What is a reflection in math

The Mirror of the Mind: Unveiling Reflections in Mathematics

(Opening Scene: A child, captivated by a shimmering pond, sees their own face reflected back. The water ripples, the image distorts. A voiceover begins, echoing the child's fascination.) Mathematics, at its core, is a language of patterns and relationships. But sometimes, the most elegant truths are hidden in the mirror, reflected back in unexpected ways. This is the world of reflection in mathematics, a concept that transcends simple mirroring and delves into the heart of symmetry, transformations, and deeper understanding. Let's embark on a journey to explore this fascinating reflection, tracing its path from basic geometry to more complex abstract concepts. (Transition to a classroom setting. A teacher writes equations on a whiteboard, highlighting key elements.)

The Essence of Reflection: A Geometric Glance

At its simplest, reflection in mathematics describes a transformation that flips a shape or figure across a line, creating a mirror image. Imagine folding a piece of paper – the crease is your line of reflection. The figures on either side of the crease are mirror images of each other. This fundamental concept underpins much of geometry, allowing us to analyze shapes, discover hidden symmetries, and solve problems involving congruency. *(Visual aid: A diagram showing a shape reflected across a line. Arrows highlight corresponding points on the original and reflected images.)* Consider a triangle with vertices A(1, 2), B(4, 5), and C(3, 1). Reflecting this triangle across the line y=x results in the image A'(2, 1), B'(5, 4), and C'(1, 3). Notice that the distance between each original point and its reflected counterpart is the same, and the line connecting them is perpendicular to the line of reflection.

Beyond the Plane: Reflections in Other Realms

While geometric reflections are visually intuitive, the concept extends far beyond two-dimensional space. Imagine a three-dimensional object reflected in a mirror – the reflected image maintains the same shape and size, but is flipped around the plane of the mirror. This principle carries into more abstract realms, like transformations in higher dimensions and even into the world of complex numbers, where reflection can be visualized as a rotation in the complex plane. *(Visual aid: A 3D model of a cube, followed by a diagram illustrating reflection in three dimensions and a complex plane.)*

Reflections in Functions and Graphs

Reflecting a function across an axis can reveal fascinating relationships within its graph. For instance, reflecting the graph of $y = x^2$ across the x-axis produces $y = -x^2$. This transformation alters the orientation of the graph, making it clear that changes in the equation correspond to significant shifts in the visual representation. *(Visual aid: Graphs of $y=x^2$ and $y=-x^2$ alongside the equation.)*

Reflections in Algebra and Calculus

The concept of reflection also finds application in algebra and calculus, influencing the behavior of equations and functions. For example, reflections in the equation of a circle can be used to manipulate the center and radius of a circle, and reflecting a curve in Calculus can affect the location and nature of its intercepts or turning points. **(Example: A short mathematical derivation, highlighting a reflection in a quadratic equation.)**

The Role of Reflection in Problem Solving

Reflection allows us to develop a deeper understanding of mathematical concepts. The process of looking back at a problem, analyzing your methods, and spotting mistakes allows for greater accuracy and efficiency in future problem-solving efforts. Reflecting on previous problems or patterns can reveal connections to new scenarios and open pathways to original approaches. **(Case study: A student reflects on a challenging geometry problem, breaking it into smaller parts and seeing a hidden symmetry through reflection.)**

Looking Forward: Further Explorations

Reflections, in various forms, are fundamental to understanding symmetry and transformations in mathematics. **(Visual aid: Examples of different types of symmetry: rotational, bilateral, and others.)** (A montage of scenes: A physicist observing reflections in a p accelerator, a cryptographer analyzing patterns in code, an artist constructing a fractal design, and an architect working on a building with mirrored surfaces.) Benefits of Understanding Reflections • Improved Problem-Solving Skills: The act of reflecting on solutions strengthens critical thinking and analytical abilities. • Enhanced Visualization: Reflections provide a clear way to visualize transformations in various mathematical contexts. • *Increased Awareness of Patterns:* Recognizing reflections helps identify hidden symmetries and patterns within complex mathematical structures. *(Returning to the opening scene, but now with the child understanding the reflections better. A voiceover concludes.)* Reflections in mathematics are more than just flips and transformations; they are lenses through which we can perceive the intricate beauty and underlying order of the universe. They invite us to delve deeper into the subject matter, to look beyond the surface and appreciate the profound connections that shape our understanding of numbers, shapes, and the world around us. **(End Scene)** 5 Advanced FAQs 1. How can reflections be applied in cryptography? Reflections are employed to encrypt and decrypt complex data through various cryptographic algorithms, enabling security in digital communication. The principles of symmetry and transformation are crucial here. 2. *What is the significance of reflection in fractal geometry?* Reflections are fundamental to constructing fractal patterns. Iterative reflections generate self-similar structures, revealing the underlying beauty and intricate detail found in nature. 3. **How are reflections used in computer graphics?** Computer graphics heavily relies on reflections to create realistic visual effects, such as mirroring objects, simulating light and shadows, and accurately depicting surfaces in three-dimensional environments. 4. **What is the relationship between reflection and group theory?** In group theory, reflection transformations create groups of symmetries. Understanding reflections is essential to analyze the properties of these groups and unravel their complex structures. 5. **How do reflections apply in non-Euclidean geometries?** In non-Euclidean geometries, reflections are defined differently, aligning with the specific postulates and axioms of the particular geometry. These transformations lead to unique spatial characteristics.

What is a Reflection in Math? Unpacking the Mirror Image Transformation

Ever looked in a mirror and seen… yourself? That’s the essence of a reflection in math! It’s a fundamental geometric transformation that essentially flips an object across a line, creating a mirror image. Think of it as folding a piece of paper along a crease, and everything on one side has an exact counterpart on the other. In the world of mathematics, this "crease" is called the **line of reflection**, and the resulting flipped figure is the **image**. Reflections are more than just a cool visual trick. They're a cornerstone of geometry, helping us understand symmetry, congruence, and the properties of shapes. Whether you're dealing with simple shapes on a 2D plane or more complex transformations in higher dimensions, the concept of reflection remains the same. Let's dive deep and explore what a reflection truly is, how it works, and why it's so important in the mathematical landscape.

Defining Reflection: The Core Concept

At its heart, a reflection is an **isometry**. This is a fancy word that means it preserves distance. If you have two points in your original shape, the distance between them will be exactly the same in the reflected image. This is crucial because it means reflections don't distort or change the size or shape of the object; they just change its orientation. Imagine you have a triangle. When you reflect it, you still have a triangle, and all its side lengths and angles remain identical to the original. This property of preserving shape and size is what makes reflections so valuable in geometric proofs and constructions.

How Does a Reflection Work? The Mechanics of Flipping

To understand how a reflection works, let's break down the key components: * **The Object (Pre-image):** This is the original figure you're starting with. It could be a point, a line, a polygon, or any geometric shape. * **The Line of Reflection:** This is the "mirror" line. The entire transformation happens with respect to this line. * **The Image (Reflected Figure):** This is the resulting figure after the reflection. It's the mirror image of the original. The key principle is that for every point in the original object, its corresponding point in the image is located on the opposite side of the line of reflection, at an equal distance from it. Crucially, the line segment connecting a point to its image is **perpendicular** to the line of reflection. Think of dropping a plumb line from a point to the mirror – it hits the mirror at a right angle, and the reflection is the same distance down that imaginary plumb line on the other side.

Types of Reflections: Where and How We Reflect

The "where" and "how" of reflection depend on the context. In 2D geometry, we most commonly encounter reflections across:

Reflection Across the x-axis

This is a very common scenario in coordinate geometry. When you reflect a point (x, y) across the x-axis, the x-coordinate stays the same, but the y-coordinate changes its sign. So, the image of (x, y) after reflection across the x-axis is (x, -y). Let's visualize this. If you have a point at (2, 3), reflecting it across the x-axis will land it at (2, -3). The x-axis acts as the horizontal mirror.

Reflection Across the y-axis

Similarly, when reflecting across the y-axis, the y-coordinate remains unchanged, but the x-coordinate is negated. The image of (x, y) after reflection across the y-axis is (-x, y). So, a point at (2, 3) reflected across the y-axis becomes (-2, 3). The y-axis acts as the vertical mirror.

Reflection Across the Origin

Reflecting across the origin (0,0) is equivalent to reflecting across the x-axis and then across the y-axis (or vice-versa). In this case, both the x and y coordinates are negated. The image of (x, y) after reflection across the origin is (-x, -y). A point at (2, 3) reflected through the origin will end up at (-2, -3). This type of reflection is sometimes called a **point reflection**.

Reflection Across Other Lines

While the axes are the most frequent lines of reflection, you can reflect any geometric figure across *any* line. This could be a diagonal line like y = x, a horizontal line like y = 5, or even a more complex slanted line. The process remains the same: for each point in the original figure, find its perpendicular projection onto the line of reflection, and then extend that perpendicular line an equal distance on the other side. This requires a bit more calculation but follows the same fundamental principles. For instance, reflecting across the line y = x swaps the x and y coordinates. So, a point (x, y) reflected across y = x becomes (y, x). This is because the line y = x is a mirror that bisects the first and third quadrants.

Key Properties of Reflections: What They Preserve and Change

Reflections are powerful because they alter specific aspects of a figure while leaving others untouched. Here's a breakdown: * **Preserved Properties:** * **Distance:** As mentioned earlier, the distance between any two points in the pre-image is the same as the distance between their corresponding points in the image. This is why reflections are isometries. * **Angles:** The measure of angles within the figure remains unchanged. * **Area:** The area of the reflected figure is identical to the area of the original. * **Orientation:** This is where things get interesting. A reflection changes the **orientation** of a figure. Imagine holding a letter 'F'. If you reflect it, you get a backward 'F'. The order of vertices might be reversed when tracing the perimeter. This is sometimes described as flipping the figure over. * **Changed Properties:** * **Position:** The location of the figure is altered. * **Direction/Orientation:** The "handedness" of the figure changes. If you have a clockwise arrangement of points in the original, the reflected image will have a counter-clockwise arrangement.

Symmetry and Reflections: The Mirror Image Connection

Reflections are intrinsically linked to the concept of **symmetry**. A shape has **reflectional symmetry** if it can be divided by a line (the line of symmetry) into two congruent halves that are mirror images of each other. Think of a butterfly. Its wings are nearly perfect mirror images across a central line. This line is a line of symmetry. Other examples include: * An isosceles triangle has one line of symmetry. * A rectangle has two lines of symmetry. * A square has four lines of symmetry. * A circle has an infinite number of lines of symmetry, passing through its center. Understanding reflections helps us identify and classify different types of symmetry in geometric shapes. This is crucial in art, design, and even the study of natural phenomena.

Reflections in the Real World: Beyond the Classroom

The concept of reflection isn't confined to textbooks and whiteboards. We encounter reflections everywhere: * **Mirrors:** The most obvious example! The glass in your bathroom, car mirrors, and shop windows all employ the principle of reflection. * **Water Surfaces:** A still lake or pond acts as a natural mirror, reflecting the sky, trees, and surrounding landscape. * **Optics and Lenses:** While not always a perfect reflection, the way light bounces off surfaces is governed by reflection principles, crucial in designing cameras, telescopes, and eyeglasses. * **Computer Graphics and Animation:** Reflections are used to create realistic lighting effects, simulate surfaces, and generate mirror-like appearances in video games and animated films. * **Tessellations and Patterns:** Repeating patterns often utilize reflections to create visually pleasing and symmetrical designs.

Reflections in Transformations: Building Blocks of Geometry

Reflections are one of the four basic **rigid transformations** (also known as isometries) in geometry, alongside translations, rotations, and glide reflections. These transformations are fundamental for understanding how shapes can be moved and manipulated while preserving their essential properties. Often, more complex transformations can be broken down into a series of simpler reflections. For example, a rotation can be achieved by performing two reflections across intersecting lines. This idea is explored in advanced geometry and linear algebra.

Reflections in 3D Space: Extending the Concept

The concept of reflection extends seamlessly into three-dimensional space. Instead of a line of reflection, we have a **plane of reflection**. An object is flipped across this plane, with each point's corresponding image being equidistant from the plane and on the opposite side, such that the line connecting the point and its image is perpendicular to the plane. Think of a 3D object being placed in front of a mirror. The mirror is the plane of reflection. This is crucial in fields like crystallography, where the symmetrical arrangement of atoms often involves reflections across planes.

Conclusion: The Enduring Power of the Mirror Image

So, what is a reflection in math? It's a powerful geometric transformation that flips an object across a line or plane, creating a mirror image. It preserves distances, angles, and area, but alters position and orientation. From the simple act of looking in a mirror to the complex designs of computer graphics, reflections play a vital role in shaping our understanding of the world and the abstract principles of mathematics. They are a testament to the elegance and universality of geometric concepts, reminding us that even the most basic ideas can have profound implications across various disciplines. Understanding reflections unlocks a deeper appreciation for symmetry, congruence, and the fundamental building blocks of geometric transformations.

In mathematics, a reflection is a fundamental geometric transformation that reveals deep insights into symmetry and spatial relationships. At its core, reflection involves flipping a shape or point across a fixed line—or more generally, a line of reflection—such that each point on the original figure is mapped to a corresponding point on the opposite side, equidistant from the line. This operation preserves distances and angles, making it an isometric transformation, meaning it maintains the size and shape of geometric figures.

Understanding the Concept of Reflection To grasp reflection fully, imagine a straight mirror held vertically across a plane of objects. When light from a point on one side strikes the mirror, the image appears at a mirror-symmetric position on the opposite side. In mathematical terms, if we define the line of reflection as a geometric axis, every point on the plane is reflected to a new point such that the line acts as a perpendicular bisector between the original and its image. The resulting image maintains the same distance from the line as the original point, but lies on the opposite side. This symmetry underpins many natural and constructed patterns observed in geometry, art, and science.

Types of Reflections in Geometry In two-dimensional geometry, there are several standard lines of reflection. The simplest is the vertical line, often taken as the y-axis, reflecting points across this axis to produce mirror images. Similarly, horizontal reflections occur across the x-axis, flipping points vertically. Beyond these, reflections can occur across any arbitrary line, including diagonals and slanted axes, each producing unique symmetric arrangements. These transformations are not limited to simple shapes—any geometric figure, from triangles to polygons, retains its structure under reflection, allowing for intricate designs and symmetrical tessellations.

Applications Across Disciplines Reflections are not merely theoretical constructs; they have tangible applications across various fields. In architecture and design, reflection symmetry inspires aesthetically pleasing and balanced structures, from classical buildings to modern art installations. In physics, reflection principles explain phenomena such as light bouncing off surfaces, crucial in optics and design of mirrors and lenses. Computer graphics heavily rely on reflection transformations to create realistic visual effects, simulating how light interacts with objects. Even in biology, symmetry through reflection appears in natural forms like butterfly wings and human faces, hinting at evolutionary advantages and

functional efficiency.

Benefits and Educational Value Studying reflections enhances spatial reasoning and problem-solving skills, essential in mathematics and engineering. It strengthens conceptual understanding of symmetry, a foundational idea that appears across mathematics and science. By visualizing and manipulating reflected shapes, learners develop a deeper intuition for geometric relationships and transformations. Reflections also serve as an accessible entry point into more advanced topics like coordinate geometry and linear algebra, where transformations are expressed algebraically. This dual strength—bridging visual intuition with rigorous mathematics—makes reflection a cornerstone concept in mathematical education.

The Future of Reflection in Advanced Mathematics and Technology As technology advances, the role of reflection continues to evolve. In computational geometry, efficient algorithms for reflecting points and shapes enable faster rendering in computer-aided design and virtual reality. In data science, symmetry detection through reflection-like transformations aids pattern recognition and machine learning models. Research in abstract algebra explores generalized reflections in group theory, expanding the concept beyond geometry into algebraic structures. Looking ahead, reflection remains a vital tool—supporting innovation in science, technology, and design—while continuing to enrich our understanding of symmetry and transformation in both natural and artificial systems.

Understanding Reflection in Math: A Comprehensive Exploration

In the realm of mathematics, the concept of reflection is a fundamental idea, deeply intertwined with geometry and transformations. It's a transformation that essentially mirrors a shape or a point across a line or a plane. Think of it like looking into a mirror: the image you see is a reflection, flipped horizontally. This intuitive understanding forms the basis of a more

rigorous mathematical definition and opens up a world of applications, from understanding symmetry to complex data analysis. This article will delve deep into what a reflection is in math, its properties, different types, and its significance across various mathematical disciplines.

Defining Reflection in Geometry

At its core, a reflection in geometry is an isometry, meaning it preserves distances and angles. When a geometric object is reflected, its size and shape remain unchanged; only its orientation is reversed. The line or plane across which the reflection occurs is called the axis of reflection or line of reflection. Every point on the original object has a corresponding image point on the reflected object. The line of reflection acts as a perpendicular bisector of the segment connecting any point to its reflected image. This means the line of reflection cuts the segment exactly in half and forms a 90-degree angle with it.

Key Properties of Reflection

Understanding the properties of reflections is crucial for grasping their mathematical implications:

1. **Preservation of Distance: If you have a point P and its reflection P', and another point Q and its reflection Q', then the distance between P and Q is exactly the same as the distance between P' and Q'. This is a hallmark of isometries.**
2. **Preservation of Angles: Similarly, any angle formed by three points in the original figure will have an identical angle formed by their reflected counterparts.**
3. **Orientation Reversal: This is perhaps the most distinctive characteristic. A reflection flips the orientation of an object. If you were to trace the perimeter of a shape in a clockwise direction, the reflected shape's perimeter traced in the same spatial direction would appear counter-clockwise. This is why a reflection is sometimes called a "flip."**
4. **Fixed Points: Any point that lies directly on the axis of reflection remains**

in its original position. These are known as fixed points of the reflection.

Types of Reflections

The most common and foundational type of reflection is a reflection across a line, primarily explored in 2D geometry. However, the concept extends to higher dimensions and specific coordinate systems.

Reflection Across the x-axis and y-axis

In the Cartesian coordinate system, reflections across the x-axis and y-axis are fundamental examples. Let's consider a point with coordinates (x, y).

1. **Reflection across the x-axis: When a point (x, y) is reflected across the x-axis, its x-coordinate remains the same, and its y-coordinate changes sign. The reflected point becomes (x, -y). Imagine folding the graph paper along the x-axis; the point would land directly below (or above) its original position.**
2. **Reflection across the y-axis: Similarly, when a point (x, y) is reflected across the y-axis, its y-coordinate remains the same, and its x-coordinate changes sign. The reflected point becomes (-x, y). This is like folding the graph paper along the y-axis.**

Reflection Across the Line y = x and y = -x

These are other important lines of reflection in the Cartesian plane.

1. **Reflection across the line y = x: When a point (x, y) is reflected across the line y = x, its coordinates are swapped. The reflected point becomes (y, x). This line passes through the origin and has a slope of 1.**
2. **Reflection across the line y = -x: For a point (x, y) reflected across the line y = -x, both coordinates change sign and are swapped. The reflected point becomes (-y, -x). This line also passes through the origin but has a slope of -1.**

Reflection Across a Point (Origin Symmetry)

While not strictly a reflection across a line, reflection across a point, typically the origin (0,0), is a related concept. Reflecting a point (x, y) across the origin results in the point (-x, -y). This is equivalent to two successive reflections: one across the x-axis followed by a reflection across the y-axis, or vice-versa. This is also known as point symmetry.

Reflection in 3D Space

The concept of reflection extends beyond two dimensions into three-dimensional space. In 3D, the axis of reflection becomes a plane of reflection. A point (x, y, z) reflected across the xy-plane, for instance, would have its z-coordinate negated, becoming (x, y, -z). Similarly, reflection across the yz-plane changes the x-coordinate to -x, resulting in (-x, y, z), and reflection across the xz-plane changes y to -y, giving (x, -y, z).

Mathematical Applications of Reflection

Reflections are not merely abstract geometric concepts; they have significant applications across various mathematical fields and beyond.

Symmetry and Tessellations

One of the most direct applications of reflection is in understanding and creating symmetry. Many natural objects and man-made designs exhibit reflectional symmetry (also known as line symmetry or bilateral symmetry). For example, a butterfly's wings or a human face often display this type of symmetry. In mathematics, this leads to the study of dihedral groups, which describe the symmetries of regular polygons, where reflections are a key component. Reflections are also crucial in constructing tessellations, which are patterns of shapes that fit together without any gaps or overlaps. By reflecting and translating basic shapes, complex and repeating patterns can be generated.

Transformational Geometry

Reflection is one of the four basic rigid transformations in geometry, alongside translation, rotation, and dilation. These transformations are used to move, resize, or change the orientation of geometric figures while preserving certain properties. Understanding reflections is vital for comprehending how shapes can be manipulated and how their properties change or remain invariant under these operations. This forms the foundation of transformational geometry.

Coordinate Geometry and Vector Transformations

In coordinate geometry, reflections are represented by specific matrix transformations. For instance, reflecting a vector across the x-axis can be achieved by multiplying it by a reflection matrix. These matrix representations are powerful tools for manipulating geometric objects computationally and are used extensively in computer graphics, robotics, and physics simulations. The concept of linear transformations heavily relies on understanding how reflections (and other transformations) affect vectors and spaces.

Wave Phenomena and Optics

The law of reflection in physics, stating that the angle of incidence equals the angle of reflection, is a direct manifestation of the geometric concept of reflection. This principle governs how light, sound, and other waves bounce off surfaces. In optics, mirrors are designed to create reflections, and the principles of reflection are used to understand image formation in various optical instruments.

Data Analysis and Machine Learning

While perhaps less intuitive, reflections can find applications in more advanced mathematical fields. For example, in some dimensionality reduction techniques or data augmentation strategies in machine learning,

applying transformations that include reflections can help in creating more robust models or exploring the data space more thoroughly. Understanding how data points are transformed under reflection can reveal underlying patterns or symmetries in the data.

Distinguishing Reflection from Other Transformations

It's important to differentiate reflection from other geometric transformations. While all are forms of isometries (except dilation), they have distinct effects:

1. **Translation: A slide in a specific direction. It moves every point by the same distance and in the same direction. No orientation reversal occurs.**
2. **Rotation: A turn around a fixed point (the center of rotation). It changes orientation but also preserves distances and angles.**
3. **Dilation: A resizing of a figure. It changes the size of the object, unlike reflections, translations, and rotations, which are rigid transformations.**

The key differentiator for reflection is its characteristic orientation reversal or "flipping" effect.

Conclusion

In essence, a reflection in math is a powerful geometric transformation that mirrors a figure across a line or plane, preserving its shape and size while reversing its orientation. From the simple act of plotting points on a Cartesian plane to the complex symmetries found in nature and the algorithms driving modern technology, the concept of reflection plays a vital and pervasive role. Understanding its properties and applications provides a deeper appreciation for the elegance and interconnectedness of mathematical principles.

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Questions & Answers About what is a reflection in math

No	Question	Answer
1	What's the simplest way to explain a reflection in math?	Imagine a mirror. A reflection in math is like flipping a shape across a line (called the line of reflection) so it looks like it's being viewed in that mirror. It's a mirror image.
2	So, if I reflect a shape, does it change size or shape?	Nope! A reflection is a rigid transformation. This means the reflected shape will be exactly the same size and shape as the original, just oriented differently.

3	What's the 'line of reflection' I keep hearing about?	The line of reflection is the imaginary line you're 'flipping' the shape over. Think of it as the 'mirror' in our analogy. It acts as the central axis for the transformation.
4	Can you reflect shapes in any direction?	Absolutely! You can reflect a shape horizontally, vertically, or even diagonally across any line you choose. The line of reflection determines the orientation of the reflected image.
5	What are some common lines of reflection used in math?	The most common lines of reflection are the x-axis, the y-axis, and the line y=x (a diagonal line). These are frequently used in graphing and coordinate geometry.
6	How does reflecting a point work on a graph?	When you reflect a point (x, y) across the x-axis, its new coordinates become (x, -y). If you reflect it across the y-axis, the new coordinates are (-x, y).
7	What's the difference between a reflection and a rotation?	A reflection flips a shape across a line, like a mirror image. A rotation turns a shape around a fixed point, like spinning it on a turntable.
8	Where do we see reflections in the real world that are like math reflections?	Think about your reflection in a still lake, or the image in a regular mirror. These are great real-world examples of reflections where the image is reversed.
9	Are reflections useful for anything in math besides just making mirror images?	Yes! Reflections are fundamental in geometry for understanding symmetry, proving theorems, and in transformations used in computer graphics and design.
10	If I reflect a shape twice, what happens?	If you reflect a shape across the same line twice, it will end up back in its original position. Reflecting across two different parallel lines is equivalent to a translation (sliding).

reflection in geometry definition, what is a reflection in math, mirror image in mathematical reflection, reflection transformation in coordinate geometry, how to define reflection in math, reflection math concept explanation, reflection symmetry in geometry, point reflection definition in math, line of reflection formula, math reflection examples and rules

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