Quick Study ACADEMIC

COLLEGE ALGEBRA

EQUATIONS & ANSWERS

SETS OF NUMBERS

The illustration shows the relationships between the various sets of numbers.

- **Natural numbers ($\mathbb{N}$):** Counting numbers, beginning at 1.
  EX: $\{1, 2, 3, \ldots\}$
- **Whole numbers ($\mathbb{W}$):** Natural numbers and 0.
  EX: $\{0, 1, 2, 3, \ldots\}$
- **Integers ($\mathbb{Z}$):** Positive and negative whole numbers.
  EX: $\{\ldots, -3, -2, -1, 0, 1, 2, 3, \ldots\}$
- **Rational numbers ($\mathbb{Q}$):** Numbers that can be written as the ratio of two integers (but not dividing by 0).
  EX: $\left\{\frac{1}{2}, \frac{7}{3}, \frac{13}{1}, -\frac{35}{100}\right\}$
- **Irrational numbers ($\mathbb{I}$):** Any number that can be written as a non-repeating, non-terminating decimal.
  EX: $\{\pi, e\}$
- **Real numbers ($\mathbb{R}$):** All the rational and irrational numbers.
  EX: $\{1, \frac{7}{5}, 2.753\}$
- **Imaginary numbers ($\mathbb{I}$):** Numbers that when squared result in a negative number.
  EX: $\{\sqrt{-1}, i, -4.7i\}$
- **Complex numbers ($\mathbb{C}$):** Real and imaginary numbers in the form $a + bi$, where a and b are real and i is imaginary.
  EX: $\{1 + i, 2 - 6.2i\}$

Exponent Rules

Rule Name	Rule	Example
Product rules	$a^x \cdot a^y = a^{x+y}$	$3^5 \cdot 3^3 = 3^{5+3} = 3^8 = 3,187$
	$a^x \cdot b^x = (a \cdot b)^x$	$2^3 \cdot 5^3 = (2 \cdot 5)^3 = 10^3 = 100$
Quotient rules	$\frac{a^x}{a^y} = a^{x-y}$	$\frac{3^5}{3^2} = 3^{5-2} = 9$
	$\frac{a^x}{b^x} = \left(\frac{a}{b}\right)^x$	$\frac{6^3}{2^3} = \left(\frac{6}{2}\right)^3 = 27$
Power rules	$(b^x)^y = b^{x \cdot y}$	$(4^3)^4 = 4^{3 \cdot 4} = 4^{12} = 16,096$
	$b^{x^y} = b^{(x^y)}$	$2^{3^2} = 2^{(3^2)} = 2^9 = 512$
	$\sqrt[y]{b^x} = b^{\frac{x}{y}}$	$\sqrt{2^4} = 2^{\frac{4}{2}} = 2^2 = 4$
	$b^{\frac{x}{y}} = \sqrt[y]{b^x}$	$27^{\frac{1}{3}} = \sqrt[3]{27} = 3$
Negative exponents	$b^{-x} = \frac{1}{b^x}$	$4^{-5} = \frac{1}{4^5} = 0.0015625$
Exponent of 0	$b^0 = 1$	$9^0 = 1$

Base of 0	$0^x = 0$, for $x > 0$	$0^5 = 0$
Exponent of 1	$b^1 = b$	$7^1 = 7$
Base of 1	$1^x = 1$	$1^{12} = 1$
Base of -1	$(-1)^x = \begin{cases} 1, & x \text{ even} \\ -1, & x \text{ odd} \end{cases}$	$(-1)^4 = 1$ $(-1)^7 = -1$

Properties & Formulas

- **Slope:** The slope or rate of change of a line is the ratio of the change in y-values over the change in x-values.
  $m = \frac{y_2 - y_1}{x_2 - x_1}$
- **Pythagorean Theorem:** $a^2 + b^2 = c^2$, where a and b are the legs of a right triangle and c is the hypotenuse.
- **Distance Formula:** $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
- **Midpoint Formula:** $M(x, y) = \frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}$
- **Quadratic Formula:** Given an equation $ax^2 + bx + c = 0$, where $a \neq 0$
  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

EQUATIONS & INEQUALITIES

Forms of Linear Equations

- **Linear function:** A function whose graph is a non-vertical line or part of a non-vertical line. There are three forms of linear equations: slope-intercept, point-slope, and standard form.
  - **Slope-intercept form:** $y = mx + b$, where m is the slope and b is the y-intercept of the line.
    EX: If a line has a slope of 2 and y-intercept of 3, the equation of the line is $y = 2x + 3$.
  - **Point-slope form:** $y - y_1 = m(x - x_1)$, where m is the slope and (x_1, y_1) is a point on the line.
    EX: If a line has a slope of -1 and contains the point $(4, -3)$, the equation of the line is $y - (-3) = -1(x - 4)$ or $y + 3 = -(x - 4)$.
  - **Standard form:** $Ax + By = C$, where A, B, and C are integers and A is positive. The slope is $-\frac{A}{B}$ and the y-intercept is $\frac{C}{B}$. This form of a line is most often used to find intercepts by plugging 0 in for x and y separately and solving.

EX: Given the line $2x + 5y = 3$, the slope is $-\frac{2}{5}$ and the y-intercept is $\frac{3}{5}$. The intercepts could also be found by substitution as follows.

x-intercept (plug in 0 for y):
$2x + 5y = 3$
$2x + 5(0) = 3$
$2x = 3$
$x = \frac{3}{2}$

y-intercept (plug in 0 for x):
$2x + 5y = 3$
$2(0) + 5y = 3$
$5y = 3$
$y = \frac{3}{5}$

Solving Linear Equations

Equivalent equation: An equation that has the same solution as the original equation before a property of equality was performed.

- Solving an equation means isolating the variable on one side of the equation and then simplifying the other side as much as possible.
- The table shows properties that can be used and examples of solving linear equations.
- Multi-step equations are solved by using combinations of the properties as needed.

Addition Property of Equality: Adding the same number or term to each side of an equation produces an equivalent equation.

For any real numbers a, b, and c, if $a = b$, then $a + c = b + c$.
EX:
$x - 4 = 2$
$x - 4 + 4 = 2 + 4$
$x = 6$

Subtraction Property of Equality: Subtracting the same number from each side of an equation produces an equivalent equation.

For any real numbers a, b, and c, if $a = b$, then $a - c = b - c$.
EX:
$x + 4 = 2$
$x + 4 - 4 = 2 - 4$
$x = -2$

Multiplication Property of Equality: Multiplying each side of an equation by the same number produces an equivalent equation.

For any real numbers a, b, and c, if $a = b$, then $ac = bc$.
EX:
$\frac{x}{5} = 3$
$5 \cdot \frac{x}{5} = 5 \cdot 3$
$x = 15$

Division Property of Equality: Dividing each side of an equation by the same nonzero number produces an equivalent equation.

For any real numbers a, b, and c, $c \neq 0$, if $a = b$, then $\frac{a}{c} = \frac{b}{c}$.
EX: $4x = 20$
$\frac{4x}{4} = \frac{20}{4}$
$x = 5$

Absolute Value Equations

- The absolute value of a number is its distance from 0 on the number line. So, an equation such as $|x| = 2$ has 2 solutions because both 2 and -2 are a distance of 2 from 0.
- **To solve:** Isolate the absolute value expression on one side of the equation and then solve the disjunction.

EX:
$|x - 3| + 5 = 7$
$|x - 3| = 2$
$x - 3 = 2$ or $x - 3 = -2$
$x - 3 + 3 = 2 + 3$ or
$x - 3 + 3 = -2 + 3$
$x = 5$ or $x = 1$

Quadratic Equations

- Quadratic equations are written in the form $ax^2 + bx + c = 0$ and can have none, one, or two real-number solutions.
- **To solve:** Graph, factor, use square roots, complete the square, and use the quadratic formula.

Choosing a Solution Method	Solution
Equation: $2x^2 - 8 = 0$	$2x^2 - 8 = 0$
Method: Square Roots.	$2x^2 = 8$
Justification: There is no x-term.	$x^2 = 4$
	$x = 2$ or -2
Equation: $x^2 + x - 6 = 0$	$x^2 + x - 6 = 0$
Method: Factoring.	$(x + 3)(x - 2) = 0$
Justification: 6 has only a few factors to check.	$x = -3$ or 2
Equation: $2x^2 + 8x - 9 = 0$	$x = \frac{-8 \pm \sqrt{8^2 - 4(2)(-9)}}{2(2)}$
Method: Quadratic Formula.	$x = \frac{-8 \pm \sqrt{136}}{4}$
Justification: The equation cannot be factored.	$x = \frac{-8 \pm 2\sqrt{34}}{4}$
	$x = -2 \pm \frac{\sqrt{34}}{2}$
Equation: $x^2 - 6x + 3 = 0$	$x^2 - 6x + 3 = 0$
Method: Completing the Square or Quadratic Formula.	$x^2 - 6x + __ = -3 + __$
Justification: The coefficient of the x^2 term is 1, but the equation cannot be factored.	$\left(\frac{6}{2}\right)^2 = \left(\frac{6}{2}\right)^2 = 3^2$
	$x^2 - 6x + 9 = -3 + 9$
	$x^2 - 6x + 9 = 6$
	$(x - 3)^2 = 6$
	$x - 3 = \pm\sqrt{6}$
	$x = 3 \pm \sqrt{6}$

You can determine how many solutions the quadratic equation will have by using the discriminant. The discriminant is the expression under the radical in the quadratic formula.

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Table of Contents Study Guide To Accompany College Algebra With Applications

1. Understanding the eBook Study Guide To Accompany College Algebra With Applications
    - The Rise of Digital Reading Study Guide To Accompany College Algebra With Applications
    - Advantages of eBooks Over Traditional Books
2. Identifying Study Guide To Accompany College Algebra With Applications
    - Exploring Different Genres
    - Considering Fiction vs. Non-Fiction
    - Determining Your Reading Goals
3. Choosing the Right eBook Platform
    - Popular eBook Platforms
    - Features to Look for in an Study Guide To Accompany College Algebra With Applications
    - User-Friendly Interface
4. Exploring eBook Recommendations from Study Guide To Accompany College Algebra With Applications
    - Personalized Recommendations
    - Study Guide To Accompany College Algebra With Applications User Reviews and Ratings

- Study Guide To Accompany College Algebra With Applications and Bestseller Lists
5. Accessing Study Guide To Accompany College Algebra With Applications Free and Paid eBooks
   - Study Guide To Accompany College Algebra With Applications Public Domain eBooks
   - Study Guide To Accompany College Algebra With Applications eBook Subscription Services
   - Study Guide To Accompany College Algebra With Applications Budget-Friendly Options
6. Navigating Study Guide To Accompany College Algebra With Applications eBook Formats
   - ePub, PDF, MOBI, and More
   - Study Guide To Accompany College Algebra With Applications Compatibility with Devices
   - Study Guide To Accompany College Algebra With Applications Enhanced eBook Features
7. Enhancing Your Reading Experience
   - Adjustable Fonts and Text Sizes of Study Guide To Accompany College Algebra With Applications
   - Highlighting and Note-Taking Study Guide To Accompany College Algebra With Applications
   - Interactive Elements Study Guide To Accompany College Algebra With Applications
8. Staying Engaged with Study Guide To Accompany College Algebra With Applications
   - Joining Online Reading Communities
   - Participating in Virtual Book Clubs
   - Following Authors and Publishers Study Guide To Accompany College Algebra With Applications
9. Balancing eBooks and Physical Books Study Guide To Accompany College Algebra With Applications
   - Benefits of a Digital Library
   - Creating a Diverse Reading Collection Study Guide To Accompany College Algebra With Applications
10. Overcoming Reading Challenges
    - Dealing with Digital Eye Strain
    - Minimizing Distractions
    - Managing Screen Time
11. Cultivating a Reading Routine Study Guide To Accompany College Algebra With Applications
    - Setting Reading Goals Study Guide To Accompany College Algebra With Applications
    - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Study Guide To Accompany College Algebra With Applications
    - Fact-Checking eBook Content of Study Guide To Accompany College Algebra With Applications
    - Distinguishing Credible Sources

13. Promoting Lifelong Learning
    - Utilizing eBooks for Skill Development
    - Exploring Educational eBooks
14. Embracing eBook Trends
    - Integration of Multimedia Elements
    - Interactive and Gamified eBooks

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