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Use Of Mathematics In Mandala Art And Its Applications

Dr. K. Rajak[1] and Mohita Soni[2]

1: Assistant Professor, Department of Mathematics

P. M. College of Excellence, Govt. Mahakoshal Autonomous Lead College, Jabalpur

2: Student, B. Sc. I Year, Major – Maths, Department of Mathematics,

P. M. College of Excellence, Govt. Mahakoshal Autonomous Lead College, Jabalpur

Abstract: Mathematics is integral to Mandala Art, primarily through the use of geometry, symmetry, and proportions to create visually appealing, balanced, and intricate designs. In this paper the authors created the mandala art by using mathematical concepts such as angles, proportion, grids and symmetry of mathematics. We also described the applications mandala art in human health and mental stress. We also observed that the Mandala art is therapy for academic stress.

Keywords. Mandala art, Mathematics in mandala art, Geometry, Symmetry, Repetition, Patterns, Rhythm, Angles, Proportion, Radial designs, Grids.

1. INTRODUCTION

Mandala painting is a form of painting that is shrouded in mystery and possesses unique artistic charm its historical roots can be traced back to ancient Indian culture. In Indian religious ceremonies Mandala painting holds a significant position being regarded as a crucial tool for communicating with deities seeking blessings and warding off evil spirits. This tradition has over time gradually integrated into the daily lives and belief systems of Indians [9]. The term Mandala originates from Sanskrit, meaning "circle" or "center," symbolizing the infinite cycle of the universe and the eternity of life in Buddhism. It is not only a manifestation of cosmic truth but also a tool for assisting meditation in Buddhist practices, representing wisdom and harmony. In Indian religious ceremonies, Mandala paintings are used to depict the images, symbols, and patterns of deities to seek their protection and blessings. These paintings, with their vibrant colors and intricate lines, are meticulously woven into splendid and exquisite artistic scrolls, immersing one in the mysterious universe and evoking an indescribable sense of power and beauty. Over time, Mandala painting gradually moved away from religious

ceremonies and became an independent art form. In India, Mandala painting gradually integrated into folk art and court art, forming a unique artistic style. At the same time, Mandala painting also gradually spread around the world, blending with different cultures and evolving into diverse artistic styles and form of expression. In Indian folk art Mandala paintings are widely used to decorate and beautify living spaces. People draw Mandala patterns on the edges of houses walls furniture etc. to pray for family peace happiness and good fortune. In the field of Indian court art Mandala paintings are endowed with supreme status they vividly depict the solemn and majestic images of deities and inviolable sacred patterns thus highlighting the nobility and dignity of the royal family. Mandala painting has gradually become a way of cultivating ones mind and spirit. By drawing mandala patterns people can purify their souls balance their minds and bodies enhance their focus and creativity. The intricate and meticulous process of mandala painting requires great patience and concentration thus it is also regarded as a form of spiritual practice and meditation. (cf.[8]).

Mandala art is not merely a decorative circular design but a carefully planned geometric composition. It is created by dividing space using grids, fixed angles and proportional distances from a central point. Traditionally, mandalas were drawn using mathematical tools such as compasses and rulers, which shows their scientific foundations.

Mathematics is integral to Mandala Art, primarily through the use of geometry, symmetry, and proportions to create visually appealing, balanced, and intricate designs. In the paper we have designed the mandala art by using mathematical concepts such as angles, proportion, grids and symmetry of mathematics. We also described the applications mandala art in human health.

2. MATHEMATICS IN MANDALA ART

Mathematics provides structure and precision to mandala art. Every mandala follows fixed measurements, angles and proportions. The use of mathematical rules ensures balance, symmetry without which a mandala design may lose its harmony. The following mathematical concepts are used to create mandala art.

3. SYMMETRY

Symmetry means balanced, proportional arrangement where parts match on opposite sides of a center or line, creating harmony in art, nature, and mathematics with key types including reflection (mirror image), rotational, and translational, often described as invariance under transformations like flipping, turning, or sliding, ensuring a figure looks the same after the change. Symmetry is a fundamental mathematical concept used in mandala art. Mandalas mainly follow radial symmetry, where patterns repeat evenly around a central point. The circular space is divided into equal parts, aligns perfectly through rotation. For example, when a mandala is divided into 12 equal sections, each section subtends an angle of 30 degree. this mathematical division ensures visual balance and uniformity throughout the design.

Types of Symmetry:

3.1.1 Line Symmetry (Reflection)

Line symmetry, commonly referred to as reflection symmetry or mirror symmetry, occurs when a figure or object can be divided by a straight line into two identical halves that are mirror images of each other. An object can be divided by a line (axis of symmetry) into two halves that are mirror images, like a butterfly or the letter 'H'. By using the mathematical concept line symmetry, the author created the following mandala image:

Fig. 3.1

3.1.2 Rotational Symmetry:

Rotational symmetry exists when a shape or figure looks exactly the same after being rotated less than 360∘360 raised to the composed with power360∘ around a centra point. A figure looks the same after being rotated less than a full circle around a central point, like a pinwheel or a square. By using the mathematical concept rotational symmetry, the author created the following mandala image:

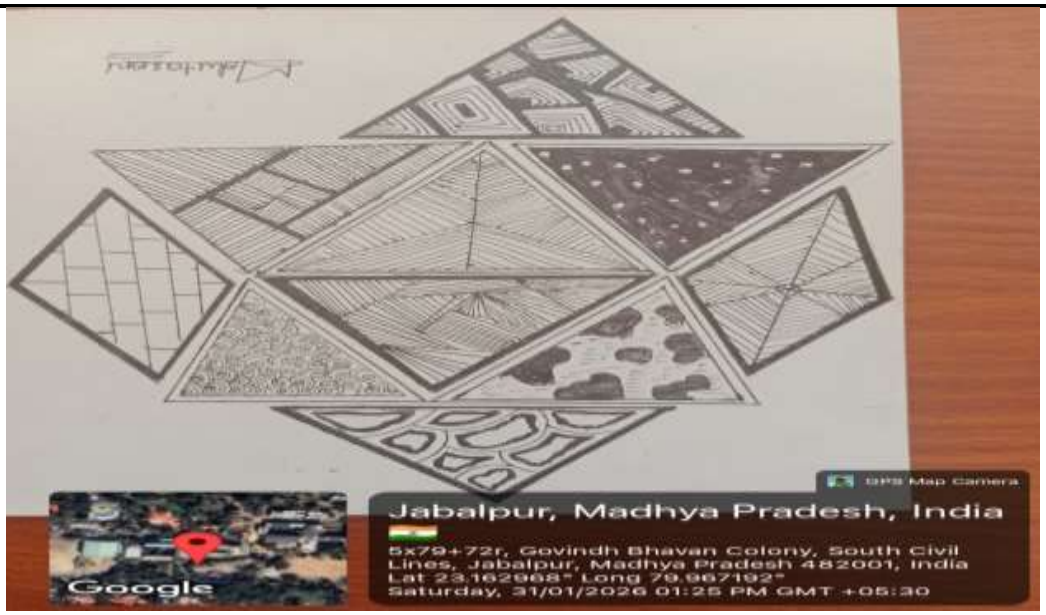


Fig. 3.2

3.1.3 Translational Symmetry

Translational symmetry occurs when an object, pattern, or system remains unchanged in shape, size, and orientation after being moved by a slide (translation) in a specific direction by a defined distance. It is a fundamental concept in geometry, art, and physics, often referred to as a shift or glide. A pattern repeats by sliding it in one or more directions, common in tessellations. By using the mathematical concept, the author created the following mandala image which represents translational symmetry:

Fig. 3.3

3.1.4 Point Symmetry

Point symmetry is a type of geometric symmetry where every part of a figure has a matching part that is the same distance from a central point but in the opposite direction. It is specifically defined as rotational symmetry of 180°. By using the mathematical concept point symmetry, the author created the following mandala image:

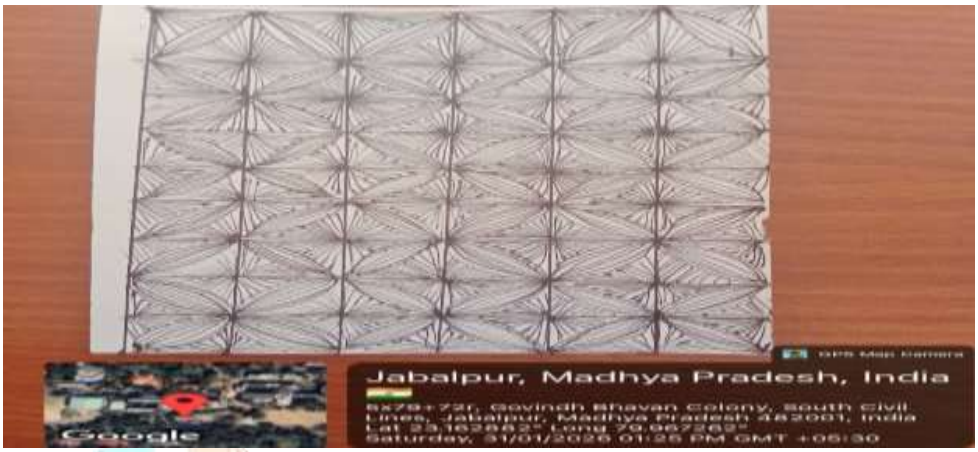
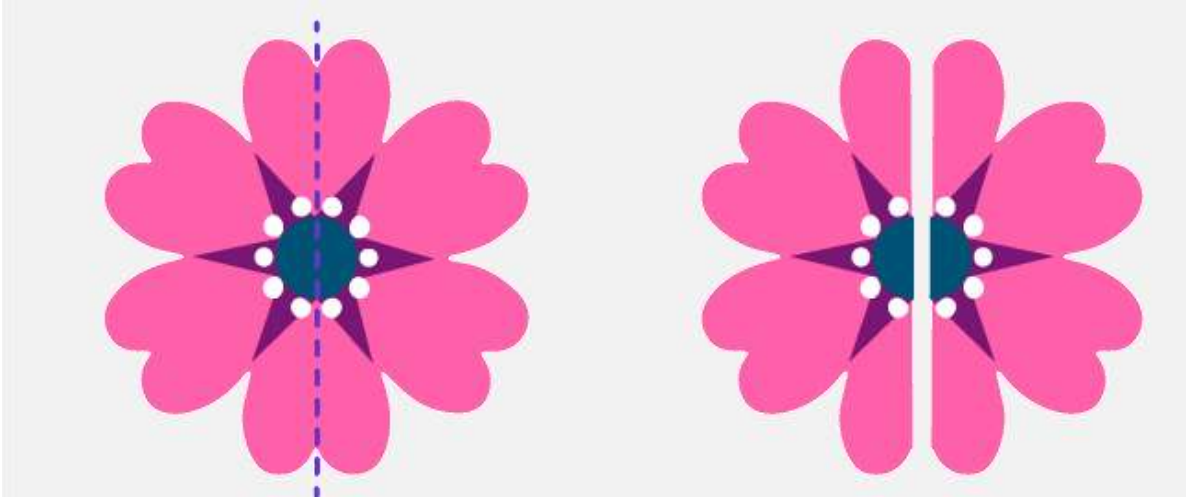


Fig. 3.4

In mathematics, especially in geometry and its applications, an object is said to have symmetry if it can be divided into two identical halves. For example, look at the given picture of a flower:

If we were to draw an imaginary line in the middle of it, we could divide it into two equal parts like this:



Note that the two parts are identical and mirror images of each other.

An object that is not symmetric is said to be asymmetric. That means that an asymmetric object cannot be divided into identical halves.

Mandana designs are often the same on both sides.

- Left and right look the same (mirror symmetry)
- Top and bottom also match
- Circular designs repeat around a center

4. Geometry

Geometry is the branch of mathematics that deals with shapes, angles, dimensions and sizes of a variety of things we see in everyday life. Geometry is derived from Ancient Greek words – 'Geo' means 'Earth' and 'metron' means 'measurement'. In Euclidean geometry, there are two-dimensional shapes and three-dimensional shapes. In a plane geometry, 2d shapes such as triangles, squares, rectangles, circles are also called flat shapes. In solid geometry, 3d shapes such as a cube, cuboid, cone, etc. are also called solids. The basic geometry is based on points, lines and planes explained in coordinate geometry. Geometry forms the backbone of mandala art. Shapes such as circles, triangles, squares, and polygons are arranged using precise spacing, proportional scaling, and symmetry. The use of concentric circles, rotational, alignment and repeated shapes show how geometry transforms simple forms into complex mandala designs.

Geometry is the study of different types of shapes, figures and sizes in Mathematics or in real life. In geometry, we learn about different angles, transformations and similarities in the figures. The basics of geometry depend on majorly point, line, angles and plane. All the geometrical shapes are based on these basic geometrical concepts.

The branches of geometry are categorized as:

- Algebraic geometry- used in curved and equation-based patterns.
- Discrete geometry- applied in girds, points and reposted units.
- Differential geometry
- Euclidean geometry- forms the basis of circles, lines, and angles.

- Convex geometry- helps in maintaining balance without overlapping shapes.
- Topology- explains continuity and connectedness of patterns.

Geometrical shapes mostly used in mandala art

4.1 Circles

In geometry, a circle is a perfectly round, two-dimensional shape consisting of all points in a plane that are the exact same distance (the radius) from a fixed central point (the center). It's a closed curve with no corners or edges, defined by its center and radius, forming the basis for understanding curves, symmetry, and many real-world objects like wheels or coins. Key Components of circle:

- **Center (O):** The fixed point from which all points on the circle are equidistant.
- **Radius (r):** The constant distance from the center to any point on the circle.
- **Diameter (d):** A line segment passing through the center, connecting two opposite points on the circle; it's twice the radius $d = 2r$
- **Circumference:** The total distance around the circle, calculated as $C = 2\pi r$.
- **Chord:** Any line segment connecting two points on the circle (the diameter is the longest chord).

By using the mathematical concepts, the author created the following mandala image:

Fig 4.1

4.2 Triangles

Triangle geometry studies triangles, which are three-sided polygons with three vertices and three internal angles that always sum to 180 degrees, forming the basis of 2D shapes in Euclidean geometry. Triangles are classified by sides (equilateral, isosceles, scalene) and angles (acute, right, obtuse). The following mandala image created by author:

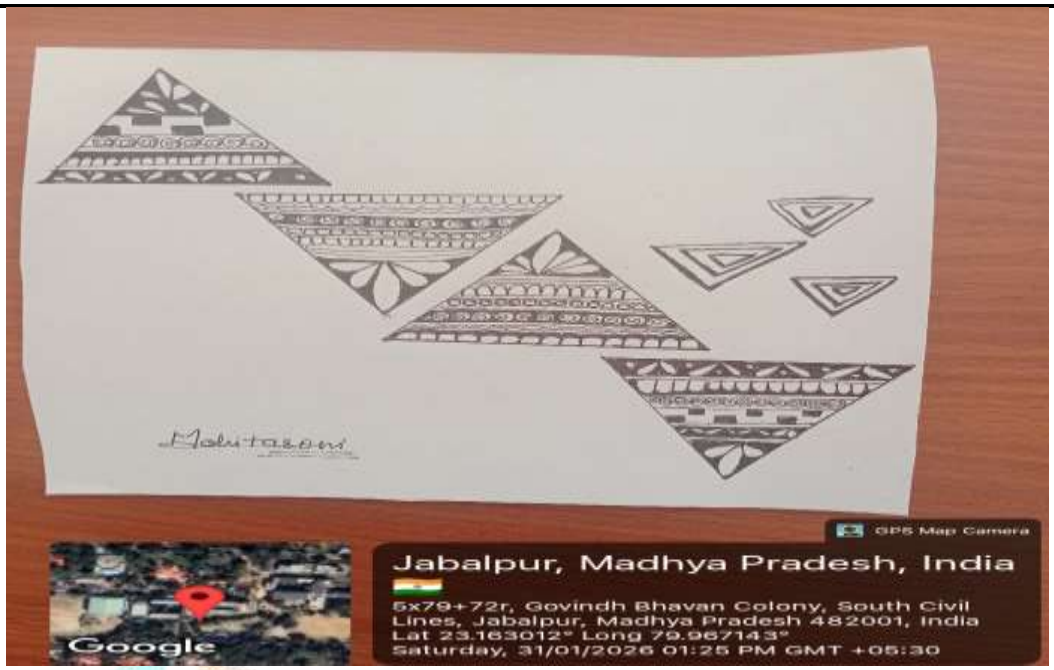


Fig 4.2

4.3 Squares

In geometry, a square is a regular four-sided polygon (quadrilateral) with four equal sides and four right (90°) angles, making it a special type of rectangle and rhombus, known for its symmetry, parallel opposite sides, and diagonals that bisect each other at 90°. Key properties include equal sides/angles, parallel sides, equal & perpendicular diagonals, and formulas for area.

Key Properties of a Square

- Sides: Four equal length sides.
- Angles: Four equal interior angles, each measuring 90° (right angles).
- Parallelism: Opposite sides are parallel.
  - Diagonals: Equal in length, bisect each other at a 90° (right) angle, and bisect the square's interior angles.
- Classification: A square is a:
  - Quadrilateral: Four-sided shape.
  - Regular Polygon: All sides and angles equal.
  - Rectangle: Has four right angles.
  - Rhombus: Has four equal sides.

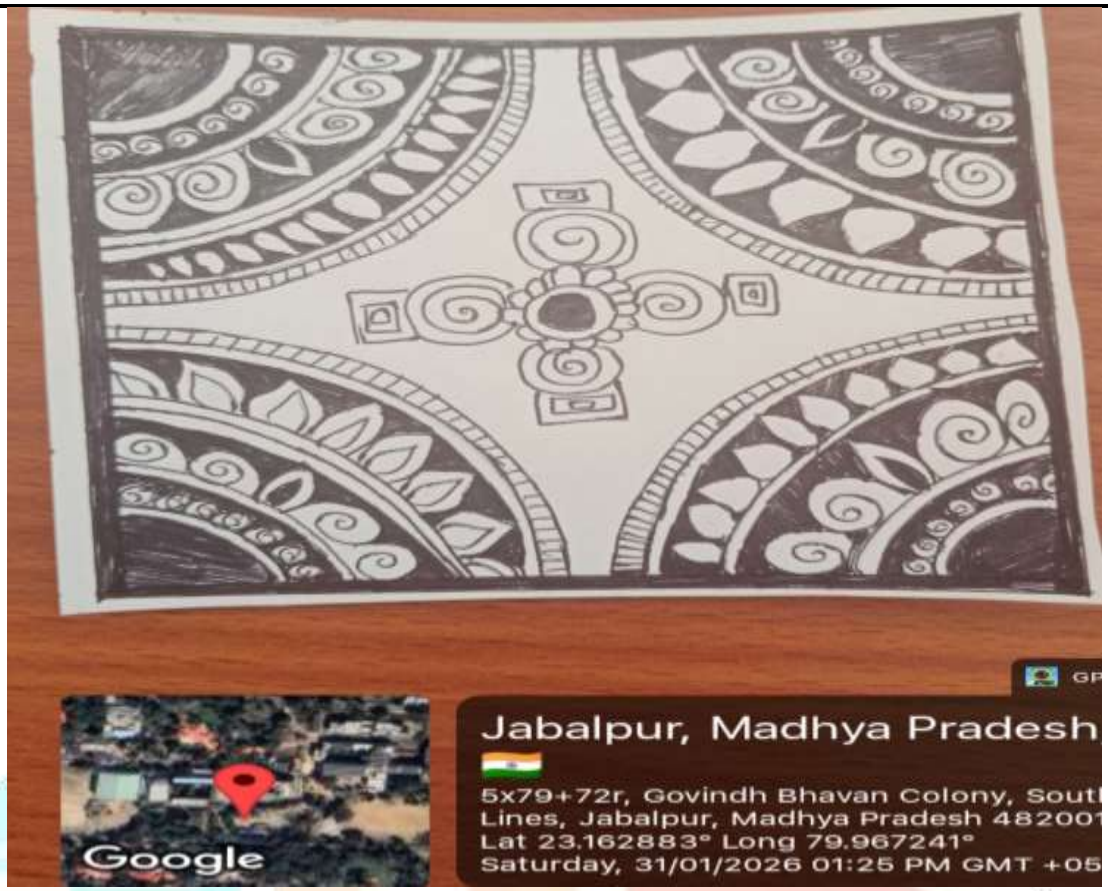


Fig 4.3

4.4 Diamonds

Diamond geometry encompasses the 2D rhombus shape (four equal sides, opposite angles equal) used in elementary math and patterns, the multifaceted 3D crystal structure of carbon (diamond cubic), and complex concepts in physics like "causal diamonds" in relativity. While "diamond" is a common term for a tilted square (rhombus), it also refers to specific cuts in jewelry (fancy shapes) or abstract mathematical objects in advanced physics describing spacetime regions.

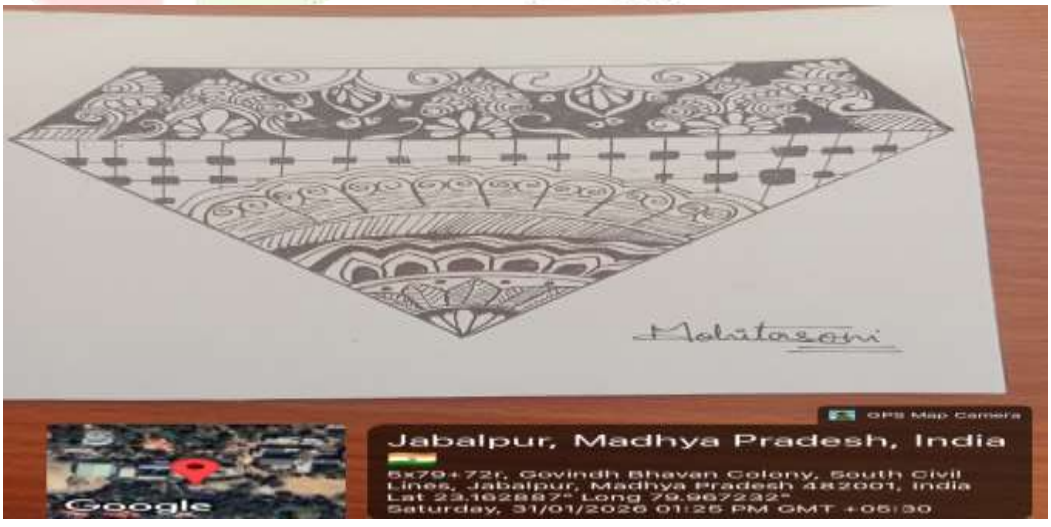


Fig 4.4

4.5 Lines and curves

In geometry, lines are straight paths, the shortest distance between points, while curves are bent paths that change direction, forming shapes like circles, arcs, or spirals, with both types crucial for defining shapes, from simple (house with straight lines) to complex (curved roads, rainbows). Lines can be horizontal, vertical, or slanting; curves can be open (endpoints don't meet) or closed (end points connect), creating fundamental elements in plane geometry for all figures.

Straight Lines (Line Segments/Rays)

- Definition: Extends infinitely in one direction, or has fixed endpoints (line segment), maintaining a constant direction.
- Types:
  - Horizontal (Sleeping): Parallel to the x-axis.
  - Vertical (Standing): Parallel to the y-axis.
  - Slanting (Diagonal): Neither horizontal nor vertical.
- Examples: Edges of a box, a ruler's edge, a tightly stretched thread.

Curved Lines (Curves)

- Definition: A line that bends and changes direction; not straight, representing a continuous change in slope.
- Types:
  - Open Curves: Endpoints don't meet (e.g., arc, spiral, parabola).
  - Closed Curves: Start and end at the same point (e.g., circle, ellipse, oval).
- Examples: A rainbow, a banana, the edge of a bowl, a racing track's turns, curly hair.

Key Geometric Concepts

- Plane Geometry: Deals with flat shapes (2D), involving points, lines, angles, and figures like circles, triangles, squares.
- Building Blocks: Lines and curves form the boundaries and shapes of all geometric figures, from simple polygons to complex shapes in nature.

Fig 4.5

These shapes are arranged in neat patterns.

5. **Repetition and Patterns**

Repetition, pattern, and rhythm are key art principles using repeated elements (lines, shapes, colors) to create unity, movement, and visual interest, with repetition being simple reuse, pattern being organized repetition, and rhythm being the visual flow or tempo created by repeating elements with variation, guiding the eye through the artwork, from predictable beats to complex, flowing tempos, adding depth and emotion.

5.1 Repetition

- Definition: The simple reuse of a single element (like a curve, color, or shape) multiple times in a design.
- Purpose: Creates unity, links different parts of the art, and emphasizes certain features.
- Example: A series of identical dots or repeated arches.

5.2 Pattern

- Definition: The predictable, regular repetition of a combination of elements (motifs).
- Purpose: Adds texture, consistency, and decorative value, often unifying a piece.
- Example: Checkerboard, floral wallpaper, or the repeated figures in a mandala.

5.3 Rhythm

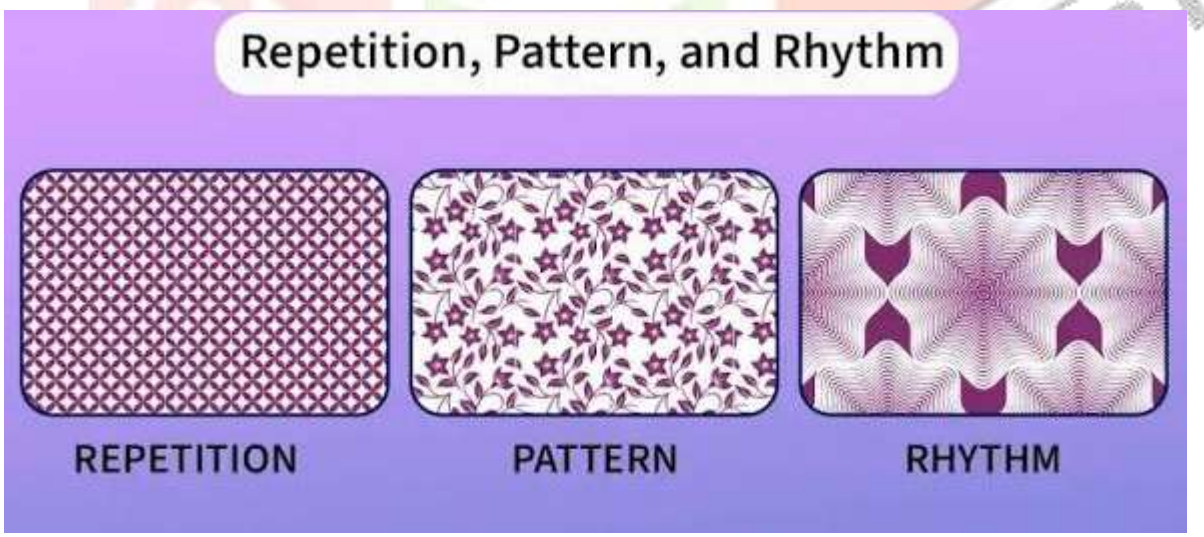
- Definition: The sense of movement or visual tempo created by the organized repetition and spacing of elements, often with variation.
- Purpose: Guides the viewer's eye, creates excitement, or evokes a feeling (like a heartbeat).
- Types of Rhythm:
    - Regular: Predictable, like a marching beat (e.g., evenly spaced columns).
    - Flowing/Alternating: Elements change or alternate, creating a fluid movement (e.g., waves).

- Progressive: Elements gradually change in size, color, or shape, suggesting time, growth, or distance (e.g., shrinking steps leading into the distance).

Fig 4.6

How They Work Together

Repetition forms the building blocks for patterns, and the varied repetition within patterns creates rhythm, transforming static elements into dynamic visual experiences that control pace and direct attention.



6. Applications of Madala Art

Art therapy covers all mind-body based approaches applied as a method to improve the psychological health of the individual in the presence of illness or any difficulty experienced by the individual. Art therapies allow the abstract and complex thoughts in the individual's mind to become concrete. One of the many different types of art therapy involves mandala. Mandala, which has a deep-rooted history, is used in art therapy today. The ease

of use and accessibility of mandalas for people of all age groups have contributed positively to the treatment of various diseases. From this perspective, mandala art therapy may be beneficial for different periodic life crises in women's lives. Midwives are health professionals who play a key role in every stage of women's health. Innovative midwifery approaches to create positive results in care at all stages of women's health are also nourished by spiritual and artistic practices. The International Confederation of Midwives has also developed a holistic and continuous care model in its midwifery care philosophy, covering women's social, emotional, spiritual, cultural, psychological and physical experiences. In line with this model, midwives' incorporating spiritual and artistic therapy methods in their care practices at all stages of women's health can make a difference in the quality of care. In this review, it is aimed to investigate the application areas of mandala art therapy in the field of midwifery, to evaluate the results of mandala art therapy in these areas and to identify gaps in the literature. [2]**.** Cancer diagnosis and treatment tend to negatively impact a person's Quality of Life (QoL). Art therapy can serve as a complementary measure to oncology care. In **[3]** the authors examine the effect of mandala art therapy on the QoL of breast cancer patients. Mandala art therapy significantly reduces academic stress among high school students.. Tailored interventions in the colleges can enhance student engagement and resilience, ultimately improving their academic performance and overall well-being. The Mandala art therapy on academic stress and overall mental health among students. (cf. [7]).

Anxiety is a psychological problem that is often experienced by individuals, especially when facing stressful situations. One of the anxiety disorders is generalized anxiety disorder (GAD). This disorder can be characterized by excessive worry about something. Mandala art therapy is an art therapy by coloring a circle shape that contains various geometric symbols. The circular shape of the mandala can help reduce anxiety. Several studies have shown that mandala art therapy is widely used to treat generalized anxiety disorder, especially in the adult age group. The mandala art therapy is effective in reducing anxiety in adult age groups. This is mainly because mandala art therapy combines art and therapy and has a therapeutic impact on generalized anxiety disorder in adults. (cf. [3]) (Se also [1], [2], [5], [6])

7. Conclusion

Mandala art clearly demonstrates that mathematics is not limited to numbers and formulas. Concepts such as geometry, symmetry, repetition, and proportion play a vital role in creating balanced and harmonious mandala designs. Thus, mandala art represents mathematics in a visual and creative form, proving that art and mathematics are deeply interconnected. The following mandala art created by Mohita Soni by using various concepts of mathematics. By using the mathematical concept line symmetry, the author created the following mandala image:

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