvian Man)
- The primary three proportional roots $\sqrt{2}$, $\sqrt{3}$, $\sqrt{4}$ and $\sqrt{5}$



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Hand's project

GEOMETRY IN MAN, NATURE, AND COSMOS

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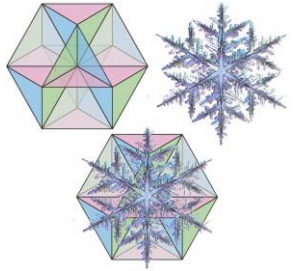
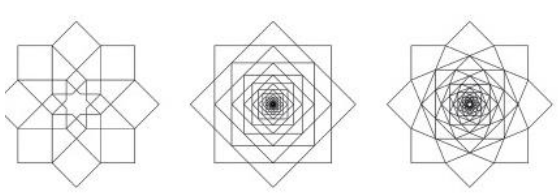
GEOMETRY IN NATURE

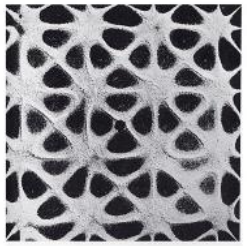


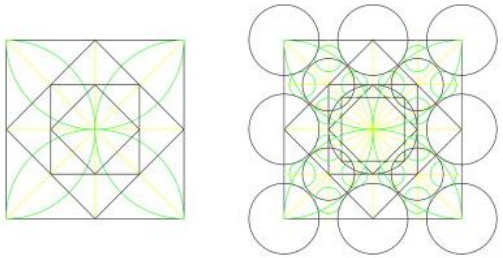
Hand's project

1. Many forms observed in nature can be related to geometry.
2. For example, the snowflake crystals and honey cells construct hexagonal geometries.
3. Flowers in nature tend to have a variety of geometries.
4. Radium crystal and sound vibrations that carry sound information are based on $\sqrt{2}$ proportions, showing the octagonal geometry.
5. Four, five, and six pointed geometries seem to be more common in nature.
6. There are many plants and other aspects of nature which exhibit the form of spiraling geometry, which is related to Fibonacci proportions based on the golden mean.

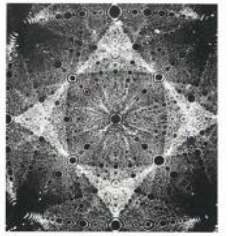


Sound vibrations in creating pattern





Radium crystal based on Octagon



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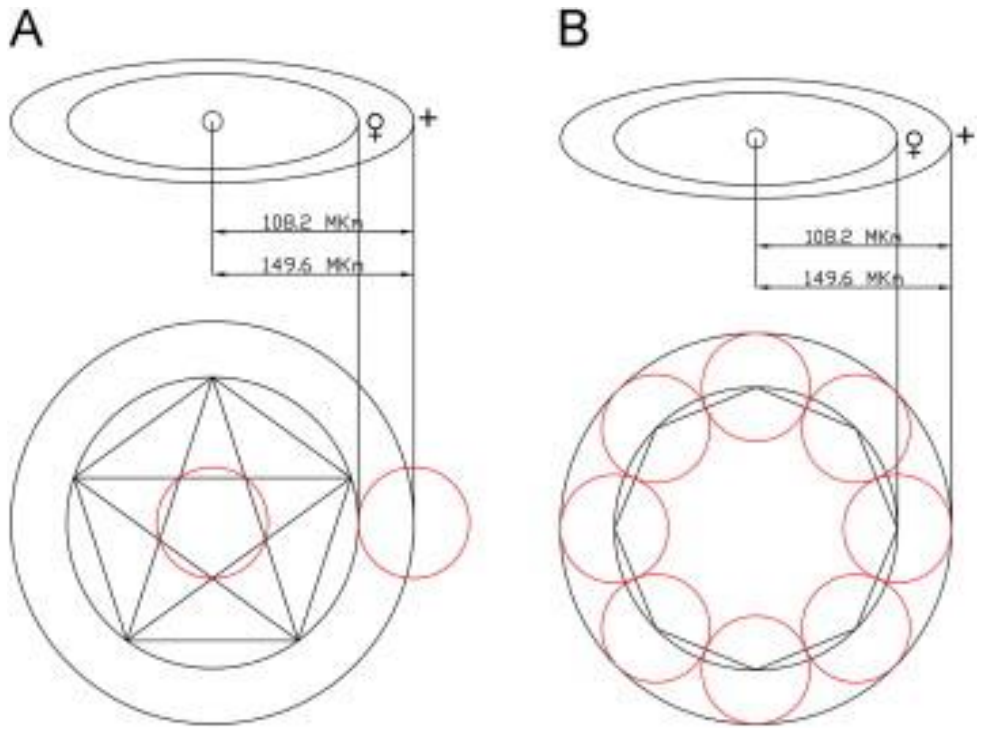
GEOMETRY IN COSMOS

- The mathematical harmony of the universe can be seen from the proportions of the planets in our solar system.
- For example, the ratio of the sacred mean can be seen in the rotations of the Venus and the Earth around the Sun in that for each five years that the Earth rotates around the Sun, the Venus rotates around it eight times.
- The connection between 5 and 8, both of which are Fibonacci numbers, is the golden mean proportion (8/5=1.6).
- The result of this motion is that the Venus “draws” a pentagon around the sun every eight years (Skinner, 2009).
- a circle is drawn, which represents the Venus' mean orbit. A pentagon is constructed inside it and a small circle placed through the arm-crossing points.
- The radius of this small circle divides the radius of the large one into golden sections and can be used to space the Venus' orbit from the Earth's orbit.
- It can be seen from the agreement between eightfold and fivefold geometries that eight touching circles are drawn from the Venus' mean orbit. In turn, the circumference circle is enclosing these eight circles, defining the Earth's mean orbit.



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GEOMETRY IN COSMOS

Golden mean is the “fingerprint” of creation!!!

https://youtu.be/jcJiRmZ9WmY?si=J9Yb_PIs6CypiAau

https://youtu.be/p9mG149Nfrk?si=mZJ91ugDUs7uTitT

https://youtube.com/shorts/WwxhBirHkcQ?si=q30QlQLX7UmxvCnZ

- Geometry is the very basis of our reality.
- we live in a coherent world governed by underlying laws ,They are always manifested in our world.
- The golden mean and proportional roots govern the proportion of our world, which can be found in the proportions of all living and nonliving forms.

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ARCHITECTURAL APPLICATIONS

Hand's project

- **Bio-Architecture concept** :Bioarchitecture is a blending of art/architecture and biomimetic/bioinspiration, and incorporates a bioinspired design from the outset in all parts of the work at all scales.
- It has been used continually in architecture through time
- See the examples carefully.

ribs with intercostal muscles

rib vaulting, Exeter Cathedral Exeter, UK (architect unknown, 1400)

human iris

artificial irises, Institut du Monde Arabe, Paris (Nouvel, 1987)

femur with force diagram (Thompson, 1917)

La Tour Eiffel, Paris, France (Eiffel, 1889)

bird wings unfolding

solar sensitive wings, Milwaukee Art Museum, Wisconsin (Calatrava, 2001)

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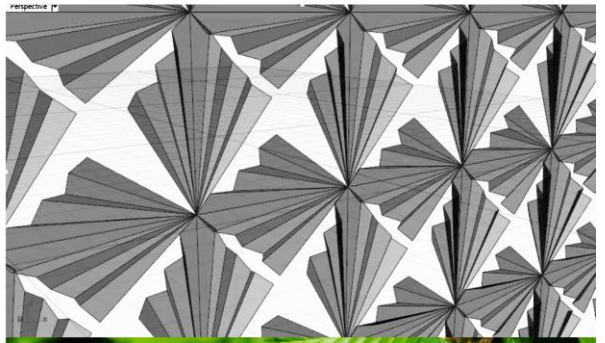
ARCHITECTURAL APPLICATIONS

- Parametric modelling is a 3D modelling technique that **uses a computational methodology to manipulate geometry**. It happens algorithmically using parameters which are geometric properties of a design model.

- Modern technology



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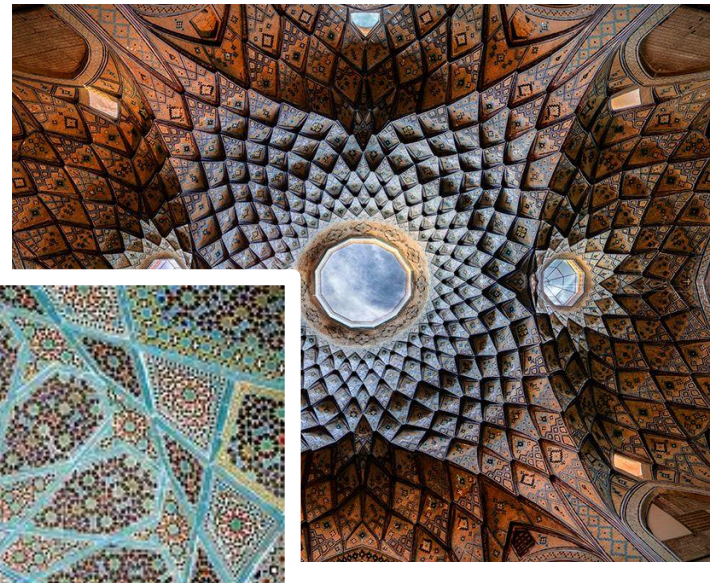
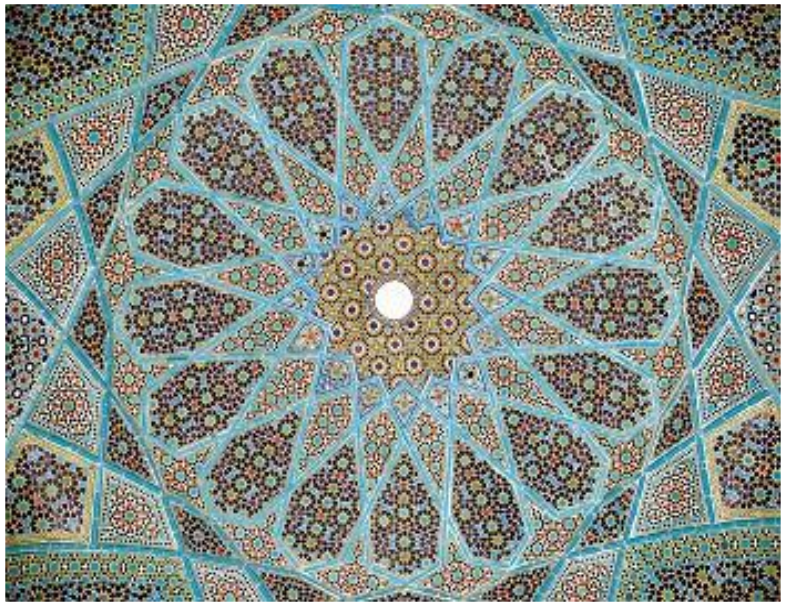
ARCHITECTURAL APPLICATIONS

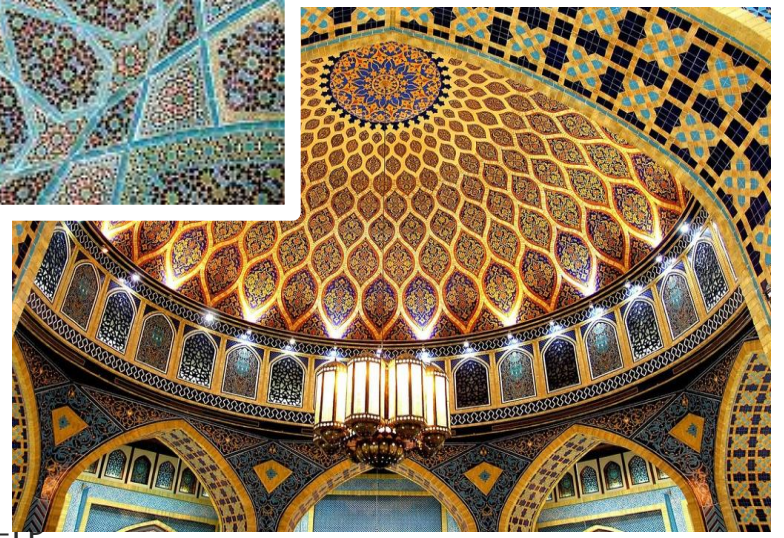
Islamic patterns and roofing

Islamic architecture is created based on the essential harmonies of nature together with various symbolic meanings and theories of perfect proportions.

The designers based their geometrical vocabulary on what they have seen in the nature around them, in an attempt to develop a codified series of proportions which may improve our psychological comfort with buildings.







Hand's project

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GEOMETRIC PROPORTIONS AS A TOOL OF DESIGN: STUDY MODEL

The system of geometric design starts from the circle (the basic unit), from which the pattern starts to unfold, creating harmonious divisions of the circle in four stages:

1. The planning stage: starting by determining the proportional systems based on the unit pattern structure within the circle of Unity. The decision is based on the symbolic meanings underlying the geometric pattern and its relation to micro–macro cosmos.
2. The division phase: construction of the basic geometric pattern.
3. Pattern order and structure: initiating the crossing lines to create the artistic shape of the pattern on natural junctions formed by those lines. This gives rise to a series of points that can be used in the development of patterns. This type of framework forms the driving geometry for the relatively simple Islamic patterns with which we are familiar.
4. Desired pattern revealing: establishing the geometric variations of the pattern and defining its boarder lines. It is derived from all the vital proportion systems based on a single unit. The process can be repeated indefinitely, presenting the same center everywhere and nowhere. It is ratio, rather than measurement, that determines the relative lengths of crucial dimensions

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THE SACRED GEOMETRY OF PERFECT FORMS IN EAST AND WEST

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GENERAL OVERVIEW

Western Classical architecture, such as that of Greece and Rome, as well as the Eastern architecture of Hinduism and Buddhism considered the circle, the square, and the triangle to be the most perfect of building forms.

the western emphasis on the periphery or circumference of each form as opposed to the eastern focus on the center

This led, in part, to the creation of building types in East and West that differ in how religious buildings look, in how they are experienced, and in how they are used.

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THE IMPORTANCE OF THE ARCHITECTURAL CENTER AND PERIPHERY – EAST AND WEST

The importance in the West of the architectural perimeter, as opposed to the center, is a result of the practice of congregational (communal) worship in Western religions.

This practice requires a space in which a congregation can assemble and readily hear the words spoken by their leader or clergyman.

Therefore, the speaker had to be situated facing the congregation in order to be heard. If the speaker were located at the center point of a square, circular, or triangular space, all those behind him would have difficulty hearing (before modern amplification) and consequently could not fully participate in the religious service.

Hence, a rectangular space with a stage located at one end evolved as the most useful space in which to hold western religious activities

Structures used to make astronomical observations are often, of necessity, circular in form

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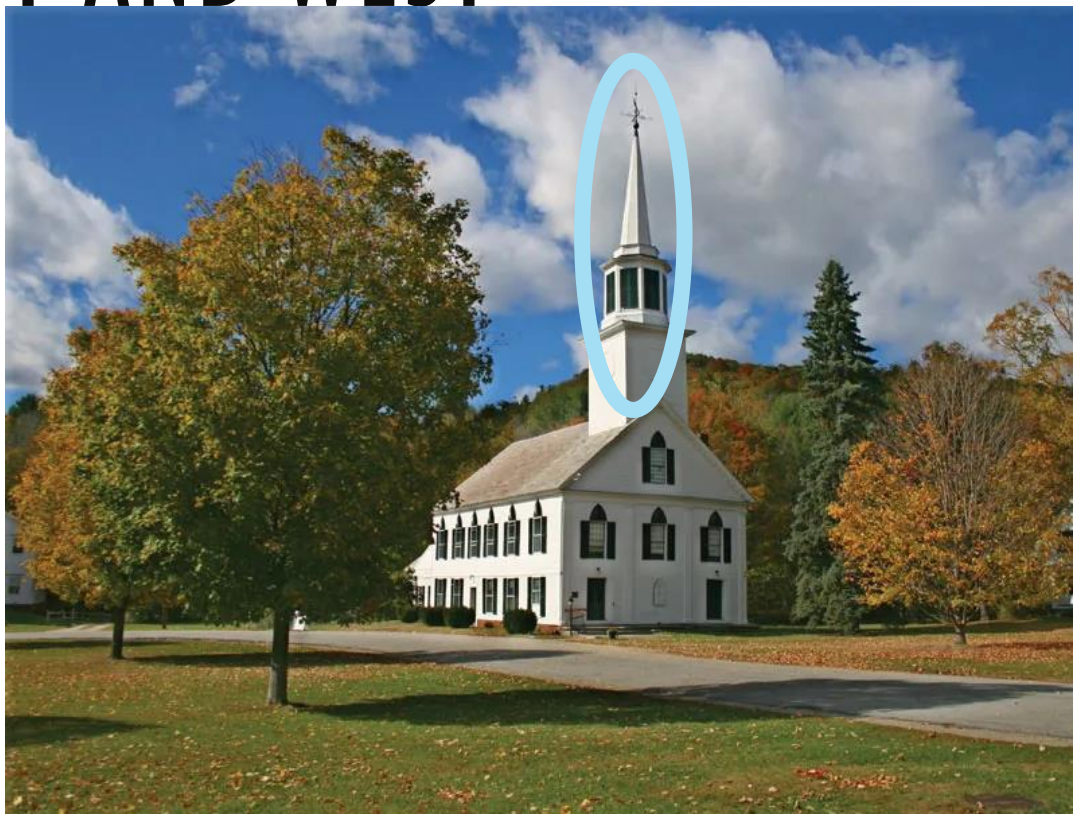
THE IMPORTANCE OF THE ARCHITECTURAL CENTER AND PERIPHERY – EAST AND WEST

Hand's project

Also, the center point of Christian, Jewish, and Islamic religious structures is not of ritual or religious significance and, therefore, is rarely architecturally marked inside the building or on the exterior.

In many Christian churches the steeple, the most salient external architectural feature, is not located over the center of the building or over the altar but instead, for structural reasons, is often placed over the foyer to the sanctuary – a point of no ritual importance at all!



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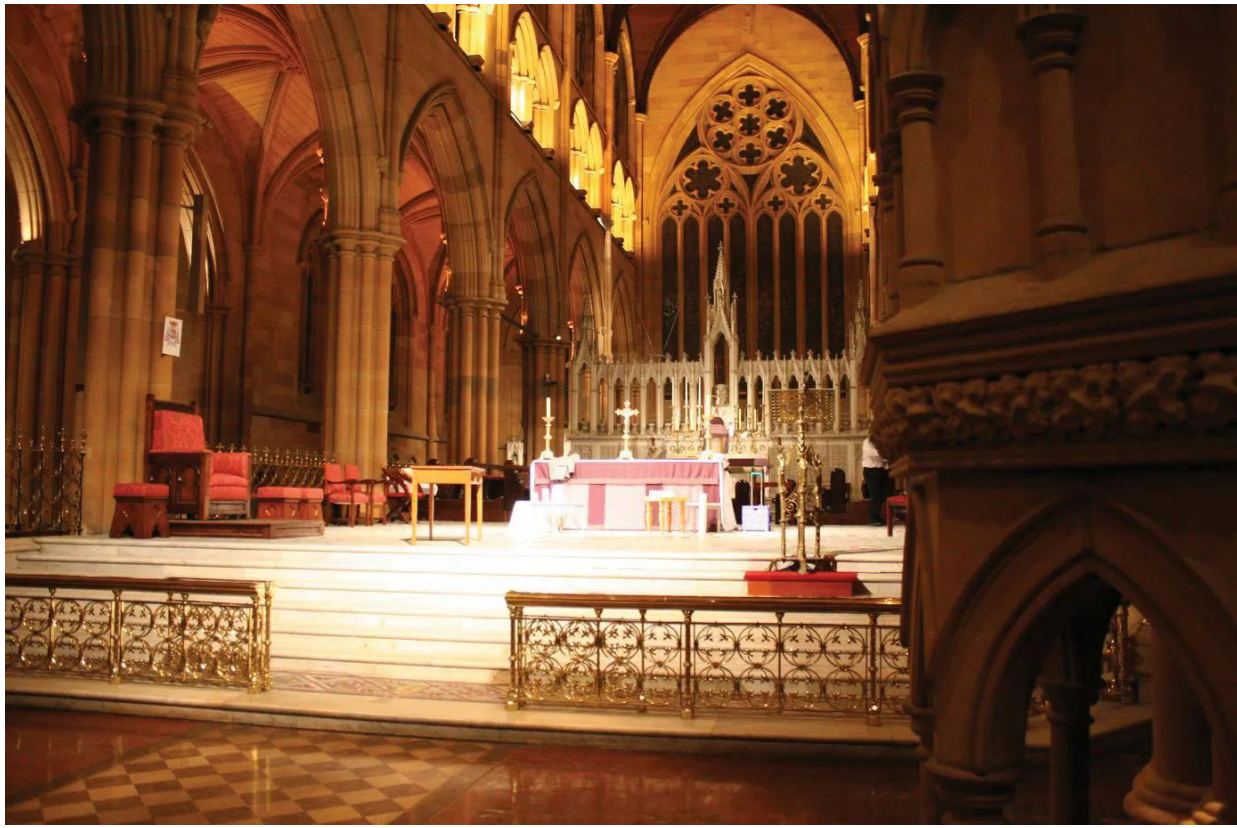
THE IMPORTANCE OF THE ARCHITECTURAL CENTER AND PERIPHERY – EAST AND WEST

In Christianity and Judaism the sanctuary is most often a rectangular area that is usually walled and enclosed by a roof.

In Western religions the essential religious rituals are communal and, therefore, a ritual space must be provided that is large enough for all members of the congregation to assemble at once.

Although external size is symbolically important in both East and West - the larger the building, the more powerful and prestigious the religious group is thought to be - the interior of Western religious buildings must enclose a large, unobstructed space to be useful for congregational purposes.



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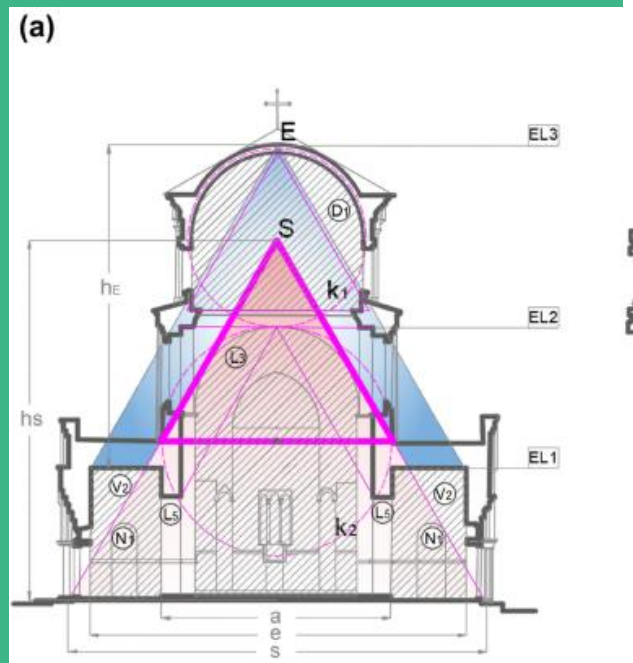

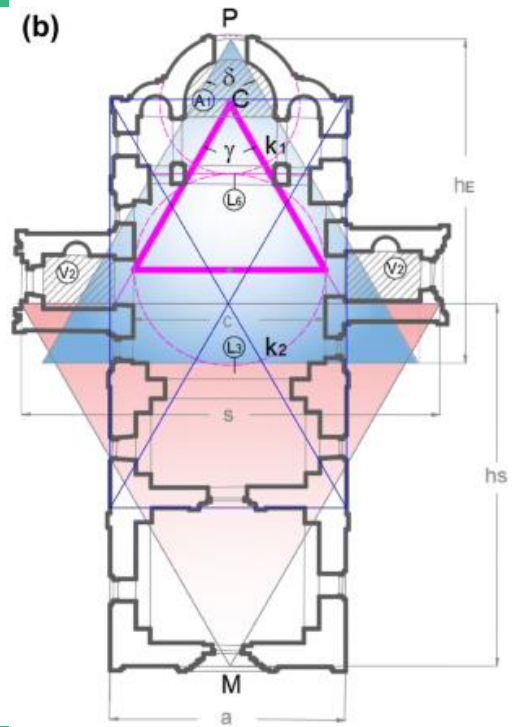

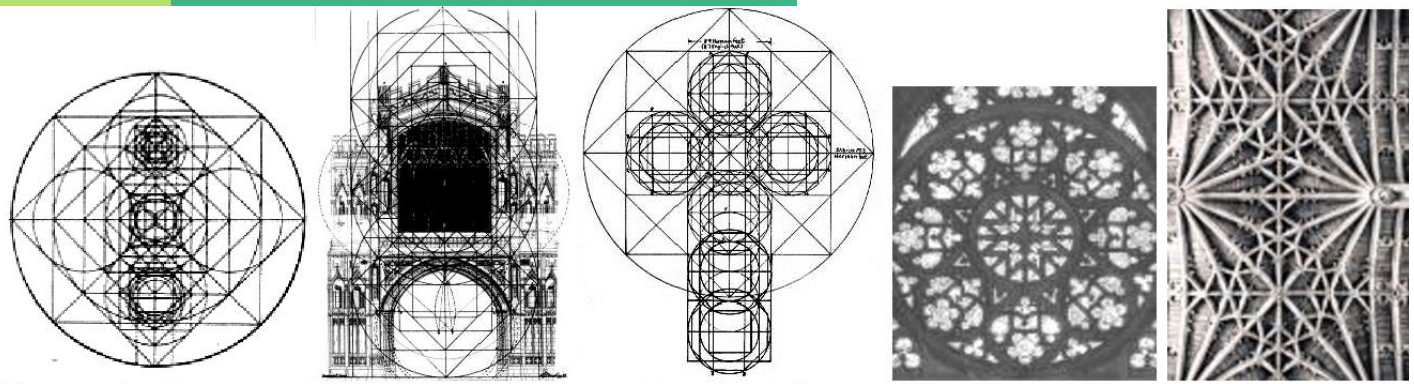

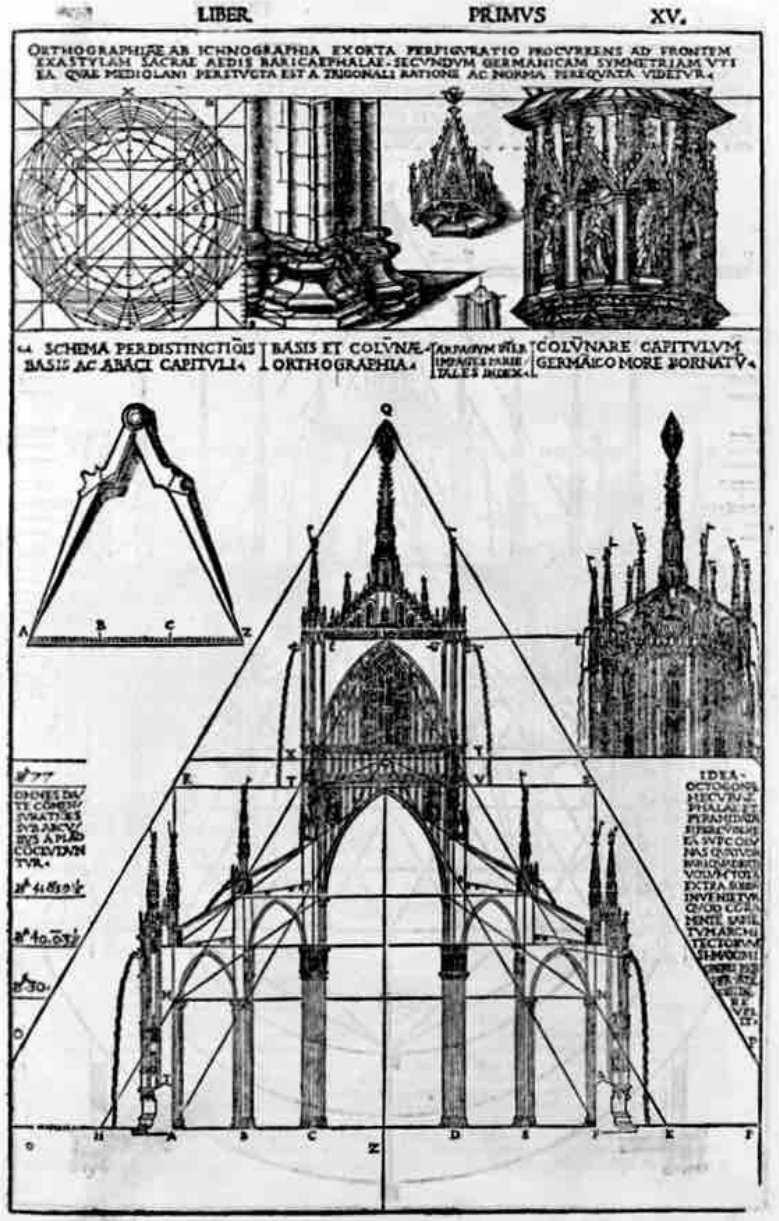

Figure 12: Octagons in Gothic architecture: (a) as invisible working lines with geometric

THE IMPORTANCE IN THE EAST OF THE CENTER AS OPPOSED TO THE PERIPHERY IS A RESULT OF PROCESSIONAL WORSHIP

Worship in Hinduism and Buddhism is essentially a processional and singular practice, not congregational.

Daily worship by Hindu and Buddhists consists of a pilgrimage from home to temple that terminates with individual prayer at the architectural, as well as ritual, center-point of the temple.

Eastern worship, therefore, is essentially processional, as opposed to congregational, because it is an actual journey that is meant to trace the path or journey of the individual's soul to salvation – an event believed to occur at the very center of an individual's being.

As an outgrowth of these beliefs, Eastern religious practice requires processional pathways or corridors to guide the worshiper along what is conceptualized as a "circular" route moving toward the center of the temple.

Consequently, there is little need for a large interior space, since the center is approached, experienced, and used individually, not communally, for devotional purposes.

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THE IMPORTANCE IN THE EAST OF THE CENTER AS OPPOSED TO THE PERIPHERY IS A RESULT OF PROCESSIONAL WORSHIP

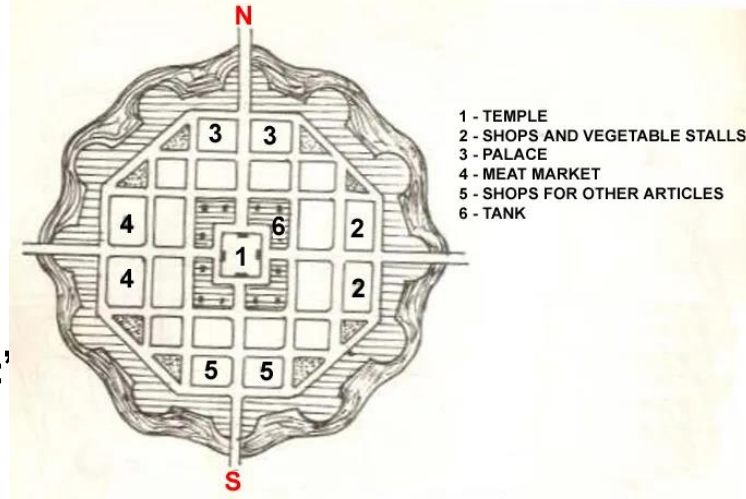
Although small room is enough, large Eastern temples most often consist of concentric corridors leading circuitously to a small room, **the inner sanctum**, where the most important religious image is located and which has enough room for individuals to conduct their devotionals and pray.

In Hindu temples, the inner sanctum is a space sufficiently large to accommodate several priests while they perform required rituals (that do not require an 4 audience) and for devotees to receive blessings from the priests after they arrive for prayer at the center of the complex.

In Hinduism and Buddhism this centermost point is ritually important because it represents the point at which the soul experiences salvation, known as **Nirvana in Buddhism and as Moksha in Hinduism**.

This is why Buddhist and Hindu monarchs build a least one temple and, indeed, often their entire capital city, in the shape consisting of concentric squares that is known as a **Mandala**.

The Mandala is a sacred, geometric diagram or map that usually consists of "concentric" squares but may include concentric circles and rarely "concentric" triangles



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Hinduism geometry architecture

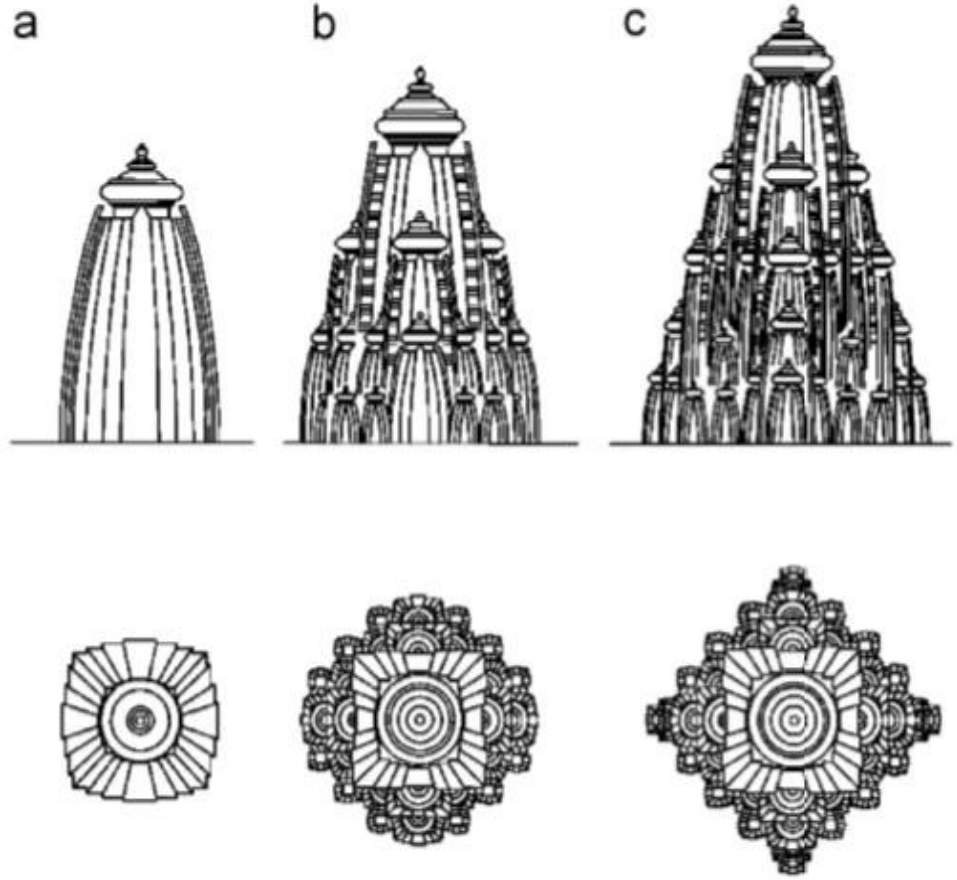
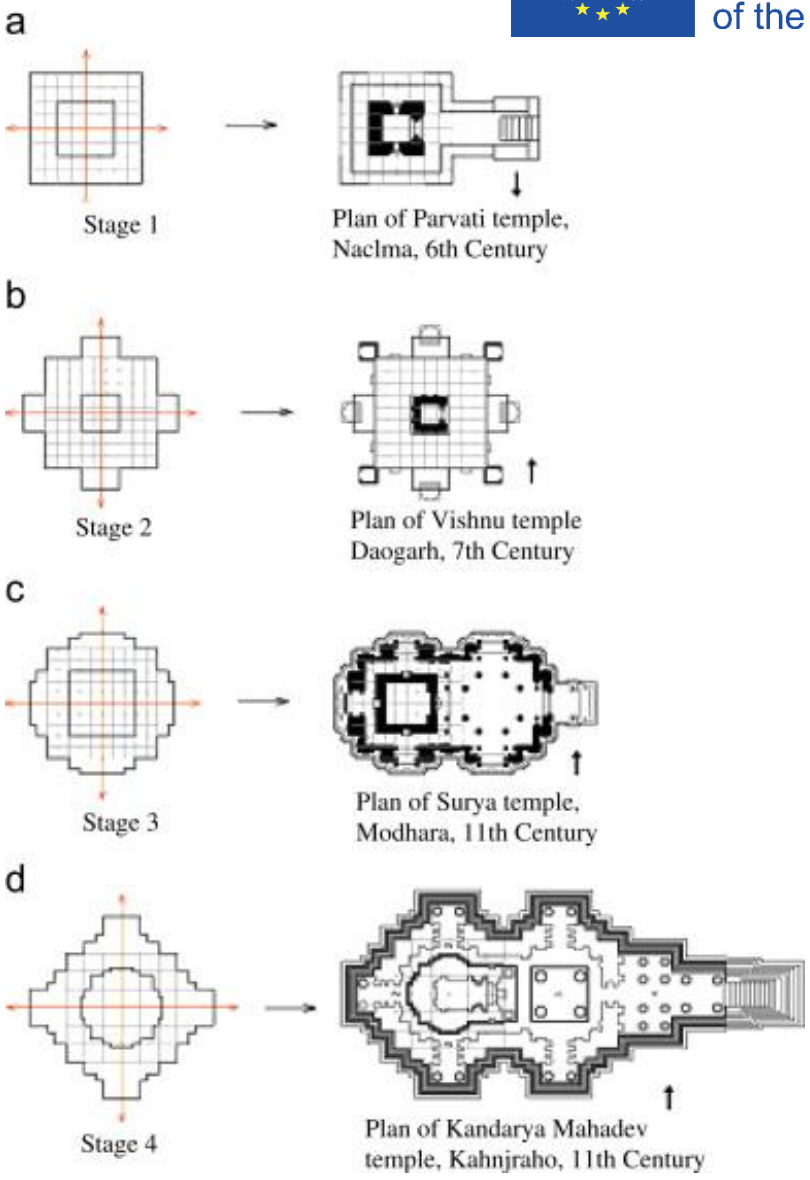


Fig. 18. Elevations and plans of: (a) *Shikhara* of Adinatha temple (900 AD); (b) *Shikhara* of Paraswanatha temple (950 AD); and (c) *Shikhara* of Kandariya Mahadev temple (1050 AD).



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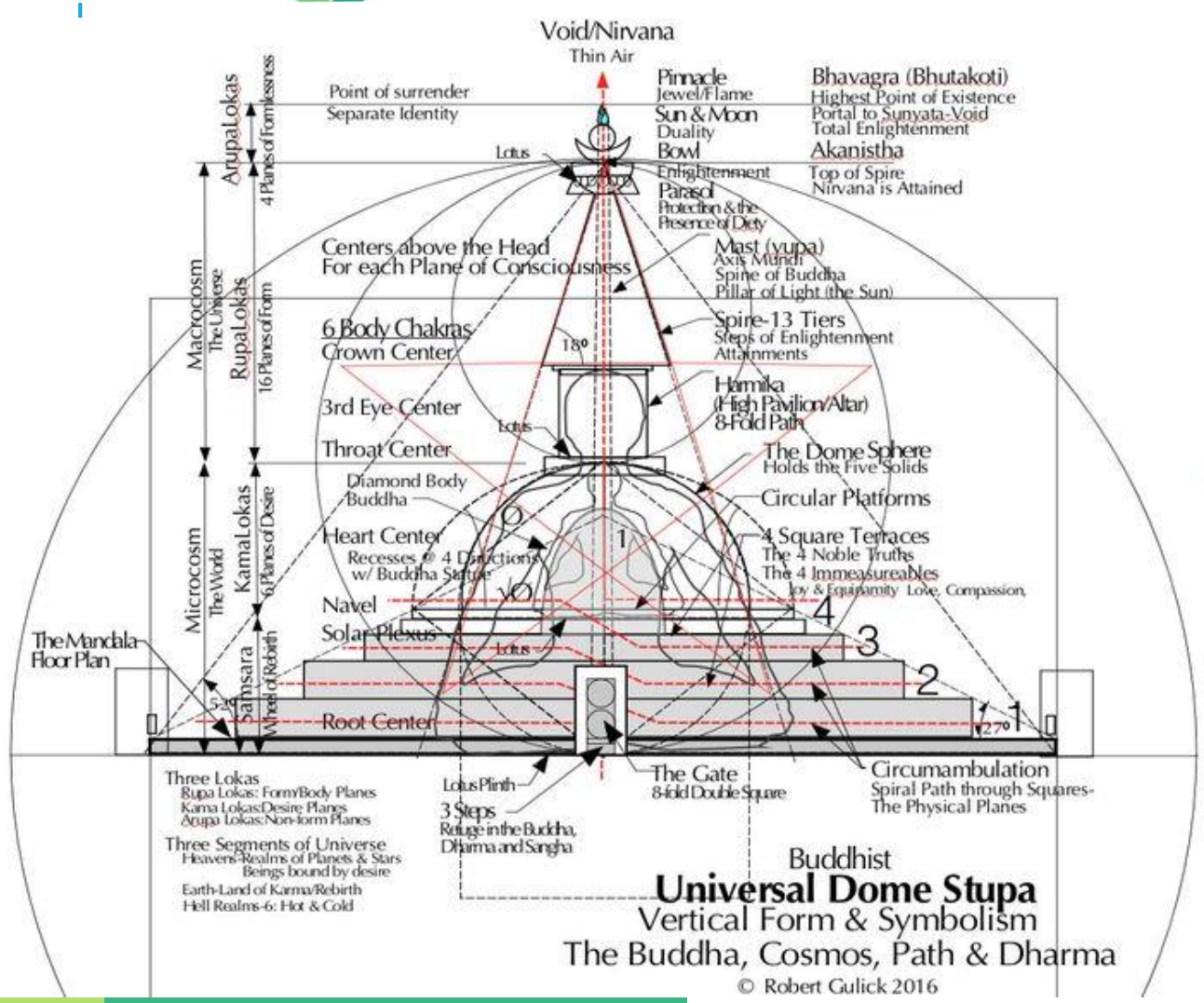

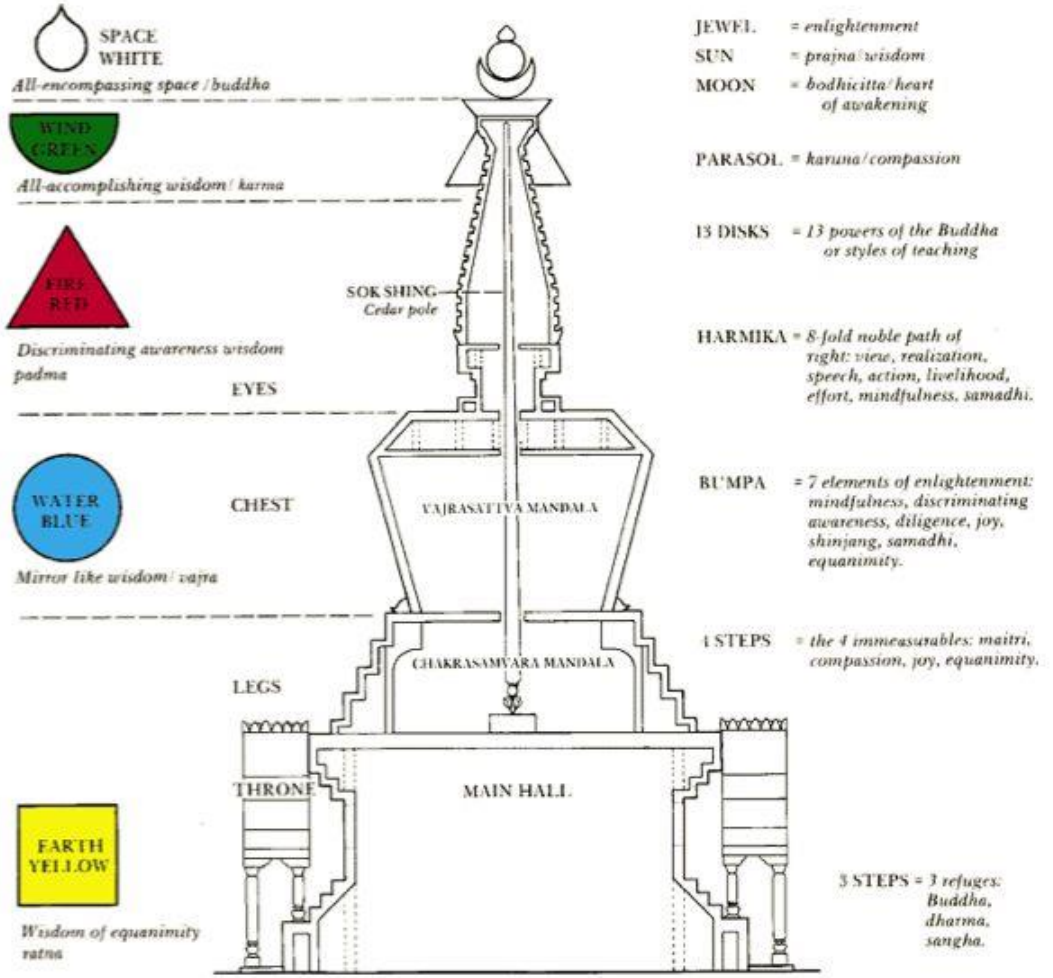

Buddhism geometry architecture

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STUDENTS EXERCISES EXAMPLES

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Hand's project

- Faculty Name : ArchitectureandDesign
- Major : Architecture Engineering
- Semester : First Semester 2023-2024

- Course Name : Geometry and Proportion in Architecture
- Teacher : Dr. Fedaa Abd-alhamid

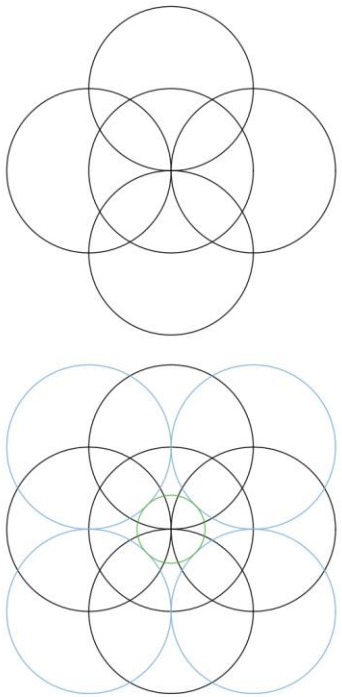
- Students Name : Batool Mohammad Hamad
- Student Id : 202111698

Geometry and Proportion in Architecture
Assignment Number 5

Geometric proportions as a tool of design .

" Construction stages of eight pointed patterns "

1) " Planning stage " :

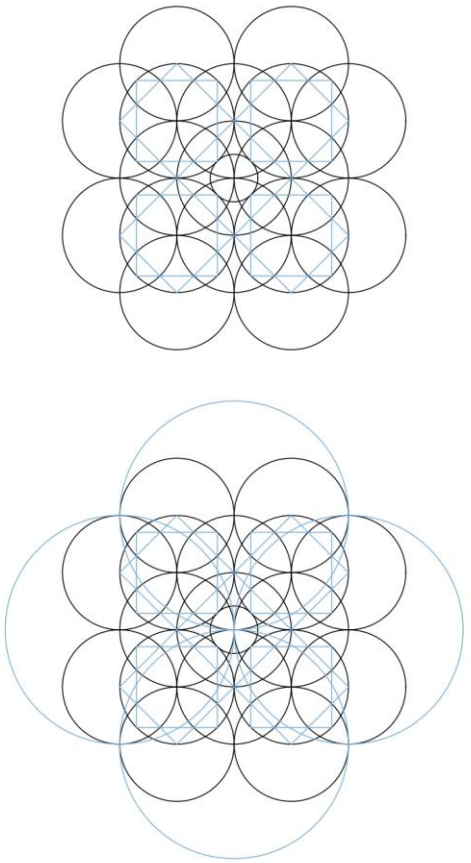


(1)

Geometric proportions as a tool of design .

" Construction stages of eight pointed patterns "

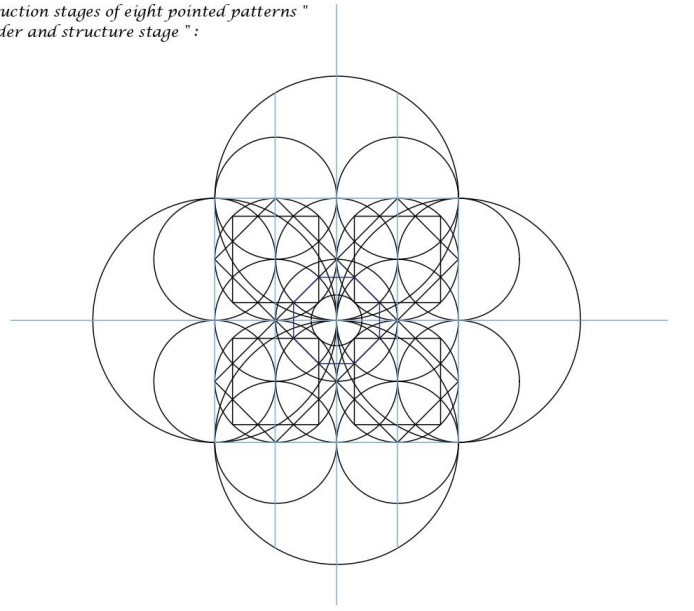
2) " The division stage " :

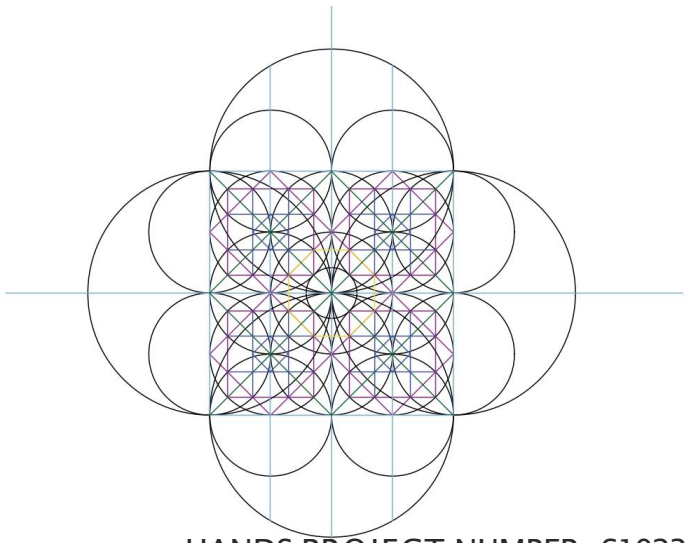


(2)

Hand's project

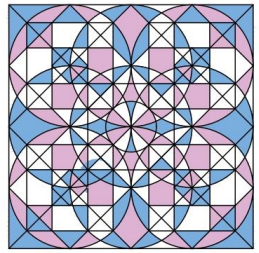
"Construction stages of eight pointed patterns "
3) " Order and structure stage ":

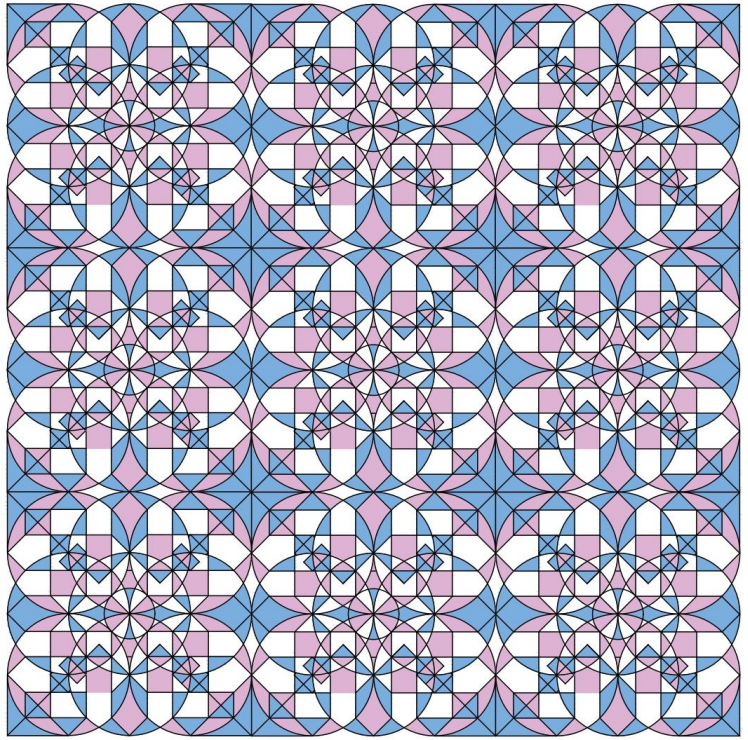




(3)

"Construction stages of eight pointed patterns "
4) " Pattern revealing stage ":





(4)

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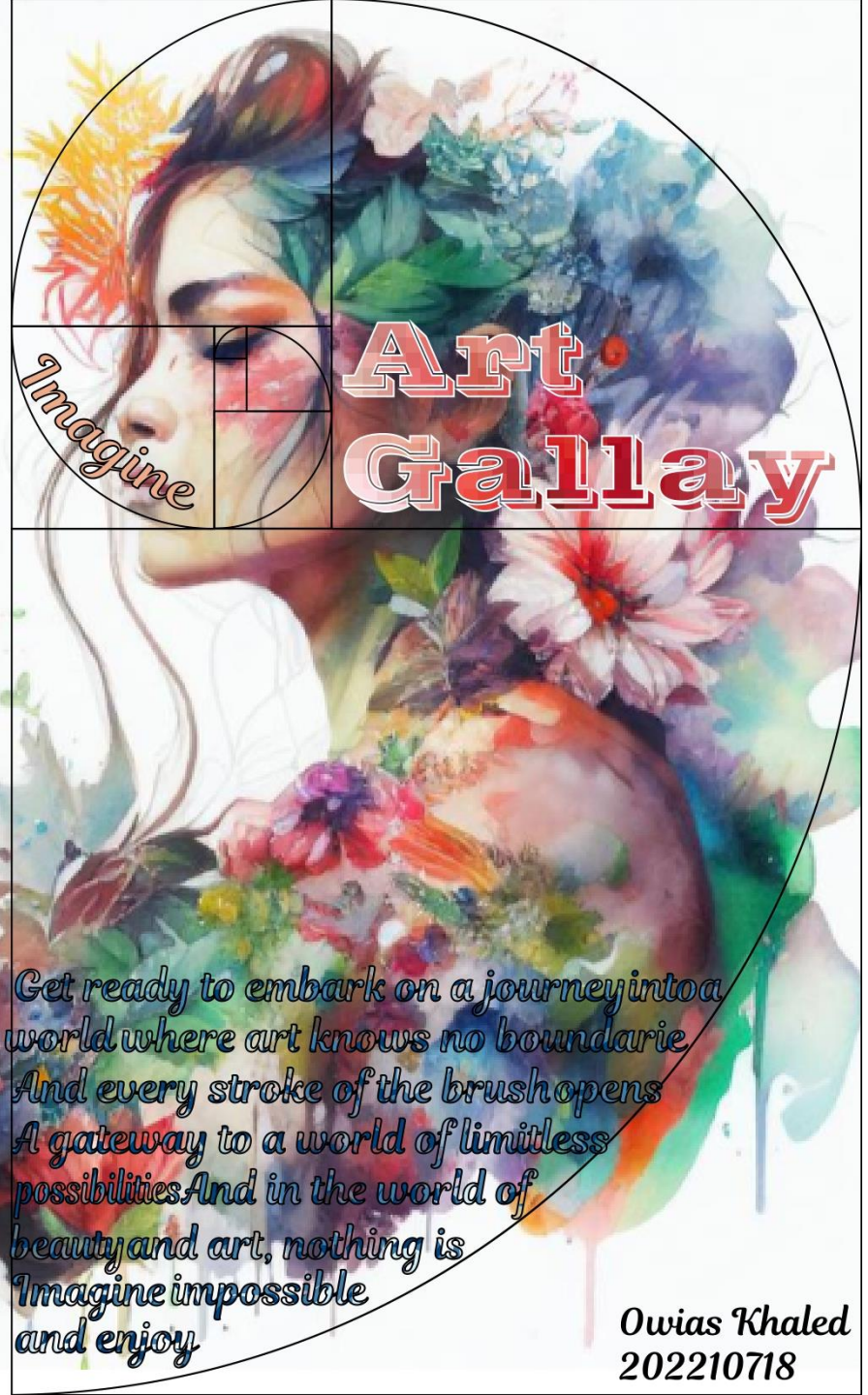
Architecture



zain ataya

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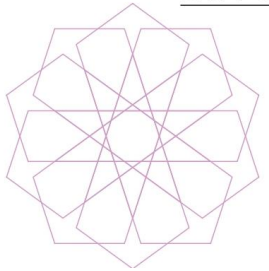
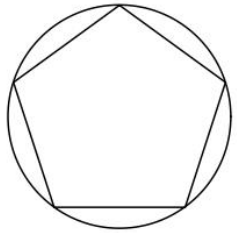
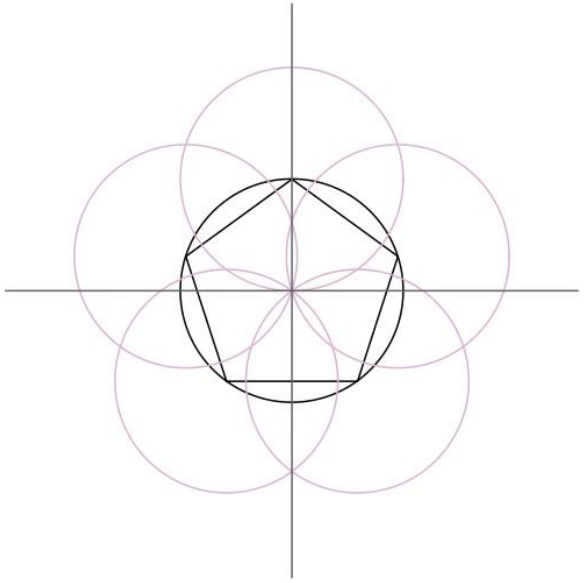
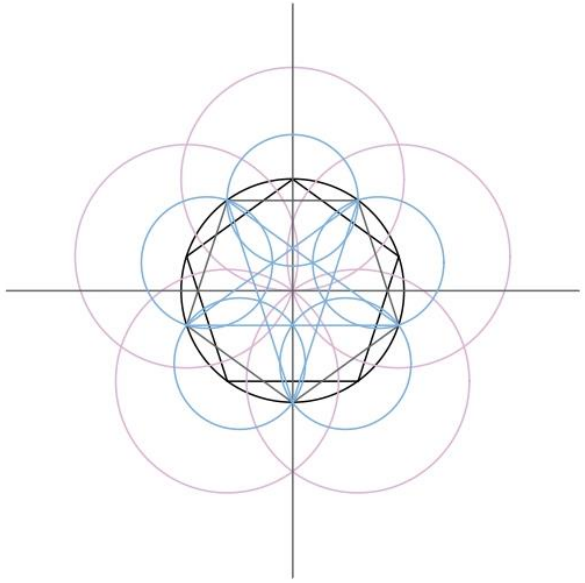
Construction stages of

five fold to ten fold patterns

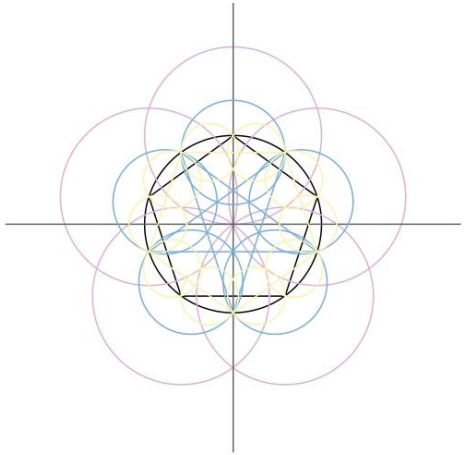


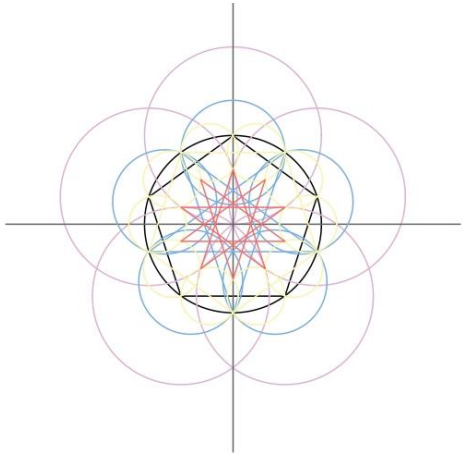




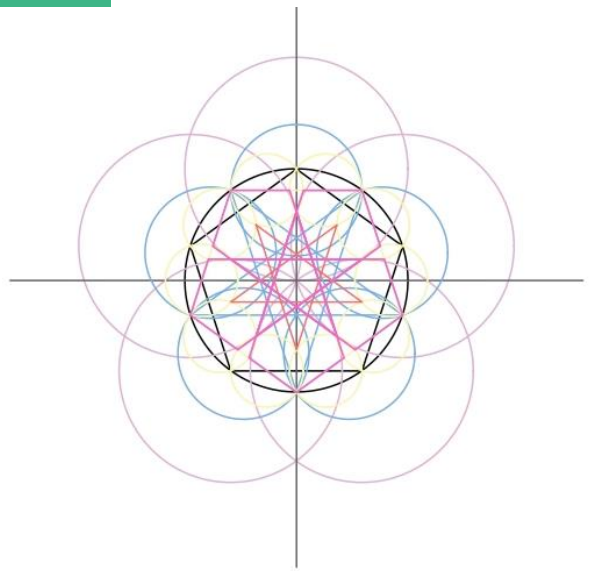


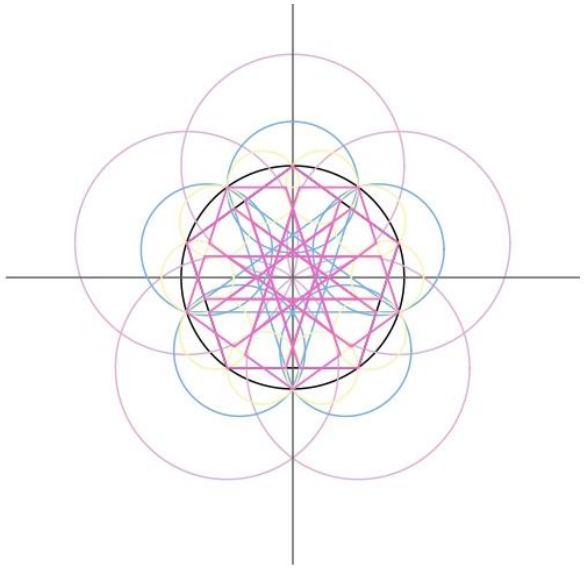
Planning stage





Division stage





Order and structure stage

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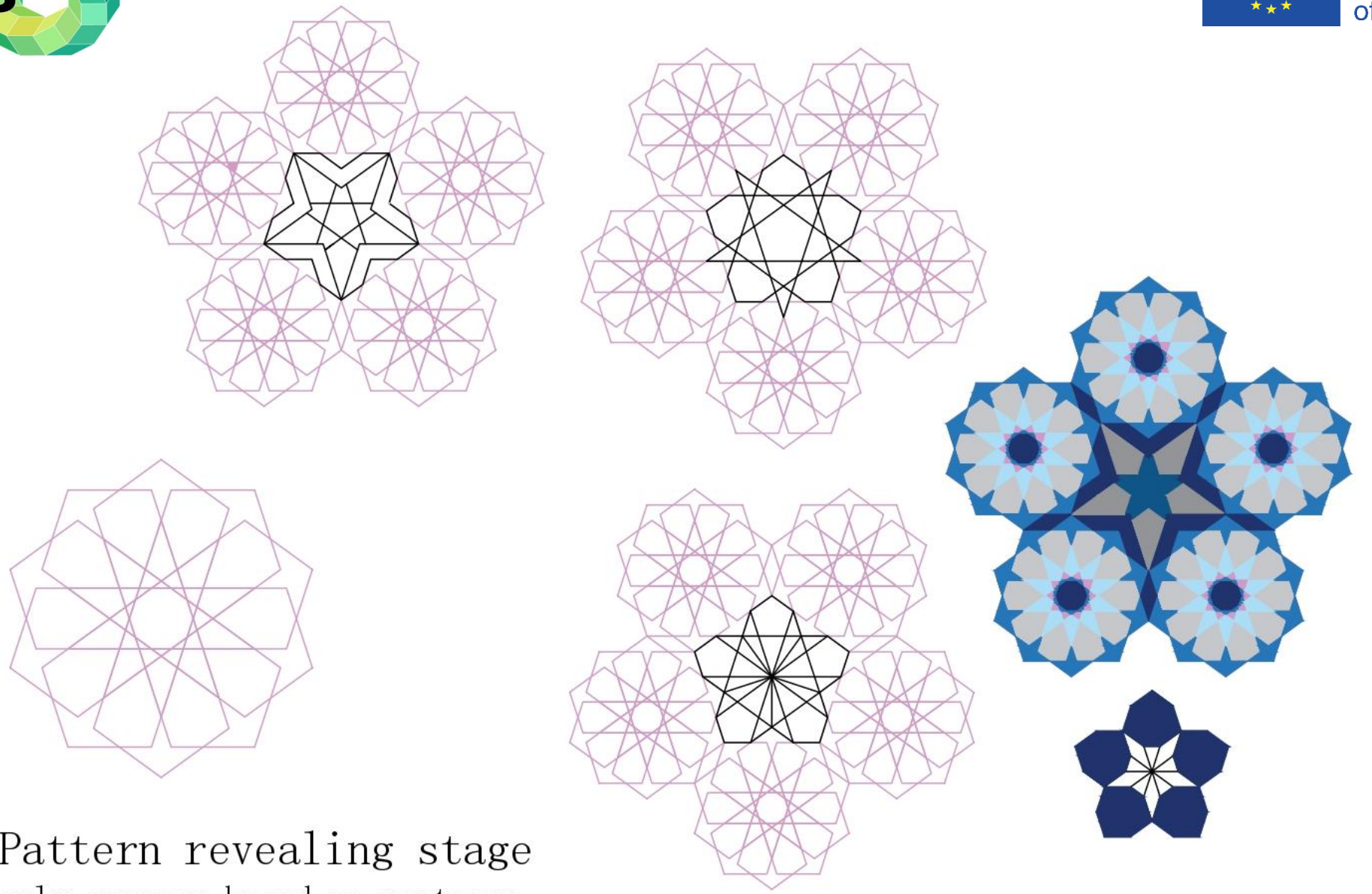
Hand's project



Pattern revealing stage

only arrange based on pentagon

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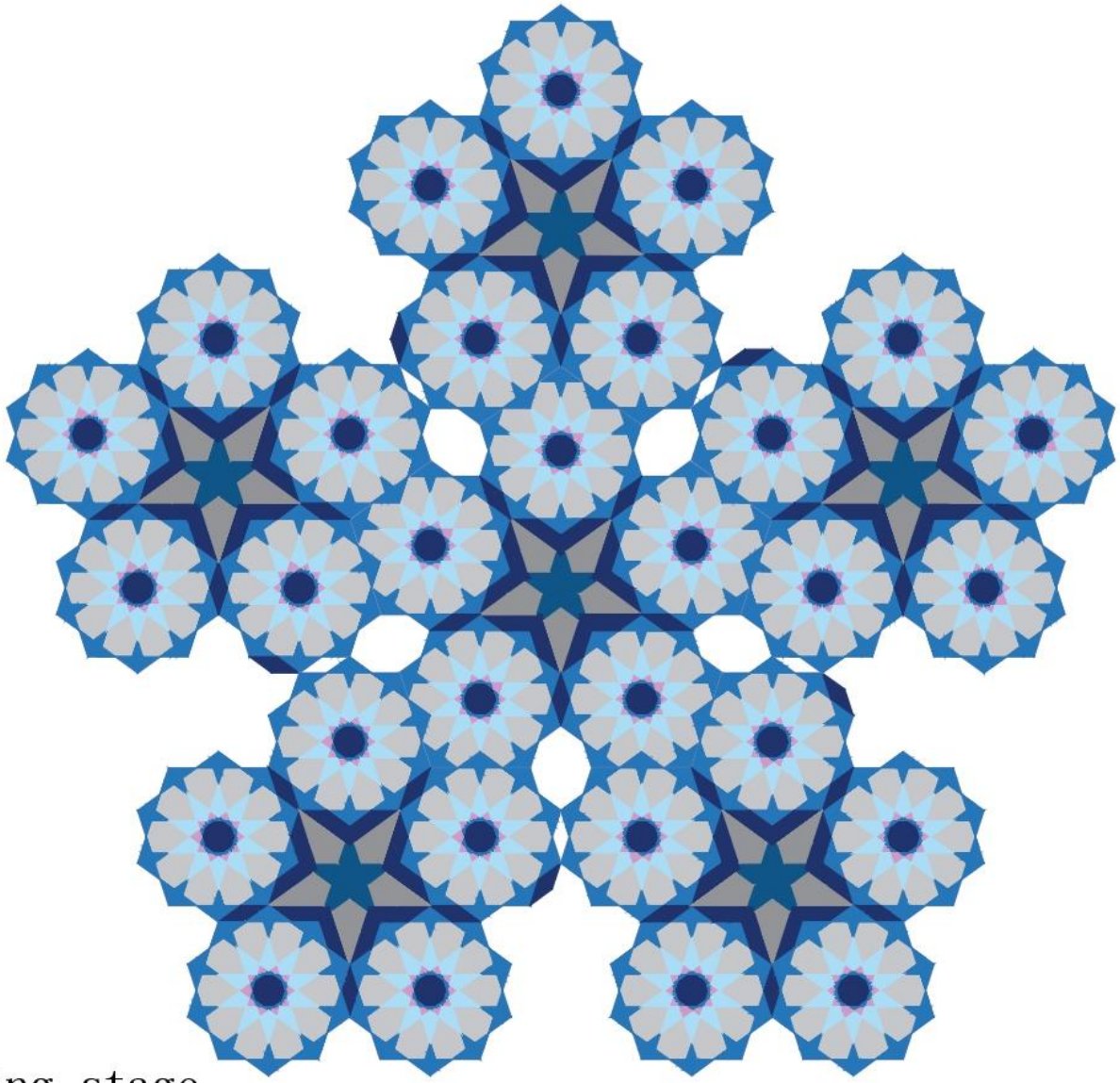
Hand's project



Pattern revealing stage

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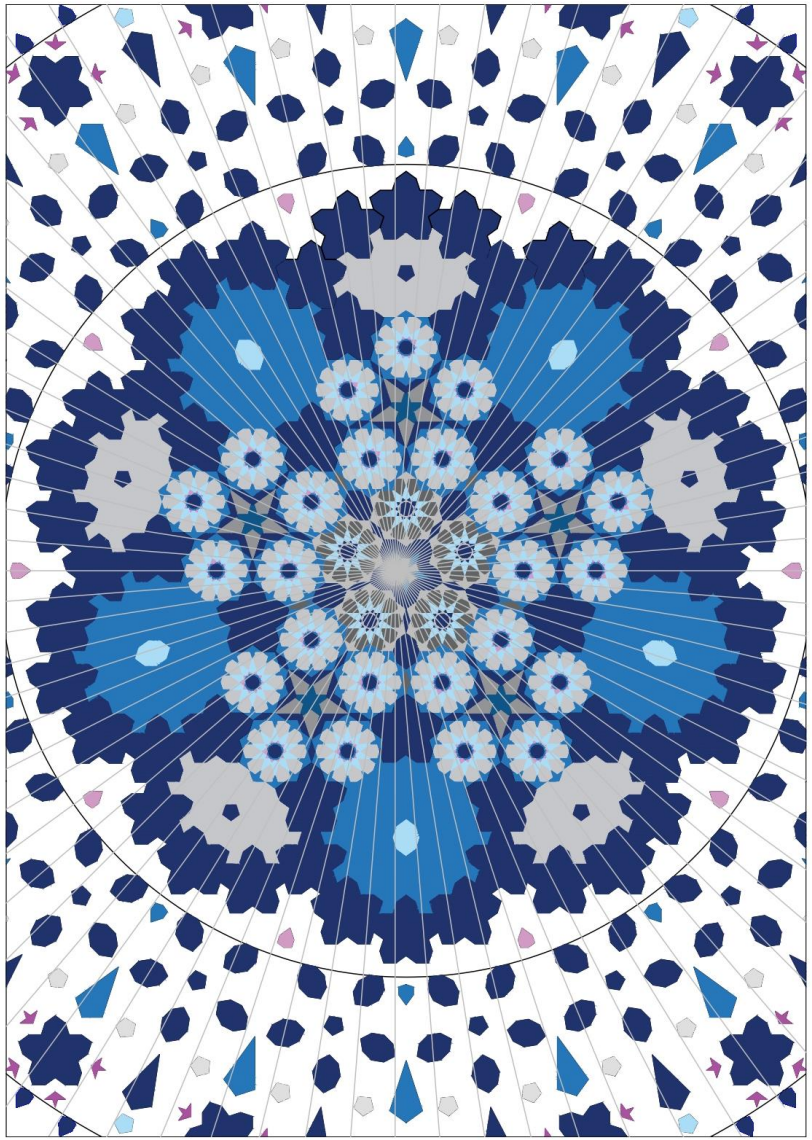

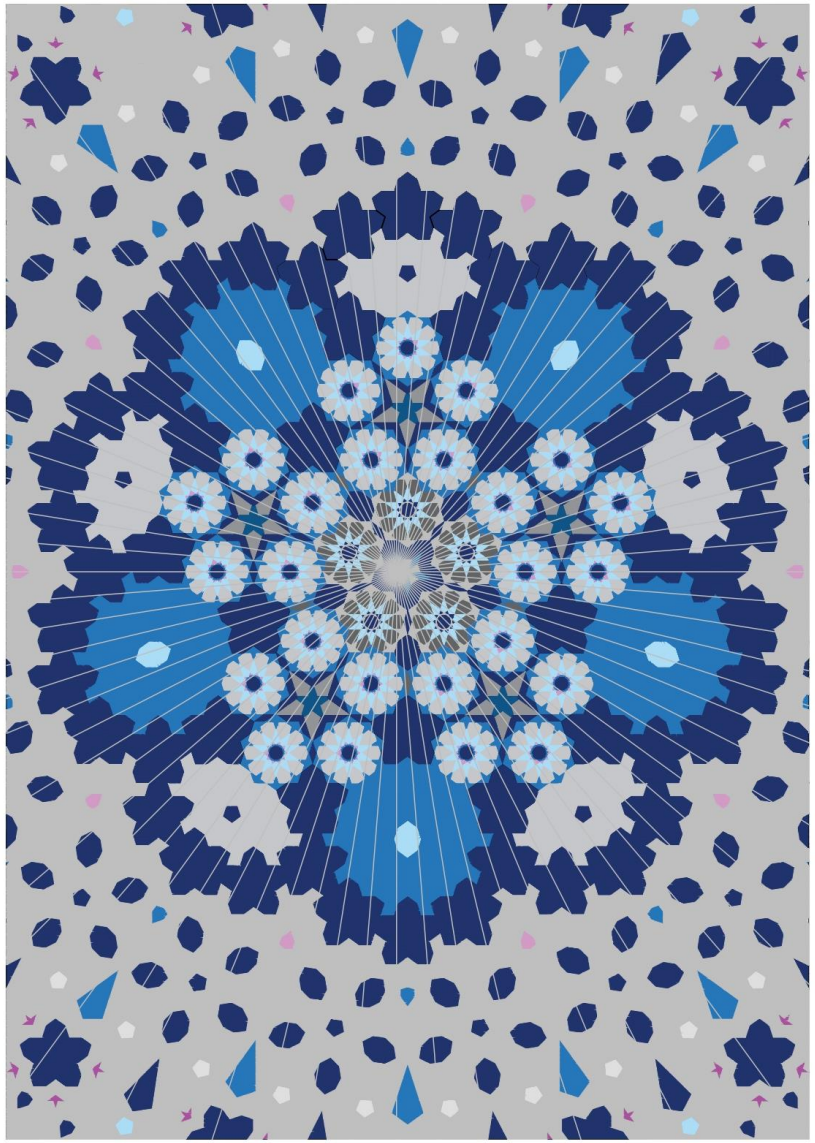

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