Algebra I
FOR DUMMIES®

NUMBER SYSTEMS

What's in a number? Its name, of course. Give your answers in the form requested!

Number System	Description	Some Examples
Natural numbers	Counting numbers; positive and nonfractional	1, 2, 3, 4, 5, …
Whole numbers	All natural numbers plus 0	0, 1, 2, 3, 4, 5, …
Integers	Positive and negative whole numbers and 0	…, −3, −2, −1, 0, 1, 2, 3, …
Rational numbers	Any number that can be written as a fraction $\frac{p}{q}$ where p and q are integers, but q is never 0	$\frac{3}{4}$ $\frac{5}{8}$ $\frac{8}{1}$
Irrational numbers	Cannot be written as a fraction; decimal equivalents never repeat or terminate	$\sqrt{2}$ $\sqrt{5}$ π
Real numbers	All rationals and irrationals; numbers that can be positioned somewhere on the real number line	$\sqrt{7}$ $\sqrt{5}$ 0
Complex numbers	Numbers of the form $a + bi$ where a and b are real numbers and $i = \sqrt{-1}$	$3 + 4i$ $-2 + i$
Perfect numbers	Numbers for which the product of their factors and the sum of their factors are the same	Factors of 6: 1, 2, 3; 6 = 1 × 2 × 3
Triangular numbers	Numbers starting with 1 and found by adding the next number to the previous sum	1, 3, 6, 10, 15, 21, 28, … (add 2, add 3, add 4, and so on)
Fibonacci numbers	Numbers beginning with 1, 1, and the next number is found by adding the previous two together	1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, …

RULES OF DIVISIBILITY

Does it divide evenly or not? These are quick tips:

- **Divisibility by 2:** Number ends in 0, 2, 4, 6, 8
  Examples: 20   64   1,138   300,006
- **Divisibility by 4:** Last two digits form a number divisible by 4
  Examples: 234,516   113,552,008
- **Divisibility by 8:** Last three digits form a number divisible by 8
  Examples: 431,220 (220 ÷ 8 = 40)   1,553,136 (136 ÷ 8 = 17)
- **Divisibility by 5:** Number ends in 0, 5
  Examples: 333,145   431,320
- **Divisibility by 10:** Number ends in 0
  Examples: 111,222,330   44,000,000
- **Divisibility by 3:** Sum of digits is a multiple of 3
  Example: 46,238,112 (4 + 6 + 2 + 3 + 8 + 1 + 1 + 2 = 24)
- **Divisibility by 9:** Sum of digits is a multiple of 9
  Example: 33,000,004 (2 + 3 + 0 + 0 + 0 + 0 + 0 + 4 = 18)

- **Divisibility by 11:** Difference between the sums of the alternating digits is divisible by 11 (result is 0, 11, 22, …)
  Example: 125,367 (1 + 5 + 6 = 12; 4 + 3 + …)
- **Divisibility by 6:** Divisible by both 2 and 3
  Example: 23,514 (Ends in 4, sum of digits is 15.)
- **Divisibility by 12:** Divisible by both 3 and 4
  Example: 113,628 (Sum of digits is 21; last two digits form "28.")

Rules of divisibility for multiples

The numbers in the product can't have common factors:

- **Divisibility by 6:** Use rules for 2 and 3
- **Divisibility by 12:** Use rules for 3 and 4 (can't use 2 and 6)
- **Divisibility by 15:** Use rules for 3 and 5
- **Divisibility by 18:** Use rules for 2 and 9 (can't use 3 and 6)
- **Divisibility by 24:** Use rules for 3 and 8 (can't use 4 and 6)

And so on.

A rule for divisibility by 7, 11, or 13 is that you divide the number in question by 1,001 and then look at the remainder. If the remainder is divisible by 7, 11, or 13, then the original number is divisible by that factor.

FACTORS AND MULTIPLES

A factor is one of the multipliers, and a multiple is the result of using factors.

Factors and Multiples	How They're Related	Some Examples
GCF: Greatest Common Factor	Largest number (factor) that divides the given numbers evenly	GCF(8, 12) = 4; GCF(60, 90, 120) = 30; GCF(12, 25) = 1
LCM: Least Common Multiple	Smallest number (multiple) that the given numbers all divide into evenly	LCM(8, 12) = 24; LCM(60, 90, 120) = 360; LCM(12, 25) = 300

ORDER OF OPERATIONS

The correct order for performing operations is necessary to get the correct answer. When two operations in the same "level" occur in an expression, perform the operations in order, moving from left to right.

Using the order of operations to simplify
$3 \cdot 2^4 - 2\sqrt{25} + 4$

Step 1: Perform all powers and roots.
Raise 2 to the fourth power and find the square root of 25.
$= 3 \cdot 16 - 2 \cdot 5 + 4$

Step 2: Perform all multiplications and divisions.
Multiply the 3 and 16 and then the 2 and 5.
$= 48 - 10 + 4$

Remember that multiplication can be indicated by a dot, ·, a times sign, ×, an asterisk, *, or by parentheses, ( ).

Step 3: Perform all additions and subtractions.
Subtract 10 from 48 and then add 4.
$= 38 + 4 = 42$

Grouping symbols can "interfere" with the order of operations. Perform any operations inside the grouping symbols first, before applying the order of operations.

Using the order of operations to simplify
$$3(4-5) + 2\sqrt{10-1} + \frac{3+11}{9-2}$$

Tackle the grouping symbols (parentheses, brackets, radicals, fraction lines).
Subtract 5 from 4, then subtract 1 from 10, then add 3 and 11, then subtract 2 from 9.
$$= 3(-1) + 2\sqrt{9} + \frac{14}{7}$$

Now to the order of operations.

Step 1: Perform all powers and roots.
Find the square root of 9.
$$= 3(-1) + 2 \cdot 3 + \frac{14}{7}$$

Step 2: Perform all multiplications and divisions.
Multiply the 3 and −1, then the 2 and 3, then divide 14 by 7.
$$= -3 + 6 + 2$$

Step 3: Perform all additions and subtractions.
Add the −3 and 6, then add the 2.
$$= 3 + 2 = 5$$

When there is no exponent showing, such as with y, you assume the exponent is 1.

To solve exponential equations when the bases are powers of the same number, rewrite as: $b^x = b^y$ and solve $x = y$.
Given $4^{x+1} = 8^x$, write each base as a power of 2: $(2^2)^{x+1} = (2^3)^x$
becomes $2^{2x+2} = 2^{3x}$. Now solve $2x + 2 = 3x$, giving $x = 2$.

RULES FOR USING EXPONENTS

An exponent is a shorthand notation telling you how many times to apply the base number. Exponents are written as superscripts and can be positive, negative, whole numbers, or fractions. Each has its own meaning.

Rules	Some Examples
Multiplying factors with the same base: Add the exponents. $x^a \cdot x^b = x^{a+b}$	$4^3 \cdot 4^5 = 4^8 = 256$
Dividing factors with the same base: Subtract the exponents. $\frac{x^a}{x^b} = x^{a-b}$ as long as $x \neq 0$.	$\frac{2^3}{2^5} = 2^{-2} = \frac{1}{2^2} = \frac{1}{4}$
Raising a power to a power: Multiply the exponents. $(x^a)^b = x^{ab}$	$(3^2)^4 = 3^8$
Taking the root of a power (fractional exponent): Divide the exponents. $\sqrt[b]{x^a} = x^{a/b}$	$9^{3/2} = \sqrt{9^3} = \sqrt{729} = 27$ or $9^{3/2} = (\sqrt{9})^3 = (3)^3 = 27$
Zero exponent: $a^0 = 1$ as long as $a \neq 0$.	$6^0 = 1$ $(-40)^0 = 1$
Negative exponent: Change to positive exponent by "changing the position" of the factor in a fraction. $a^{-n} = \frac{1}{a^n}$	$4^{-2} = \frac{1}{4^2} = \frac{1}{16}$ $\frac{1}{3^{-4}} = 3^4 = 81$
Negative fractional exponent: Apply both rules from above. $a^{-m/n} = \frac{1}{\sqrt[n]{a^m}}$	$16^{-3/4} = \frac{1}{16^{3/4}} = \frac{1}{\sqrt[4]{16^3}} = \frac{1}{8}$

Basic Algebra

P.M. Cohn

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Table of Contents Basic Algebra

1. Understanding the eBook Basic Algebra
    - The Rise of Digital Reading Basic Algebra
    - Advantages of eBooks Over Traditional Books
2. Identifying Basic Algebra
    - 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 Basic Algebra
    - User-Friendly Interface
4. Exploring eBook Recommendations from Basic Algebra
    - Personalized Recommendations
    - Basic Algebra User Reviews and Ratings
    - Basic Algebra and Bestseller Lists
5. Accessing Basic Algebra Free and Paid eBooks
    - Basic Algebra Public Domain eBooks
    - Basic Algebra eBook Subscription Services
    - Basic Algebra Budget-Friendly Options

- Interactive and Gamified eBooks

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