GENERAL

list of properties in math

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Introduction

Mathematics is a language built on patterns, relationships, and rules that describe the world around us. Whether you're a student, a teacher, or simply a curious mind, understanding the foundational **properties in math**is essential for unlocking deeper concepts and solving complex problems. This article offers a thorough exploration of the most important mathematical properties, organized into clear categories and presented with real world examples. By the end, you'll have a solid reference that you can return to whenever you need a refresher or a deeper insight.

Arithmetic Properties

1. Commutative Property

The commutative property states that the order of addition or multiplication does not affect the result:

- Addition: a + b = b + a
- Multiplication: a × b = b × a

Example: 7 + 3 = 3 + 7 = 10, and 4 × 5 = 5 × 4 = 20.

2. Associative Property

The associative property allows you to group numbers differently without changing the outcome:

- Addition: (a + b) + c = a + (b + c)
- Multiplication: (a × b) × c = a × (b × c)

Example: (2 + 3) + 4 = 2 + (3 + 4) = 9.

3. Distributive Property

This property links addition and multiplication:

- a × (b + c) = a × b + a × c

Example: 3 × (4 + 5) = 3 × 4 + 3 × 5 = 12 + 15 = 27.

4. Identity Property

Every number has an identity element for addition and multiplication:

- Additive identity: a + 0 = a
- Multiplicative identity: a × 1 = a

Example: 8 + 0 = 8, and 7 × 1 = 7.

5. Inverse Property

Each number has an additive and multiplicative inverse:

- Additive inverse: a + (–a) = 0
- Multiplicative inverse (for non zero a): a × (1/a) = 1

Example: 5 + (–5) = 0, and 9 × (1/9) = 1.

Number Properties

1. Even and Odd Numbers

An integer is **even** if it's divisible by 2; otherwise, it's **odd**. Even numbers can be written as 2k, odd numbers as 2k + 1.

2. Prime Numbers

Primes are integers greater than 1 with exactly two distinct positive divisors: 1 and the number itself. The first few primes are 2, 3, 5, 7, 11, and 13.

3. Composite Numbers

Composite numbers have more than two positive divisors. For example, 12 = 2 × 2 × 3.

4. Perfect Numbers

A perfect number equals the sum of its proper divisors. The smallest perfect number is 6 (1 + 2 + 3). Others include 28, 496, and 8128.

5. Fibonacci Sequence

Each number is the sum of the two preceding ones. Starting with 0 and 1, the sequence begins 0, 1, 1, 2, 3, 5, 8, 13, ….

6. Square and Cubic Numbers

A square number is an integer squared (n^2). A cubic number is an integer cubed (n^3). Examples: $4^2 = 16$, $3^3 = 27$.

7. Rational vs. Irrational Numbers

Rational numbers can be expressed as a fraction a/b, whereas irrational numbers cannot be written as a simple fraction (e.g., " 2, < 'à

Algebraic Properties

1. Idempotent Property

An operation is idempotent if applying it multiple times yields the same result as applying it once: a "• a = a.

2. Absorbing Property

In ring theory, an element a absorbs b under multiplication if a × b = 0.

3. Distributive Over Addition and Subtraction

Beyond multiplication, some operations distribute over addition and subtraction, such as the difference of squares: $a^2 – b^2 = (a + b)(a – b)$.

Function Properties

1. Injective (One to One)

A function f is injective if distinct inputs produce distinct outputs: f(a) = f(b) implies a = b.

2. Surjective (Onto)

A function f is surjective if every element in the codomain is an image of at least one element from the domain.

3. Bijective

A function is bijective when it is both injective and surjective, establishing a perfect pairing between domain and codomain.

4. Even and Odd Functions

An even function satisfies f(–x) = f(x). An odd function satisfies f(–x) = –f(x). Example: f(x) = x^2 is even; f(x) = x^3 is odd.

5. Continuous and Discontinuous

A function is continuous at a point if its limit equals its value there. Discontinuities can be removable, jump, or infinite.

6. Differentiable and Non Differentiable

A function is differentiable at a point if its derivative exists there. The absolute value function |x| is non differentiable at x = 0.

7. Monotonicity

A function is monotonic if it is either entirely non decreasing or non increasing. Strictly monotonic functions are either strictly increasing or strictly decreasing.

Geometric Properties

1. Convex and Concave Shapes

A convex shape has all interior angles less than 180°; a concave shape has at least one interior angle greater than 180°.

2. Symmetry

- Reflective symmetry: A shape is symmetrical across a line if one side mirrors the other.
- Rotational symmetry: A shape looks the same after a rotation less than 360°.
- Translational symmetry: A shape repeats at regular intervals.

3. Similarity and Congruence

Similar figures share the same shape but not necessarily the same size. Congruent figures are identical in shape and size.

4. Pythagorean Property

In a right triangle, the square of the hypotenuse equals the sum of the squares of the other two sides: $a^2 + b^2 = c^2$.

5. Trigonometric Identities

Key identities include:

- sin²;, ² 6÷;#¸ = 1
- tan;, Ò 6–ã¸ / cos;€
- sin(2;,’ Ò " 6–ã¸ cos;€

Set Theory Properties

1. Subset and Proper Subset

A set A is a subset of B (A "† B) if every element of A is also in B. A proper subset (A ", B) excludes equality.

2. Union and Intersection

The union of sets A and B (A "* B) contains all elements in either set. The intersection (A ") B) contains elements common to both.

3. Complement

The complement of a set A (A œ) consists of all elements not in A, relative to a universal set U.

4. Cartesian Product

The Cartesian product A × B is the set of all ordered pairs (a, b) where a " A and b " B.

5. Power Set

The power set of A, denoted P(A), is the set of all subsets of A.

Logical Properties

1. Truth Tables

Logical operators such as AND, OR, NOT, and XOR are evaluated using truth tables. For example, the AND operator is true only when both operands are true.

2. Tautology and Contradiction

A tautology is a statement that is always true (e.g., P "(¬P). A contradiction is always false (e.g., P "' ¬P).

3. De Morgan’s Laws

These laws relate conjunction and disjunction through negation:

- ¬(P "' Q) = ¬P "(¬Q
- ¬(P "(Q) = ¬P "' ¬Q

Probability Properties

1. Additive Rule

For mutually exclusive events A and B: P(A "* B) = P(A) + P(B).

2. Multiplication Rule

For independent events A and B: P(A ") B) = P(A) × P(B).

3. Conditional Probability

Defined as P(A|B) = P(A ") B) / P(B). It measures the probability of A given that B has occurred.

4. Bayes’ Theorem

Provides a way to update probabilities based on new evidence:

P(A|B) = [P(B|A) × P(A)] / P(B).

5. Law of Total Probability

If events B •, B ,, …, B ™ partition the sample space, then P(A) = :2 „ Ä!Ö"• „!Ö"'à

Linear Algebra Properties

1. Matrix Multiplication

Matrix multiplication is associative but not commutative: (AB)C = A(BC) but AB "` BA in general.

2. Determinant Properties

- det(AB) = det(A) × det(B)
- det(A {¹) = 1/det(A), provided A is invertible
- det(A @) = det(A)

3. Eigenvalues and Eigenvectors

For a square matrix A, a non zero vector v is an eigenvector if Av = ;·`, where ;² —2 F†R 6÷'&W7 öæF–ær V–vVàvalue.

4. Orthogonality

Vectors u and v are orthogonal if their dot product u·v = 0. Orthogonal matrices satisfy Q @Q = I.

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