CollegeAlgebra

Sets of Numbers

- The **natural numbers** are the set of numbers used when counting; these are the numbers $\{1, 2, 3, 4, 5, \ldots\}$.
- The **whole numbers** are the set of natural numbers and zero; these are the numbers $\{0, 1, 2, 3, 4, 5, \ldots\}$.
- The **integers** are the set of whole numbers and their opposites; these are the numbers $\{\ldots, -3, -2, -1, 0, 1, 2, 3, \ldots\}$.
- The **rational numbers** are the set of numbers that can be expressed as a fraction of two integers where the denominator is not zero. Rational numbers include the set of natural numbers, whole numbers, and integers.

EX: $-5, \frac{3}{4}, 0, 2, \sqrt{16}, 2\frac{1}{2}, 0.\overline{6}, 2.35$

- The **irrational numbers** are the set of numbers that cannot be expressed as a fraction of two integers.

EX: $\pi, e, \sqrt{3}, \sqrt[3]{10}$

- The **real numbers** are the set of rational numbers and irrational numbers.

EX: $-4, \pi, \frac{7}{8}, \sqrt{5}, \sqrt{64}, 0.125, \sqrt[3]{25}, 0.\overline{7}$

- The **imaginary numbers** are the set of square roots of negative numbers, written in the form bi, where b is a nonzero real number and $i = \sqrt{-1}$.

EX: $-5i, i, 3i, \sqrt{-9}, -\sqrt{-100}$

- The **complex numbers** are the set of real numbers plus an imaginary number, written in the form $a + bi$, where a and b are real numbers and $i = \sqrt{-1}$.

EX: $9 + 2i, -6 + i, -4 - 3i, 7 - 6i, 5i$

Solving Equations

When you perform the same operation to each side of an equation, the result is a new equation that has the same solution. Equations that have the same solution(s) are equivalent equations.

Using the Addition Property of Equality

The **Addition Property of Equality** states that when the same number is added to equal numbers, the sums are equal.

RULE: If a, b, and c are any real numbers and $a = b$, then $a + c = b + c$.

EX: $2 + 7 = 2 + 7$

Applying this property to equations, when the same number is added to each side of an equation, the result is an equivalent equation.

EX: If $x - 3 = 11$, then $x - 3 + 3 = 11 + 3$, or $x = 14$

Using the Subtraction Property of Equality

The **Subtraction Property of Equality** states that when the same number is subtracted from equal numbers, the differences are equal.

RULE: If a, b, and c are any real numbers and $a = b$, then $a - c = b - c$.

EX: $12 - 8 = 12 - 8$

Applying this property to equations, when the same number is subtracted from each side of an equation, the result is an equivalent equation.

EX: If $y + 7 = 15$, then $y + 7 - 7 = 15 - 7$, or $y = 8$

Using the Multiplication Property of Equality

The **Multiplication Property of Equality** states that when equal numbers are multiplied by the same number, the products are equal.

RULE: If a, b, and c are any real numbers and $a = b$, then $ac = bc$.

EX: $5 \cdot 4 = 5 \cdot 4$

Applying this property to equations, when both sides of an equation are multiplied by the same real number, the result is an equivalent equation.

EX: If $\frac{x}{6} = 3$, then $\left(\frac{x}{6}\right)6 = (3)6$, or $x = 18$

Using the Division Property of Equality

The **Division Property of Equality** states that when equal numbers are divided by the same nonzero number, the quotients are equal.

RULE: If a, b, and c are any real numbers, $c \neq 0$, and $a = b$, then $\frac{a}{c} = \frac{b}{c}$.

EX: $\frac{15}{5} = \frac{15}{5}$

Applying this property to equations, when both sides of an equation are divided by the same nonzero real number, the result is an equivalent equation.

EX: If $7x = 21$, then $\frac{7x}{7} = \frac{21}{7}$, or $x = 3$

Solving Multistep Equations

Some equations require more than one inverse operation to solve. The goal when solving a multistep equation is to isolate the variable (i.e., get it by itself). To do this, use the properties of equality. If there are like terms on one side of an equation, they should be combined before using the properties.

EX: Solve the equation $5x - 3x - 1 = 15$

a.	$5x + 3x - 1 = 15$	a. Original equation
b.	$8x - 1 = 15$	b. Combine like terms.
c.	$8x - 1 + 1 = 15 + 1$	c. Use the Addition Property of Equality to undo the subtraction and isolate the variable term.
d.	$8x = 16$	d. Simplify.
e.	$\frac{8x}{8} = \frac{16}{8}$	e. Use the Division Property of Equality to undo the multiplication and isolate the variable.
f.	$x = 2$	f. Simplify.

Variables on Both Sides

When an equation has variables on both sides, the objective is to get all variable terms on the same side of the equation by using either the Addition or Subtraction Property of Equality.

EX: Solve the equation $6m - 8 = 2m$

a.	$6m - 8 = 2m$	a. Original equation
b.	$6m - 2m - 8 = 2m - 2m$	b. Use the Subtraction Property of Equality to move the variable term to one side.
c.	$4m - 8 = 0$	c. Simplify.
d.	$4m - 8 + 8 = 0 + 8$	d. Use the Addition Property of Equality to isolate the variable term.
e.	$4m = 8$	e. Simplify.
f.	$\frac{4m}{4} = \frac{8}{4}$	f. Use the Division Property of Equality to isolate the variable.
g.	$m = 2$	g. Simplify.

Solving Absolute Value Equations

The **absolute value** of a number is its distance from zero on the number line. Therefore, the equation $|x| = 4$ has two solutions, 4 and −4, since both have a distance of 4 units from zero on the number line.

To solve an equation $|x| = b$, where b is a positive number, solve the disjunction $x = b$ or $x = -b$.

EX: Solve the equation $|x + 7| = 3$

a. $|x + 7| = 3$	a. Original equation.
b. $x + 7 = 3$ or $x + 7 = -3$	b. Write as a disjunction.
c. $x + 7 - 7 = 3 - 7$ or $x + 7 - 7 = -3 - 7$	c. Use the Subtraction Property of Equality on both equations to isolate the variable.
d. $x = -4$ or $x = -10$	d. Simplify.

Solving Inequalities

An **inequality** shows the relationship between two numbers or expressions. The solution of an inequality is the set of numbers that make the inequality true.

Addition & Subtraction Properties

The **Addition and Subtraction Properties of Inequality** state that adding or subtracting the same number on each side of an inequality produces an equivalent inequality. If a, b, and c are real numbers, then the following are true:

Addition Property of Inequality: If $a > b$, then $a + c > b + c$; if $a < b$, then $a + c < b + c$.

Subtraction Property of Inequality: If $a > b$, then $a - c > b - c$; if $a < b$, then $a - c < b - c$.

Note that similar statements hold true for $\geq$ and $\leq$.

NUMERIC EXAMPLES

Addition Property of Inequality: Since $4 > 2$, then $4 + 1 > 2 + 1$; since $3 < 5$, then $3 + 6 < 5 + 6$.

Subtraction Property of Inequality: Since $9 > 2$, then $9 - 1 > 2 - 1$; since $4 < 7$, then $4 - 2 < 7 - 2$.

ALGEBRAIC EXAMPLES

Addition Property of Inequality: If $p - 3 < 11$, then $p - 3 + 3 < 11 + 3$, or $p < 14$.

Subtraction Property of Inequality: If $x + 9 > 16$, then $x + 9 - 9 > 16 - 9$, or $x > 7$.

Multiplication & Division Properties

The **Multiplication and Division Properties of Inequality** state that multiplying or dividing each side of an inequality by a positive number makes an equivalent inequality. These properties also state that multiplying or dividing each side of an inequality by a negative number and reversing the direction of the inequality symbol make an equivalent inequality.

Given a, b, and c are real numbers:

Where c is positive	Where c is negative
If $a < b$, then $ac < bc$.	If $a < b$, then $ac > bc$.
If $a > b$, then $ac > bc$.	If $a > b$, then $ac < bc$.

Note that similar statements hold true for $\geq$ and $\leq$.

NUMERIC EXAMPLES

Multiplication Property of Inequality:

Since $2 < 5$, then $2 \cdot 3 < 5 \cdot 3$; since $2 < 5$, then $2 \cdot (-3) > 5 \cdot (-3)$.

Since $6 > 4$, then $6 \cdot 4 > 4 \cdot 4$; since $6 > 4$, then $6 \cdot (-4) < 4 \cdot (-4)$.

Division Property of Inequality:

Since $4 < 6$, then $\frac{4}{2} < \frac{6}{2}$; since $4 < 6$, then $\frac{4}{-2} > \frac{6}{-2}$.

Since $9 > 3$, then $\frac{9}{3} > \frac{3}{3}$; since $9 > 3$, then $\frac{9}{-3} < \frac{3}{-3}$.

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