Mathematics vocabulary word wall cards provide a display of mathematics content words and associated visual cues to assist in vocabulary development. The cards should be used as an instructional tool for teachers and then as a reference for all students. The cards are designed for print use only.

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Real Numbers
The set of all rational and irrational numbers

<table>
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<tr>
<th>Natural Numbers</th>
<th>{1, 2, 3, 4 ...}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Numbers</td>
<td>{0, 1, 2, 3, 4 ...}</td>
</tr>
<tr>
<td>Integers</td>
<td>{... -3, -2, -1, 0, 1, 2, 3 ...}</td>
</tr>
<tr>
<td>Rational Numbers</td>
<td>the set of all numbers that can be written as the ratio of two integers with a non-zero denominator (e.g., $2\frac{3}{5}$, -5, 0.3, $\sqrt{16}$, $\frac{13}{7}$)</td>
</tr>
<tr>
<td>Irrational Numbers</td>
<td>the set of all nonrepeating, nonterminating decimals (e.g., $\sqrt{7}$, $\pi$, -0.2322322322223...)</td>
</tr>
</tbody>
</table>
Absolute Value

\[ |5| = 5 \quad |\ -5\ | = 5 \]

The distance between a number and zero
### Order of Operations

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grouping Symbols</strong></td>
<td>(()) (\sqrt{)} {}  |  []</td>
</tr>
<tr>
<td><strong>Exponents</strong></td>
<td>(a^n)</td>
</tr>
<tr>
<td><strong>Multiplication</strong></td>
<td>Left to Right</td>
</tr>
<tr>
<td><strong>Division</strong></td>
<td>Left to Right</td>
</tr>
<tr>
<td><strong>Addition</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Subtraction</strong></td>
<td></td>
</tr>
</tbody>
</table>
Expression

A representation of a quantity that may contain numbers, variables or operation symbols

\[ X \]

\[-\sqrt{26}\]

\[ 3^4 + 2m \]

\[ ax^2 + bx + c \]

\[ 3(y + 3.9)^2 - \frac{8}{9} \]
Variable

\[2(y + \sqrt{3})\]

\[9 + x = 2.08\]

\[d = 7c - 5\]

\[A = \pi r^2\]
Coefficient

\((-4) + \frac{2}{3}ab - \frac{1}{2}\)

\(-7y\sqrt{5}\)

\(\pi r^2\)
Term

$3x + 2y - 8$

3 terms

$-5x^2 - x$

2 terms

$\frac{2}{3}ab$

1 term
Scientific Notation

$ a \times 10^n$

$1 \leq |a| < 10$ and $n$ is an integer

### Examples:

<table>
<thead>
<tr>
<th>Standard Notation</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>17,500,000</td>
<td>$1.75 \times 10^7$</td>
</tr>
<tr>
<td>-84,623</td>
<td>$-8.4623 \times 10^4$</td>
</tr>
<tr>
<td>0.0000026</td>
<td>$2.6 \times 10^{-6}$</td>
</tr>
<tr>
<td>-0.080029</td>
<td>$-8.0029 \times 10^{-2}$</td>
</tr>
<tr>
<td>$(4.3 \times 10^5) (2 \times 10^{-2})$</td>
<td>$(4.3 \times 2) (10^5 \times 10^{-2}) = 8.6 \times 10^{5+(-2)} = 8.6 \times 10^3$</td>
</tr>
<tr>
<td>$\frac{6.6 \times 10^6}{2 \times 10^3}$</td>
<td>$\frac{6.6}{2} \times \frac{10^6}{10^3} = 3.3 \times 10^{6-3} = 3.3 \times 10^3$</td>
</tr>
</tbody>
</table>
Exponential Form

\[ a^n = a \cdot a \cdot a \cdot a \ldots, \ a \neq 0 \]

**Examples:**

\[
\begin{align*}
2 \cdot 2 \cdot 2 &= 2^3 = 8 \\
n \cdot n \cdot n \cdot n &= n^4 \\
3 \cdot 3 \cdot 3 \cdot x \cdot x &= 3^3 x^2 = 27x^2
\end{align*}
\]
Negative Exponent

\[ a^{-n} = \frac{1}{a^n}, \ a \neq 0 \]

Examples:

\[
\begin{align*}
4^{-2} &= \frac{1}{4^2} = \frac{1}{16} \\
\frac{x^4}{y^{-2}} &= \frac{1}{\frac{1}{y^2}} = x^4 \cdot \frac{y^2}{1} = x^4 y^2 \\
(2 - a)^{-2} &= \frac{1}{(2 - a)^2}, \ a \neq 2
\end{align*}
\]
Zero Exponent

\[ a^0 = 1, \ a \neq 0 \]

Examples:

\[
\begin{align*}
(-5)^0 &= 1 \\
(3x + 2)^0 &= 1 \\
(x^2y^{-5}z^8)^0 &= 1 \\
4m^0 &= 4 \cdot 1 = 4 \\
\left(\frac{2}{3}\right)^0 &= 1
\end{align*}
\]
Product of Powers Property

\[ a^m \cdot a^n = a^{m+n} \]

Examples:

1. \[ x^4 \cdot x^2 = x^{4+2} = x^6 \]
2. \[ a^3 \cdot a = a^{3+1} = a^4 \]
3. \[ w^7 \cdot w^{-4} = w^{7+(-4)} = w^3 \]
Power of a Power Property

\[(a^m)^n = a^{m \cdot n}\]

Examples:

\[
(y^4)^2 = y^{4 \cdot 2} = y^8
\]

\[
(g^2)^{-3} = g^{2 \cdot (-3)} = g^{-6} = \frac{1}{g^6}
\]
Power of a Product Property

\[(ab)^m = a^m \cdot b^m\]

Examples:

\[
(-3a^4b)^2 = (-3)^2 \cdot (a^4)^2 \cdot b^2 = 9a^8b^2
\]

\[
\frac{-1}{(2x)^3} = \frac{-1}{2^3 \cdot x^3} = \frac{-1}{8x^3}
\]
Quotient of Powers Property

\[
\frac{a^m}{a^n} = a^{m-n}, \quad a \neq 0
\]

Examples:

\[
\frac{x^6}{x^5} = x^{6-5} = x^1 = x
\]

\[
\frac{y^{-3}}{y^{-5}} = y^{-3-(-5)} = y^2
\]

\[
\frac{a^4}{a^4} = a^{4-4} = a^0 = 1
\]
**Power of Quotient Property**

\[
\left( \frac{a}{b} \right)^m = \frac{a^m}{b^m}, \quad b \neq 0
\]

**Examples:**

\[
\left( \frac{y^3}{3} \right)^4 = \frac{y^{3 \cdot 4}}{3^4} = \frac{y}{81}
\]

\[
\left( \frac{5}{t^{-3}} \right)^{-3} = 5^{-3} t^3 = \frac{1}{5^3} \cdot t^3 = \frac{t^3}{5^3} = \frac{t^3}{125}
\]
### Polynomial

<table>
<thead>
<tr>
<th>Example</th>
<th>Name</th>
<th>Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 6x</td>
<td>monomial</td>
<td>1 term</td>
</tr>
<tr>
<td>3t – 1 12xy³ + 5x⁴y</td>
<td>binomial</td>
<td>2 terms</td>
</tr>
<tr>
<td>2x² + 3x – 7</td>
<td>trinomial</td>
<td>3 terms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nonexample</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>5mⁿ⁻³ – 8</td>
<td>variable exponent</td>
</tr>
<tr>
<td>n⁻³ + 9</td>
<td>negative exponent</td>
</tr>
</tbody>
</table>
Degree of a Polynomial

The largest exponent or the largest sum of exponents of a term within a polynomial

<table>
<thead>
<tr>
<th>Polynomial</th>
<th>Degree of Each Term</th>
<th>Degree of Polynomial</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-7m^3n^5$</td>
<td>$-7m^3n^5 \rightarrow$ degree 8</td>
<td>8</td>
</tr>
<tr>
<td>$2x + 3$</td>
<td>$2x \rightarrow$ degree 1 3 $\rightarrow$ degree 0</td>
<td>1</td>
</tr>
<tr>
<td>$6a^3 + 3a^2b^3 - 21$</td>
<td>$6a^3 \rightarrow$ degree 3 $3a^2b^3 \rightarrow$ degree 5 $-21 \rightarrow$ degree 0</td>
<td>5</td>
</tr>
</tbody>
</table>
Leading Coefficient

The coefficient of the first term of a polynomial written in descending order of exponents

Examples:

\[
\begin{align*}
7a^3 - 2a^2 + 8a - 1 \\
-3n^3 + 7n^2 - 4n + 10 \\
16t - 1
\end{align*}
\]
Add Polynomials
(Group Like Terms – Horizontal Method)

Example:

\[(2g^2 + 6g - 4) + (g^2 - g)\]

\[= 2g^2 + 6g - 4 + g^2 - g\]

(Group like terms and add)

\[= (2g^2 + g^2) + (6g - g) - 4\]

\[= 3g^2 + 5g - 4\]
Add Polynomials
(Align Like Terms – Vertical Method)

Example:

\[(2g^3 + 6g^2 - 4) + (g^3 - g - 3)\]

(Align like terms and add)

\[
\begin{array}{c}
2g^3 + 6g^2 \\
+ g^3 \\
\hline
3g^3 + 6g^2
\end{array}
\]

\[
\begin{array}{c}
- 4 \\
- g - 3 \\
\hline
- g - 7
\end{array}
\]
Subtract Polynomials

(Group Like Terms - Horizontal Method)

Example:

\[(4x^2 + 5) - (-2x^2 + 4x - 7)\]

(Add the inverse.)

\[= (4x^2 + 5) + (2x^2 - 4x + 7)\]

\[= 4x^2 + 5 + 2x^2 - 4x + 7\]

(Group like terms and add.)

\[= (4x^2 + 2x^2) - 4x + (5 + 7)\]

\[= 6x^2 - 4x + 12\]
Subtract Polynomials

(Align Like Terms - Vertical Method)

Example:

\[(4x^2 + 5) - (-2x^2 + 4x - 7)\]

(Arrange like terms then add the inverse and add the like terms.)

\[4x^2 + 5 + 2x^2 - 4x + 7\]

\[6x^2 - 4x + 12\]
Multiply Binomials

Apply the distributive property.

\[(a + b)(c + d) = a(c + d) + b(c + d) = ac + ad + bc + bd\]

Example: \((x + 3)(x + 2)\)

\[
= (x + 3)(x + 2)
= x(x + 2) + 3(x + 2)
= x^2 + 2x + 3x + 6
= x^2 + 5x + 6
\]
Multiply Polynomials

Apply the distributive property.

\[(x + 2)(3x^2 + 5x + 1)\]

\[= x(3x^2 + 5x + 1) + 2(3x^2 + 5x + 1)\]

\[= x \cdot 3x^2 + x \cdot 5x + x \cdot 1 + 2 \cdot 3x^2 + 2 \cdot 5x + 2 \cdot 1\]

\[= 3x^3 + 5x^2 + x + 6x^2 + 10x + 2\]

\[= 3x^3 + 11x^2 + 11x + 2\]
Multiply Binomials
(Model)

Apply the distributive property.

Example: 

\[(x + 3)(x + 2)\]

\[x^2 + 2x + 3x + 6 = x^2 + 5x + 6\]
Multiply Binomials

(Graphic Organizer)

Apply the distributive property.

Example: \((x + 8)(2x - 3)\)

\[= (x + 8)(2x + -3)\]

\[
\begin{array}{c|c|c}
  & 2x & -3 \\
\hline
  x & 2x^2 & -3x \\
  + & 16x & -24 \\
\hline
  8 & & \\
\end{array}
\]

\[2x^2 + 16x + -3x + -24 = 2x^2 + 13x - 24\]
Multiply Binomials
(Squaring a Binomial)

\[(a + b)^2 = a^2 + 2ab + b^2\]
\[(a - b)^2 = a^2 - 2ab + b^2\]

Examples:

\[
(3m + n)^2 = 9m^2 + 2(3m)(n) + n^2
= 9m^2 + 6mn + n^2
\]

\[
(y - 5)^2 = y^2 - 2(5)(y) + 25
= y^2 - 10y + 25
\]
Multiply Binomials
(Sum and Difference)

\[(a + b)(a - b) = a^2 - b^2\]

Examples:

\[(2b + 5)(2b - 5) = 4b^2 - 25\]

\[(7 - w)(7 + w) = 49 - w^2\]
Factors of a Monomial

The number(s) and/or variable(s) that are multiplied together to form a monomial

<table>
<thead>
<tr>
<th>Examples:</th>
<th>Factors</th>
<th>Expanded Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>$5b^2$</td>
<td>$5 \cdot b^2$</td>
<td>$5 \cdot b \cdot b$</td>
</tr>
<tr>
<td>$6x^2y$</td>
<td>$6 \cdot x^2 \cdot y$</td>
<td>$2 \cdot 3 \cdot x \cdot x \cdot y$</td>
</tr>
<tr>
<td>$-\frac{5p^2q^3}{2}$</td>
<td>$\frac{-5}{2} \cdot p^2 \cdot q^3$</td>
<td>$\frac{1}{2} \cdot (-5) \cdot p \cdot p \cdot q \cdot q \cdot q$</td>
</tr>
</tbody>
</table>
Factoring
(Greatest Common Factor)

Find the greatest common factor (GCF) of all terms of the polynomial and then apply the distributive property.

Example: \[ 20a^4 + 8a \]

\[ 2 \cdot 2 \cdot 5 \cdot a \cdot a \cdot a \cdot a + 2 \cdot 2 \cdot 2 \cdot a \]

\[ \text{common factors} \]

\[ \text{GCF} = 2 \cdot 2 \cdot a = 4a \]

\[ 20a^4 + 8a = 4a(5a^3 + 2) \]
Factoring  
(By Grouping)  
For trinomials of the form  
\[ ax^2 + bx + c \]

Example:  
\[ 3x^2 + 8x + 4 \]

\[
\text{ac} = 3 \cdot 4 = 12  
\text{Find factors of ac that add to equal b}  
12 = 2 \cdot 6 \rightarrow 2 + 6 = 8
\]

\[
3x^2 + 2x + 6x + 4  
(3x^2 + 2x) + (6x + 4)  
x(3x + 2) + 2(3x + 2)  
(3x + 2)(x + 2)
\]

Rewrite 8x as 2x + 6x  
Group factors  
Factor out a common binomial
Factoring
(Perfect Square Trinomials)

\[a^2 + 2ab + b^2 = (a + b)^2\]
\[a^2 - 2ab + b^2 = (a - b)^2\]

Examples:

\[
x^2 + 6x + 9 = x^2 + 2 \cdot 3 \cdot x + 3^2
= (x + 3)^2
\]

\[
4x^2 - 20x + 25 = (2x)^2 - 2 \cdot 2x \cdot 5 + 5^2
= (2x - 5)^2
\]
Factoring
(Difference of Squares)

\[ a^2 - b^2 = (a + b)(a - b) \]

Examples:

\[
\begin{align*}
    x^2 - 49 &= x^2 - 7^2 = (x + 7)(x - 7) \\
    4 - n^2 &= 2^2 - n^2 = (2 - n)(2 + n) \\
    9x^2 - 25y^2 &= (3x)^2 - (5y)^2 \\
                     &= (3x + 5y)(3x - 5y)
\end{align*}
\]
Difference of Squares
(Model)

\[a^2 - b^2 = (a + b)(a - b)\]
Divide Polynomials
(Monomial Divisor)

Divide each term of the dividend by the monomial divisor

Example:

\[
(12x^3 - 36x^2 + 16x) \div 4x
\]

\[
= \frac{12x^3 - 36x^2 + 16x}{4x}
\]

\[
= \frac{12x^3}{4x} - \frac{36x^2}{4x} + \frac{16x}{4x}
\]

\[
= 3x^2 - 9x + 4
\]
Divide Polynomials
(Binomial Divisor)

Factor and simplify

Example:

\[(7w^2 + 3w - 4) \div (w + 1)\]

\[
= \frac{7w^2 + 3w - 4}{w + 1}
\]

\[
= \frac{(7w - 4)(w + 1)}{w + 1}
\]

\[
= 7w - 4
\]
Square Root

Simplify square root expressions.

Examples:

\[ \sqrt{9x^2} = \sqrt{3^2 \cdot x^2} = \sqrt{(3x)^2} = 3x \]

\[ -\sqrt{(x - 3)^2} = -(x - 3) = -x + 3 \]

Squaring a number and taking a square root are inverse operations.
Cube Root

Simplify cube root expressions.

Examples:

\[
\begin{align*}
\sqrt[3]{64} &= \sqrt[3]{4^3} = 4 \\
\sqrt[3]{-27} &= \sqrt[3]{(-3)^3} = -3 \\
\sqrt[3]{x^3} &= x
\end{align*}
\]

Cubing a number and taking a cube root are inverse operations.
Simplify Numerical Expressions Containing Square or Cube Roots

Simplify radicals and combine like terms where possible.

Examples:

\[
\frac{1}{2} - \sqrt{32} - \frac{11}{2} + \sqrt{8} = -\frac{10}{2} - 4\sqrt{2} + 2\sqrt{2} = -5 - 2\sqrt{2}
\]

\[
\sqrt{18} - 2\sqrt[3]{27} = 3\sqrt{2} - 2(3) = 3\sqrt{2} - 6
\]
Add and Subtract Monomial Radical Expressions

Add or subtract the numerical factors of the like radicals.

**Examples:**

\[
6\sqrt[3]{5} - 4\sqrt[3]{5} - \sqrt[3]{5} \\
= (6 - 4 - 1)\sqrt[3]{5} = \sqrt[3]{5}
\]

\[
2x\sqrt{3} + 5x\sqrt{3} \\
= (2 + 5)x\sqrt{3} = 7x\sqrt{3}
\]

\[
2\sqrt{3} + 7\sqrt{2} - 2\sqrt{3} \\
= (2 - 2)\sqrt{3} + 7\sqrt{2} = 7\sqrt{2}
\]
Product Property of Radicals

The nth root of a product equals the product of the nth roots.

\[ n\sqrt{ab} = n\sqrt{a} \cdot n\sqrt{b} \]

\[ a \geq 0 \text{ and } b \geq 0 \]

Examples:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Simplified</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sqrt{4x} = \sqrt{4} \cdot \sqrt{x} = 2\sqrt{x} )</td>
<td></td>
</tr>
<tr>
<td>( \sqrt{5a^3} = \sqrt{5} \cdot \sqrt{a^3} = a\sqrt{5a} )</td>
<td></td>
</tr>
<tr>
<td>( \sqrt[3]{16} = \sqrt[3]{8 \cdot 2} = \sqrt[3]{8} \cdot \sqrt[3]{2} = 2\sqrt[3]{2} )</td>
<td></td>
</tr>
</tbody>
</table>
Quotient Property of Radicals

The nth root of a quotient equals the quotient of the nth roots of the numerator and denominator.

\[ \sqrt[n]{\frac{a}{b}} = \frac{\sqrt[n]{a}}{\sqrt[n]{b}} \]

\[ a \geq 0 \text{ and } b > 0 \]

Example:

\[ \sqrt{\frac{5}{y^2}} = \frac{\sqrt{5}}{\sqrt{y^2}} = \frac{\sqrt{5}}{y}, y \neq 0 \]
Zero Product Property

If $ab = 0$, then $a = 0$ or $b = 0$.

Example:

$$(x + 3)(x - 4) = 0$$

$(x + 3) = 0$ or $(x - 4) = 0$

$x = -3$ or $x = 4$

The solutions or roots of the polynomial equation are -3 and 4.
Solutions or Roots

\[ x^2 + 2x = 3 \]

Solve using the zero product property.

\[ x^2 + 2x - 3 = 0 \]
\[ (x + 3)(x - 1) = 0 \]
\[ x + 3 = 0 \quad \text{or} \quad x - 1 = 0 \]
\[ x = -3 \quad \text{or} \quad x = 1 \]

The solutions or roots of the polynomial equation are -3 and 1.
Zeros

The zeros of a function $f(x)$ are the values of $x$ where the function is equal to zero.

$$f(x) = x^2 + 2x - 3$$

Find $f(x) = 0$.

$$0 = x^2 + 2x - 3$$

$$0 = (x + 3)(x - 1)$$

$$x = -3 \text{ or } x = 1$$

The zeros of the function $f(x) = x^2 + 2x - 3$ are -3 and 1 and are located at the $x$-intercepts $(-3,0)$ and $(1,0)$.

The zeros of a function are also the solutions or roots of the related equation.
**x-Intercepts**

The **x-intercepts** of a graph are located where the graph crosses the x-axis and where \( f(x) = 0 \).

\[
f(x) = x^2 + 2x - 3
\]

\[
0 = (x + 3)(x - 1)
\]

\[
0 = x + 3 \text{ or } 0 = x - 1
\]

\[
x = -3 \text{ or } x = 1
\]

The zeros are -3 and 1.

The **x-intercepts** are:

-3 or (-3,0)
and
1 or (1,0)
Coordinate Plane

Quadrant I
Quadrant II
Quadrant III
Quadrant IV

y axis
x axis

Origin

ordered pair \((x, y)\)
Literal Equation

A formula or equation that consists primarily of variables

Examples:

\[ Ax + By = C \]

\[ A = \frac{1}{2} bh \]

\[ V = lwh \]

\[ F = \frac{9}{5} C + 32 \]

\[ A = \pi r^2 \]
Vertical Line

\[ x = a \]

(where \( a \) can be any real number)

Example: \( x = -4 \)

Vertical lines have undefined slope.
Horizontal Line

\[ y = c \]

(where \( c \) can be any real number)

Example: \( y = 6 \)

Horizontal lines have a slope of 0.
Quadratic Equation (Solve by Factoring)

\[ ax^2 + bx + c = 0 \]
\[ a \neq 0 \]

Example solved by factoring:

<table>
<thead>
<tr>
<th>Quadratic equation</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x^2 - 6x + 8 = 0 )</td>
<td>((x - 2)(x - 4) = 0 )</td>
</tr>
<tr>
<td>((x - 2) = 0 ) or ((x - 4) = 0 )</td>
<td>Set factors equal to 0</td>
</tr>
<tr>
<td>( x = 2 ) or ( x = 4 )</td>
<td>Solve for ( x )</td>
</tr>
</tbody>
</table>

Solutions to the equation are 2 and 4.
Solutions are \( \{2, 4\} \)
Quadratic Equation  
(Solve by Graphing)  
\[ ax^2 + bx + c = 0 \]
\[ a \neq 0 \]

Example solved by graphing:  
\[ x^2 - 6x + 8 = 0 \]

Graph the related function  
\[ f(x) = x^2 - 6x + 8. \]

Solutions to the equation are the \( x \)-coordinates \{2, 4\} of the points where the function crosses the \( x \)-axis.
# Quadratic Equation

(Exact/Type of Real Solutions)

\[ ax^2 + bx + c = 0, \quad a \neq 0 \]

<table>
<thead>
<tr>
<th>Examples</th>
<th>Graph of the related function</th>
<th>Number and Type of Solutions/Roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x^2 - x = 3 )</td>
<td><img src="image" alt="Graph of ( x^2 - x = 3 ) function" /></td>
<td>2 distinct Real roots (crosses x-axis twice)</td>
</tr>
<tr>
<td>( x^2 + 16 = 8x )</td>
<td><img src="image" alt="Graph of ( x^2 + 16 = 8x ) function" /></td>
<td>1 distinct Real root with a multiplicity of two (double root) (touches x-axis but does not cross)</td>
</tr>
<tr>
<td>( \frac{1}{2}x^2 - 2x + 3 = 0 )</td>
<td><img src="image" alt="Graph of ( \frac{1}{2}x^2 - 2x + 3 = 0 ) function" /></td>
<td>0 Real roots</td>
</tr>
</tbody>
</table>
Inequality

An algebraic sentence comparing two quantities

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;</td>
<td>less than</td>
</tr>
<tr>
<td>≤</td>
<td>less than or equal to</td>
</tr>
<tr>
<td>&gt;</td>
<td>greater than</td>
</tr>
<tr>
<td>≥</td>
<td>greater than or equal to</td>
</tr>
<tr>
<td>≠</td>
<td>not equal to</td>
</tr>
</tbody>
</table>

Examples:  
-10.5 > -9.9 – 1.2
8 < 3t + 2
x – 5y ≥ -12
x ≤ -11
r ≠ 3
Graph of an Inequality

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Example</th>
<th>Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; ; &gt;</td>
<td>$x &lt; 3$</td>
<td><img src="image1.png" alt="Graph of $x &lt; 3$" /></td>
</tr>
<tr>
<td>$\leq ; \geq$</td>
<td>$-3 \geq y$</td>
<td><img src="image2.png" alt="Graph of $-3 \geq y$" /></td>
</tr>
<tr>
<td>$\neq$</td>
<td>$t \neq -2$</td>
<td><img src="image3.png" alt="Graph of $t \neq -2$" /></td>
</tr>
</tbody>
</table>
Transitive Property of Inequality

<table>
<thead>
<tr>
<th>If</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a &lt; b \text{ and } b &lt; c$</td>
<td>$a &lt; c$</td>
</tr>
<tr>
<td>$a &gt; b \text{ and } b &gt; c$</td>
<td>$a &gt; c$</td>
</tr>
</tbody>
</table>

Examples:

- If $4x < 2y$ and $2y < 16$, then $4x < 16$.
- If $x > y - 1$ and $y - 1 > 3$, then $x > 3$. 
Addition/Subtraction Property of Inequality

<table>
<thead>
<tr>
<th>If</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a &gt; b$</td>
<td>$a + c &gt; b + c$</td>
</tr>
<tr>
<td>$a \geq b$</td>
<td>$a + c \geq b + c$</td>
</tr>
<tr>
<td>$a &lt; b$</td>
<td>$a + c &lt; b + c$</td>
</tr>
<tr>
<td>$a \leq b$</td>
<td>$a + c \leq b + c$</td>
</tr>
</tbody>
</table>

Example:

\[
d - 1.9 \geq -8.7
\]
\[
d - 1.9 + 1.9 \geq -8.7 + 1.9
\]
\[
d \geq -6.8
\]
## Multiplication Property of Inequality

<table>
<thead>
<tr>
<th>If</th>
<th>Case</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a &lt; b$</td>
<td>$c &gt; 0$, positive</td>
<td>$ac &lt; bc$</td>
</tr>
<tr>
<td>$a &gt; b$</td>
<td>$c &gt; 0$, positive</td>
<td>$ac &gt; bc$</td>
</tr>
<tr>
<td>$a &lt; b$</td>
<td>$c &lt; 0$, negative</td>
<td>$ac &gt; bc$</td>
</tr>
<tr>
<td>$a &gt; b$</td>
<td>$c &lt; 0$, negative</td>
<td>$ac &lt; bc$</td>
</tr>
</tbody>
</table>

**Example:** If $c = -2$

\[
5 > -3
\]

\[
5(-2) \not< -3(-2)
\]

\[
-10 < 6
\]
# Division Property of Inequality

<table>
<thead>
<tr>
<th>If</th>
<th>Case</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a &lt; b$</td>
<td>$c &gt; 0$, positive</td>
<td>$\frac{a}{c} &lt; \frac{b}{c}$</td>
</tr>
<tr>
<td>$a &gt; b$</td>
<td>$c &gt; 0$, positive</td>
<td>$\frac{a}{c} &gt; \frac{b}{c}$</td>
</tr>
<tr>
<td>$a &lt; b$</td>
<td>$c &lt; 0$, negative</td>
<td>$\frac{a}{c} &gt; \frac{b}{c}$</td>
</tr>
<tr>
<td>$a &gt; b$</td>
<td>$c &lt; 0$, negative</td>
<td>$\frac{a}{c} &lt; \frac{b}{c}$</td>
</tr>
</tbody>
</table>

Example: If $c = -4$

\[
\begin{align*}
-90 & \geq -4t \\
\frac{-90}{-4} & \geq \frac{-4t}{-4} \\
22.5 & \leq t
\end{align*}
\]
Linear Equation
(Standard Form)

\[ Ax + By = C \]

(A, B and C are integers; A and B cannot both equal zero)

Example:

\[-2x + y = -3\]

The graph of the linear equation is a straight line and represents all solutions \((x, y)\) of the equation.
Linear Equation
(Slope-Intercept Form)

\[ y = mx + b \]

(slope is \( m \) and \( y \)-intercept is \( b \))

Example: \( y = \frac{-4}{3}x + 5 \)

\( m = \frac{-4}{3} \)

\( b = 5 \)
Linear Equation
(Point-Slope Form)

\[ y - y_1 = m(x - x_1) \]
where \( m \) is the slope and \((x_1, y_1)\) is the point

Example:
Write an equation for the line that passes through the point \((-4,1)\) and has a slope of 2.

\[ y - 1 = 2(x - (-4)) \]
\[ y - 1 = 2(x + 4) \]
\[ y = 2x + 9 \]
## Equivalent Forms of a Linear Equation

### Forms of a Linear Equation

<table>
<thead>
<tr>
<th>Example</th>
<th>$3y = 6 - 4x$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slope-Intercept</strong></td>
<td>$y = -\frac{4}{3}x + 2$</td>
</tr>
<tr>
<td>$y = mx + b$</td>
<td></td>
</tr>
<tr>
<td><strong>Point-Slope</strong></td>
<td>$y - (-2) = -\frac{4}{3}(x - 3)$</td>
</tr>
<tr>
<td>$y - y_1 = m(x - x_1)$</td>
<td></td>
</tr>
<tr>
<td><strong>Standard</strong></td>
<td>$4x + 3y = 6$</td>
</tr>
<tr>
<td>$Ax + By = C$</td>
<td></td>
</tr>
</tbody>
</table>
Slope

A number that represents the rate of change in $y$ for a unit change in $x$

The slope indicates the steepness of a line.

Slope $= \frac{2}{3}$
Slope Formula

The ratio of vertical change to horizontal change

slope = \( m = \frac{\text{change in } y}{\text{change in } x} = \frac{y_2 - y_1}{x_2 - x_1} \)
Slopes of Lines

Line $p$ has a **positive** slope.

Line $n$ has a **negative** slope.

Vertical line $s$ has an **undefined** slope.

Horizontal line $t$ has a **zero** slope.
Perpendicular Lines

Lines that intersect to form a right angle

Perpendicular lines (not parallel to either of the axes) have slopes whose product is -1.

Example:

The slope of line $n = -2$. The slope of line $p = \frac{1}{2}$.

$-2 \cdot \frac{1}{2} = -1$, therefore, $n$ is perpendicular to $p$. 
Parallel Lines

Lines in the same plane that do not intersect are parallel. Parallel lines have the same slopes.

Example:
The slope of line $a = -2$. The slope of line $b = -2$.

$-2 = -2$, therefore, $a$ is parallel to $b$. 
# Mathematical Notation

<table>
<thead>
<tr>
<th>Equation/Inequality</th>
<th>Set Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x = -5$</td>
<td>${-5}$</td>
</tr>
<tr>
<td>$x = 5 \text{ or } x = -3.4$</td>
<td>${5, -3.4}$</td>
</tr>
<tr>
<td>$y &gt; \frac{8}{3}$</td>
<td>${y : y &gt; \frac{8}{3}}$</td>
</tr>
<tr>
<td>$x \leq 2.34$</td>
<td>${x \mid x \leq 2.34}$</td>
</tr>
<tr>
<td>Empty (null) set</td>
<td>${}$</td>
</tr>
<tr>
<td>All Real Numbers</td>
<td>${x : x \in \mathbb{R}}$</td>
</tr>
</tbody>
</table>
System of Linear Equations
(Graphing)

\[
\begin{align*}
-x + 2y &= 3 \\
2x + y &= 4
\end{align*}
\]

The solution, \((1, 2)\), is the only ordered pair that satisfies both equations (the point of intersection).
System of Linear Equations (Substitution)

\[ \begin{align*}
  x + 4y &= 17 \\
  y &= x - 2
\end{align*} \]

Substitute \( x - 2 \) for \( y \) in the first equation.

\[ x + 4(x - 2) = 17 \]

\[ x = 5 \]

Now substitute 5 for \( x \) in the second equation.

\[ y = 5 - 2 \]

\[ y = 3 \]

The solution to the linear system is (5, 3), the ordered pair that satisfies both equations.
System of Linear Equations
(Elimination)

\[
\begin{align*}
-5x - 6y &= 8 \\
5x + 2y &= 4
\end{align*}
\]

Add or subtract the equations to eliminate one variable.

\[
\begin{align*}
-5x - 6y &= 8 \\
+ 5x + 2y &= 4
\end{align*}
\]

\[-4y = 12 \quad \Rightarrow \quad y = -3\]

Now substitute -3 for y in either original equation to find the value of x, the eliminated variable.

\[
-5x - 6(-3) = 8
\]

\[x = 2\]

The solution to the linear system is (2,-3), the ordered pair that satisfies both equations.
# System of Linear Equations

(Number of Solutions)

<table>
<thead>
<tr>
<th>Number of Solutions</th>
<th>Slopes and $y$-intercepts</th>
<th>Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>One solution</td>
<td>Different slopes</td>
<td><img src="image1" alt="Graph" /></td>
</tr>
<tr>
<td>No solution</td>
<td>Same slope and different $y$-intercepts</td>
<td><img src="image2" alt="Graph" /></td>
</tr>
<tr>
<td>Infinitely many solutions</td>
<td>Same slope and same $y$-intercepts</td>
<td><img src="image3" alt="Graph" /></td>
</tr>
</tbody>
</table>
Graphing Linear Inequalities

<table>
<thead>
<tr>
<th>Example</th>
<th>Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y \leq x + 2$</td>
<td>![Graph of $y \leq x + 2$]</td>
</tr>
<tr>
<td>$y &gt; -x - 1$</td>
<td>![Graph of $y &gt; -x - 1$]</td>
</tr>
</tbody>
</table>

The graph of the solution of a linear inequality is a half-plane bounded by the graph of its related linear equation. Points on the boundary are included unless the inequality contains only < or >.
System of Linear Inequalities

Solve by graphing:

\[
\begin{align*}
y &> x - 3 \\
y &\leq -2x + 3
\end{align*}
\]

The solution region contains all ordered pairs that are solutions to both inequalities in the system.

(-1,1) is one of the solutions to the system located in the solution region.
Dependent and Independent Variable

\[ x, \text{ independent variable} \]
(input values or domain set)

\[ y, \text{ dependent variable} \]
(output values or range set)

Example:

\[ y = 2x + 7 \]
Dependent and Independent Variable (Application)

Determine the distance a car will travel going 55 mph.

\[ d = 55h \]

<table>
<thead>
<tr>
<th>independent</th>
<th>( h )</th>
<th>( d )</th>
<th>dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>165</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Graph of a Quadratic Equation

\[ y = ax^2 + bx + c \]

\[ a \neq 0 \]

Example:

\[ y = x^2 + 2x - 3 \]

The graph of the quadratic equation is a curve (parabola) with one line of symmetry and one vertex.
Vertex of a Quadratic Function

For a given quadratic \( y = ax^2 + bx + c \), the vertex \((h, k)\) is found by computing \( h = \frac{-b}{2a} \) and then evaluating \( y \) at \( h \) to find \( k \).

Example: \( y = x^2 + 2x - 8 \)

\[
h = \frac{-b}{2a} = \frac{-2}{2(1)} = -1
\]

\[
k = (-1)^2 + 2(-1) - 8
\]

\[
k = -9
\]

The vertex is \((-1, -9)\).

Line of symmetry is \( x = h \).
\[
x = -1
\]
Quadratic Formula

Used to find the solutions to any quadratic equation of the form,

\[ f(x) = ax^2 + bx + c \]

\[ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

Example: \( g(x) = 2x^2 - 4x - 3 \)

\[
x = \frac{-(-4) \pm \sqrt{(-4)^2 - 4(2)(-3)}}{2(2)}
\]

\[
x = \frac{2 + \sqrt{10}}{2}, \frac{2 - \sqrt{10}}{2}
\]
Relation
A set of ordered pairs

Examples:

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>-6</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>-1</td>
</tr>
</tbody>
</table>

Example 1

\{(0,4), (0,3), (0,2), (0,1)\}

Example 3
Function
(Definition)

A relationship between two quantities in which every input corresponds to exactly one output.

A relation is a function if and only if each element in the domain is paired with a unique element of the range.
Functions (Examples)

Example 1:

<table>
<thead>
<tr>
<th>$x$</th>
<th>$y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>-1</td>
<td>2</td>
</tr>
</tbody>
</table>

Example 2:

$\{(−3,4), (0,3), (1,2), (4,6)\}$

Example 3:

Example 4:
Domain

A set of input values of a relation

Examples:

<table>
<thead>
<tr>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>$g(x)$</td>
</tr>
<tr>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

The **domain** of $g(x)$ is $\{-2, -1, 0, 1\}$.

The **domain** of $f(x)$ is all real numbers.
# Range

A set of output values of a relation

## Examples:

<table>
<thead>
<tr>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>$g(x)$</td>
</tr>
<tr>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

The **range** of $g(x)$ is {0, 1, 2, 3}.

The **range** of $f(x)$ is all real numbers greater than or equal to zero.
Function Notation

\[ f(x) \]

\( f(x) \) is read “the value of \( f \) at \( x \)” or “\( f \) of \( x \)”

Example:

\[
\begin{align*}
  f(x) &= -3x + 5, \text{ find } f(2). \\
  f(2) &= -3(2) + 5 \\
  f(2) &= -6 + 5 \\
  f(2) &= -1
\end{align*}
\]

Letters other than \( f \) can be used to name functions, e.g., \( g(x) \) and \( h(x) \)
Parent Functions
(Linear, Quadratic)

Linear
\[ f(x) = x \]

Quadratic
\[ f(x) = x^2 \]
Parent functions can be transformed to create other members in a family of graphs.

<table>
<thead>
<tr>
<th>Translations</th>
<th>Description</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g(x) = f(x) + k$</td>
<td>is the graph of $f(x)$ translated vertically</td>
<td>$k$ units up when $k &gt; 0$.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$k$ units down when $k &lt; 0$.</td>
</tr>
<tr>
<td>$g(x) = f(x - h)$</td>
<td>is the graph of $f(x)$ translated horizontally</td>
<td>$h$ units right when $h &gt; 0$.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$h$ units left when $h &lt; 0$.</td>
</tr>
</tbody>
</table>
Transformations of Parent Functions (Reflection)

Parent functions can be transformed to create other members in a family of graphs.

| Reflections | $g(x) = -f(x)$  
is the graph of $f(x)$ – | reflected over the $x$-axis. |
|-------------|------------------|----------------------|
|             | $g(x) = f(-x)$  
is the graph of $f(x)$ – | reflected over the $y$-axis. |
Transformations of Parent Functions (Vertical Dilations)

Parent functions can be transformed to create other members in a family of graphs.

<table>
<thead>
<tr>
<th>Dilations</th>
<th>$g(x) = a \cdot f(x)$ is the graph of $f(x)$ –</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>vertical dilation</strong> (stretch) if $a &gt; 1$.</td>
</tr>
<tr>
<td></td>
<td>Stretches away from the $x$-axis</td>
</tr>
<tr>
<td></td>
<td><strong>vertical dilation</strong> (compression) if $0 &lt; a &lt; 1$.</td>
</tr>
<tr>
<td></td>
<td>Compresses toward the $x$-axis</td>
</tr>
</tbody>
</table>
Linear Function
(Transformational Graphing)

Translation

\[ g(x) = x + b \]

Examples:

\[ f(x) = x \]
\[ t(x) = x + 4 \]
\[ h(x) = x - 2 \]

Vertical translation of the parent function,

\[ f(x) = x \]
Linear Function

(Transformational Graphing)

Vertical Dilation \((m > 0)\)

\[ g(x) = mx \]

Examples:

\[ f(x) = x \]
\[ t(x) = 2x \]
\[ h(x) = \frac{1}{2}x \]

Vertical dilation (stretch or compression) of the parent function, \( f(x) = x \)
Linear Function
(Transformational Graphing)
Vertical Dilation/Reflection ($m < 0$)
$g(x) = mx$

Examples:
$f(x) = x$
$t(x) = -x$
$h(x) = -3x$
$d(x) = -\frac{1}{3}x$

Vertical dilation (stretch or compression) with a reflection of $f(x) = x$
Quadratic Function
(Transformational Graphing)
Vertical Translation
\[ h(x) = x^2 + c \]

Examples:
\[ f(x) = x^2 \]
\[ g(x) = x^2 + 2 \]
\[ t(x) = x^2 - 3 \]

Vertical translation of \( f(x) = x^2 \)
Quadratic Function
(Transformational Graphing)
Vertical Dilation \((a>0)\)
\[ h(x) = ax^2 \]

Examples:
\[ f(x) = x^2 \]
\[ g(x) = 2x^2 \]
\[ t(x) = \frac{1}{3}x^2 \]

Vertical dilation (stretch or compression) of
\[ f(x) = x^2 \]
**Quadratic Function**  
(Transformational Graphing)  
**Vertical Dilation/Reflection** \( (a<0) \)  
\[ h(x) = ax^2 \]

Examples:  
\[ f(x) = x^2 \]  
\[ g(x) = -2x^2 \]  
\[ t(x) = -\frac{1}{3}x^2 \]

Vertical dilation (stretch or compression) with a reflection of \( f(x) = x^2 \)
Quadratic Function
(Transformational Graphing)

Horizontal Translation

\[ h(x) = (x \pm c)^2 \]

Examples:

\[ f(x) = x^2 \]
\[ g(x) = (x + 2)^2 \]
\[ t(x) = (x - 3)^2 \]

Horizontal translation of \( f(x) = x^2 \)
Multiple Representations of Functions

Equation

\[ y = \frac{1}{2}x - 2 \]

Table

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-3</td>
</tr>
<tr>
<td>0</td>
<td>-2</td>
</tr>
<tr>
<td>2</td>
<td>-1</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Graph

Words

y equals one-half x minus 2
Direct Variation

\[ y = kx \quad \text{or} \quad k = \frac{y}{x} \]

constant of variation, \( k \neq 0 \)

Example:

\[ y = 3x \quad \text{or} \quad 3 = \frac{y}{x} \]

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-6</td>
</tr>
<tr>
<td>-1</td>
<td>-3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

\[ 3 = \frac{-6}{-2} = \frac{-3}{-1} = \frac{3}{1} = \frac{6}{2} \]

The graph of all points describing a direct variation is a line passing through the origin.
Inverse Variation

\[ y = \frac{k}{x} \quad \text{or} \quad k = xy \]

constant of variation, \( k \neq 0 \)

Example:

\[ y = \frac{3}{x} \quad \text{or} \quad xy = 3 \]

The graph of all points describing an inverse variation relationship are two curves that are reflections of each other.
Scatterplot

Graphical representation of the relationship between two numerical sets of data

![Scatterplot Diagram]
Positive Linear Relationship (Correlation)

In general, a relationship where the dependent \((y)\) values increase as independent values \((x)\) increase.
Negative Linear Relationship (Correlation)

In general, a relationship where the dependent (y) values decrease as independent (x) values increase.
No Linear Relationship (Correlation)

No relationship between the dependent ($y$) values and independent ($x$) values.
Curve of Best Fit (Linear)

Equation of Curve of Best Fit

\[ y = 11.731x + 193.85 \]
Curve of Best Fit
(Quadratic)

Equation of Curve of Best Fit
\[ y = -0.01x^2 + 0.7x + 6 \]
Outlier Data

(Graphic)