

$$y = mx + b$$



$$A = l \times w$$

$$\frac{a}{b}, b \neq 0$$



# PRE-ALGEBRA FORMULA REVIEW

KEY FORMULAS.  
CLEAR CONCEPTS.  
CONFIDENT SUCCESS.

$$\text{percent} = \frac{\text{part}}{\text{whole}} \times 100$$

$$a(b+c) \downarrow \\ = ab + ac$$

$$\frac{a}{c} + \frac{b}{c} = \frac{a+b}{c}$$

$$d = rt$$

$$\text{mean} = \frac{\text{sum of values}}{\text{number of values}}$$



COMPLETE  
FORMULAS



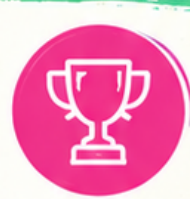
EASY TO  
UNDERSTAND



STUDY  
SMARTER



BUILD  
CONFIDENCE



ACHIEVE  
SUCCESS

# PRE-ALGEBRA

## Build the Bridge Into Algebra

Number rules, fractions, percents, ratios, equations, geometry, and data made clear before students step into Algebra 1.

### Formula Snapshot

#### FRACTIONS

$$\frac{a}{b} + \frac{c}{d} = \frac{ad + bc}{bd}$$

common denominator

#### PERCENTS

part = percent · whole  
use percent as a decimal

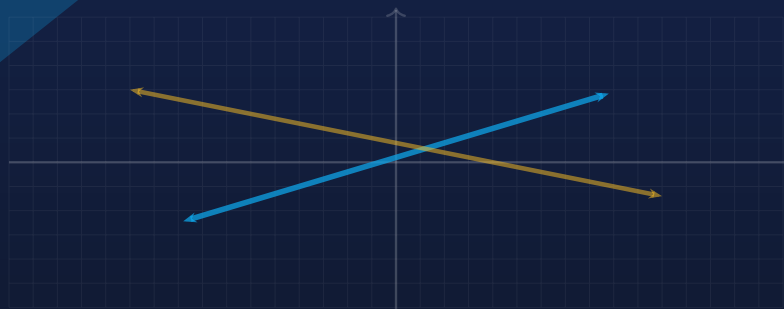
#### GEOMETRY

$$a^2 + b^2 = c^2$$

right triangles

[Number Fluency](#)
[Plain-English Tutor Notes](#)
[Algebra Readiness](#)

Whole Numbers • Fractions • Decimals • Percents • Ratios • Equations • Geometry • Data



# Welcome to the Pre-Algebra Formula Review

Pre-Algebra is where arithmetic becomes algebra. The goal is not to memorize a pile of rules; the goal is to make the basics automatic enough that variables, equations, and graphs feel natural.

## USE FIRST Formula

Read the rule before starting practice.

## WATCH FOR Restrictions

Denominators, signs, units, and the correct whole matter.

## THEN TRY Example

Check one worked example before doing ten problems.

## FINISH WITH Practice

Scan the hub when a topic needs another pass.



### HOW TO STUDY

Use this guide in small loops: review one rule, do a few examples, and notice the restriction. Fractions need nonzero denominators, percent problems need the correct whole, and geometry formulas need matching units.

## How to read every section

Each topic uses the same color-coded blocks.

### Formula table

the rules

### Tutor's Note

plain English

### Example

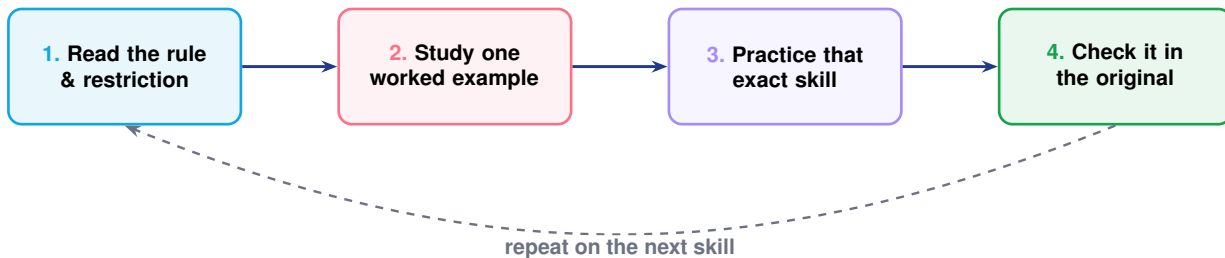
worked problem

### Visual

see the idea

## The study loop

Run this cycle on each skill until it feels automatic.



# What's Inside

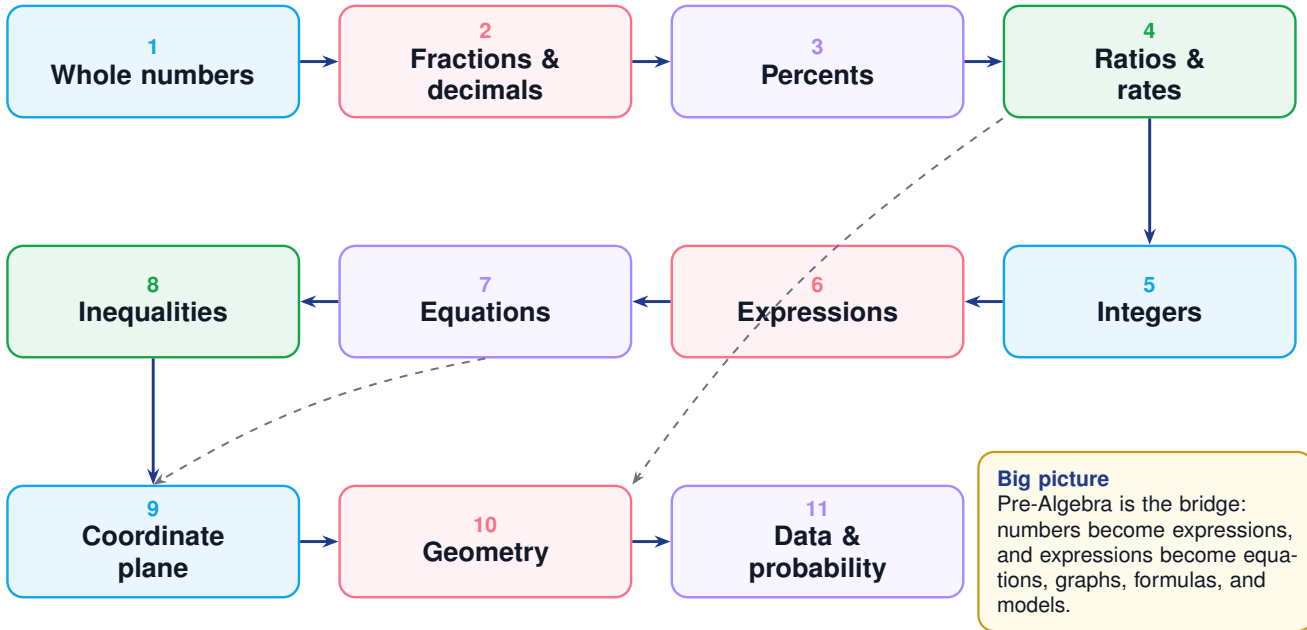
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Each section pairs the **formula** with a plain-English **Tutor's Note**, a worked example, and quick watch-outs.



# Pre-Algebra Roadmap

Pre-Algebra turns number skills into algebra habits. You start with operations and number sense, then move into expressions, equations, exponents, coordinate graphs, measurement, geometry, and data.



**Big picture**  
Pre-Algebra is the bridge: numbers become expressions, and expressions become equations, graphs, formulas, and models.



If an algebra step feels hard, check the earlier skill: signs, fractions, order of operations, or choosing the correct whole in a percent problem.

**Every number lives on the number line** Whole numbers, integers, fractions, and decimals are all points on one line — negatives to the left of 0, positives to the right.



# 1 Whole Numbers, Properties & Order

## Number rules

**Place value**

A digit's value depends on its position: ones, tens, hundreds, tenths, hundredths, and so on.

**Order of operations**

Parentheses, exponents, multiply or divide left to right, then add or subtract left to right.

**Commutative property**

$$a + b = b + a \text{ and } ab = ba.$$

**Associative property**

$$(a + b) + c = a + (b + c) \text{ and } (ab)c = a(bc).$$

**Distributive property**

$$a(b + c) = ab + ac.$$

**Identity properties**

$$a + 0 = a \text{ and } a \cdot 1 = a.$$

**Inverse properties**

$$a + (-a) = 0 \text{ and } a \cdot \frac{1}{a} = 1 \text{ when } a \neq 0.$$

### Tutor's Note

Order of operations keeps everyone evaluating expressions the same way. Multiplication and division are a team: do whichever appears first from left to right. Addition and subtraction work the same way.

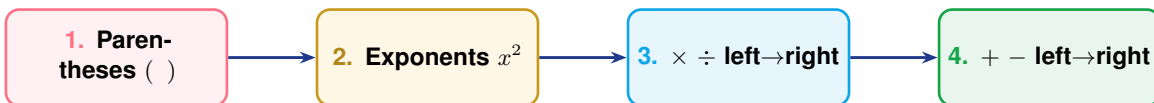
**Example**  
 $18 - 3(2 + 4)^2 \div 6$ . Parentheses: 6. Exponent: 36. Multiply/divide:  $3 \cdot 36 \div 6 = 18$ . Then  $18 - 18 = 0$ .



PEMDAS

PEMDAS does not mean all multiplication before all division. Work multiplication and division left to right.

**Order of operations (PEMDAS)** Work top to bottom, but multiply/divide share a step (left to right) and so do add/subtract.



## 2 Factors, Multiples & Number Types

### Factors and number sense

<b>Factor</b>	A whole number that divides another whole number evenly.
<b>Multiple</b>	A result of multiplying a number by a whole number.
<b>Prime number</b>	A whole number greater than 1 with exactly two factors: 1 and itself.
<b>Composite number</b>	A whole number greater than 1 with more than two factors.
<b>GCF</b>	Greatest common factor: the largest factor shared by numbers.
<b>LCM</b>	Least common multiple: the smallest positive multiple shared by numbers.
<b>GCF-LCM connection</b>	For positive integers $a, b$ : $\text{gcd}(a, b) \cdot \text{lcm}(a, b) = ab$ .
<b>Divisibility: 2, 5, 10</b>	By 2 if even; by 5 if ending in 0 or 5; by 10 if ending in 0.
<b>Divisibility: 3, 4, 6, 9</b>	By 3 or 9 if the digit sum is divisible by 3 or 9; by 4 if the last two digits form a multiple of 4; by 6 if divisible by 2 and 3.

#### Tutor's Note

GCF helps you simplify and factor. LCM helps you build common denominators. Prime factorization is the cleanest way to find both.

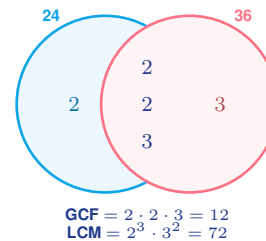
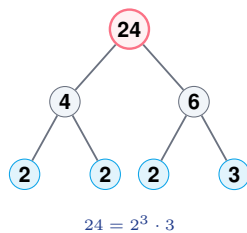
$24 = 2^3 \cdot 3$  and  $36 = 2^2 \cdot 3^2$ .  $\text{GCF} = 2^2 \cdot 3 = 12$  and  $\text{LCM} = 2^3 \cdot 3^2 = 72$ .

**Example**



Zero is a multiple of every nonzero whole number, but it is not used as the least positive common multiple.

**Prime factor trees & the GCF/LCM Venn** Break each number into primes, then share them: the overlap is the GCF and the whole picture is the LCM.



### 3 Fractions & Mixed Numbers

#### Fraction operations

<b>Equivalent fractions</b>	$\frac{a}{b} = \frac{ak}{bk}$ when $b \neq 0$ and $k \neq 0$ .
<b>Simplify</b>	$\frac{a}{b}$ is simplified by dividing numerator and denominator by their GCF, with $b \neq 0$ .
<b>Add/subtract</b>	$\frac{a}{b} + \frac{c}{d} = \frac{ad + bc}{bd}$ , with $b, d \neq 0$ .
<b>Multiply</b>	$\frac{a}{b} \cdot \frac{c}{d} = \frac{ac}{bd}$ , with $b, d \neq 0$ .
<b>Divide</b>	$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}$ , with $b, c, d \neq 0$ .
<b>Reciprocal</b>	The reciprocal of $\frac{a}{b}$ is $\frac{b}{a}$ , with $a, b \neq 0$ .
<b>Mixed to improper</b>	$a\frac{b}{c} = \frac{ac + b}{c}$ for positive mixed numbers; keep a negative sign outside until the end.
<b>Part of a whole</b>	A fraction $\frac{a}{b}$ means $a$ parts out of $b$ equal parts.

#### Tutor's Note

To add or subtract fractions, the denominators must name the same size pieces. To multiply, go straight across. To divide, keep the first fraction, change division to multiplication, and flip the second fraction.

$$\frac{2}{3} + \frac{5}{6} = \frac{4}{6} + \frac{5}{6} = \frac{9}{6} = \frac{3}{2} = 1\frac{1}{2}$$

Example

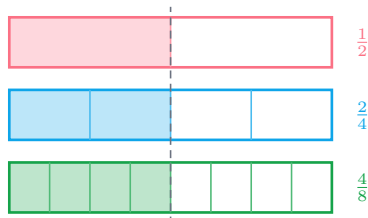


#### DENOMINATORS

A denominator can never be 0. Division by zero is undefined.

#### Fraction models: equivalent fractions

The same amount can be cut into more, smaller pieces. Each bar below is shaded *half*, so  $\frac{1}{2} = \frac{2}{4} = \frac{4}{8}$ .

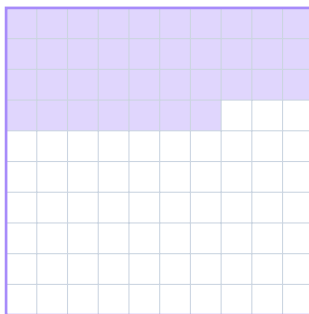


## 4 Decimals, Percents & Money Math

### Decimal and percent formulas

<b>Add/subtract decimals</b>	Line up the decimal points, then add or subtract as usual.
<b>Multiply decimals</b>	Multiply as whole numbers, then place the point so the answer has the total number of decimal places.
<b>Divide decimals</b>	Move both decimals right until the divisor is whole, then divide.
<b>Decimal to percent</b>	Move the decimal two places right: $0.37 = 37\%$ .
<b>Percent to decimal</b>	Move the decimal two places left: $85\% = 0.85$ .
<b>Percent to fraction</b>	$p\% = \frac{p}{100}$ , then simplify if possible.
<b>Percent equation</b>	part = percent · whole, using percent as a decimal.
<b>Percent change</b>	$\frac{\text{new} - \text{old}}{\text{old}} \cdot 100\%$ , where $\text{old} \neq 0$ .
<b>Simple interest</b>	$I = Prt$ and $A = P + I = P(1 + rt)$ .
<b>Tax / tip / markup</b>	Total = original amount $\times (1 + r)$ , where $r$ is the rate as a decimal.
<b>Discount / markdown</b>	Sale price = original price $\times (1 - r)$ , where $r$ is the discount rate.

**Percent means “out of 100”** Shade a  $10 \times 10$  grid: each little square is 1%. The same value is a fraction over 100 and a decimal.



$$37\% = 0.37 = \frac{37}{100}$$

**Percent bar: part = percent  $\times$  whole**



$$0.25 \times 80 = 20$$

#### Tutor's Note

The most common percent mistake is choosing the wrong whole. The whole is the original or total amount that the percent is based on.



**Example**  
A jacket costs \$80 and is discounted 25%. Discount =  $0.25(80) = 20$ , so the sale price is \$60.



MONEY

Round money to the nearest cent only at the end unless the problem tells you to round earlier.

## 5 Ratios, Rates & Proportions

### Proportion tools

#### Ratio

$a : b$ ,  $a$  to  $b$ , and  $\frac{a}{b}$  all compare two quantities.

#### Rate

A ratio with different units, such as miles per hour.

#### Unit rate

A rate with denominator 1.

#### Proportion

$\frac{a}{b} = \frac{c}{d}$  means  $ad = bc$ , with  $b, d \neq 0$ .

#### Scale factor

scale factor =  $\frac{\text{new length}}{\text{original length}}$

#### Similar figures

Corresponding side lengths are proportional and corresponding angles match.

#### Constant of proportionality

$y = kx$ , where  $k = \frac{y}{x}$  when  $x \neq 0$ .

#### Proportional graph

A proportional relationship graphs as a straight line through  $(0, 0)$ .

#### Unit price

unit price =  $\frac{\text{total cost}}{\text{number of units}}$

#### Distance, rate, time

$d = rt$ ; so  $r = \frac{d}{t}$  and  $t = \frac{d}{r}$ .

#### Percent proportion

$\frac{\text{part}}{\text{whole}} = \frac{\text{percent}}{100}$ , with whole  $\neq 0$ .

### Tutor's Note

A proportion is two equal ratios. Cross-multiplication works because multiplying both sides by the denominators clears the fractions.

**Example**  
If 3 notebooks cost \$7.50, the unit rate is  $7.50 \div 3 = \$2.50$  per notebook.

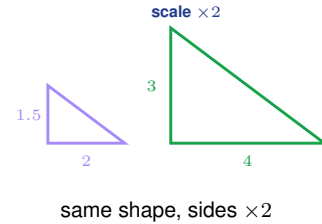
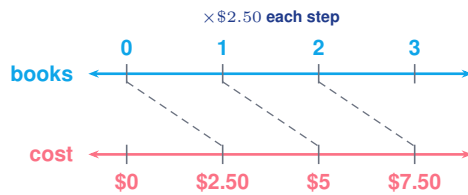


UNITS

Ratios compare. Rates compare with units. Keep units attached until the answer makes sense.



**Ratio tables & similar figures** Scale both quantities by the same number and the ratio stays the same.



**6 Integers & Absolute Value**

**Signed number rules**

**Add same signs**

Add absolute values and keep the common sign.

**Add different signs**

Subtract absolute values and keep the sign of the number farther from 0.

**Subtract**

$$a - b = a + (-b).$$

**Multiply/divide signs**

Same signs give positive; different signs give negative.

**Zero pairs**

$$a + (-a) = 0; \text{ opposites cancel in addition.}$$

**Absolute value**

$|a|$  is the distance from 0, so  $|a| \geq 0$ .

**Opposites**

$a$  and  $-a$  are the same distance from 0 in opposite directions.

**Coordinate distance on a line**

Distance between  $a$  and  $b$  is  $|a - b|$ .

**Tutor's Note**

For multiplying or dividing, count negatives: an even number of negative signs gives a positive result; an odd number gives a negative result.

$-7 + 12 = 5$  because the signs are different, so subtract  $12 - 7$  and keep the sign of 12.

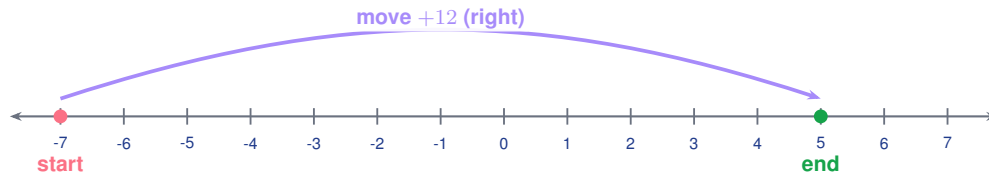
**Example**



Do not treat subtraction like multiplication. For  $5 - (-3)$ , add the opposite:  
 $5 + 3 = 8$ .



**Adding integers on a number line** Start at the first number, then *move*: right to add a positive, left to add a negative.



$$-7 + 12 = 5. \quad \text{The two points are } |-7 - 5| = 12 \text{ apart.}$$

## 7 Expressions, Equations & Inequalities

### Algebra basics

<b>Expression</b>	Numbers, variables, and operations without an equals sign.
<b>Equation</b>	A statement that two expressions are equal.
<b>Evaluate</b>	Substitute a number for a variable and simplify.
<b>Substitution</b>	Replace a variable with a given value, then use order of operations.
<b>Combine like terms</b>	Add/subtract coefficients of terms with the same variable part.
<b>Distribute</b>	$a(b + c) = ab + ac$ .
<b>One-step equation</b>	$x + a = b \Rightarrow x = b - a$ and $ax = b \Rightarrow x = \frac{b}{a}$ when $a \neq 0$ .
<b>Two-step equation</b>	For $ax + b = c$ , subtract $b$ first, then divide by $a$ when $a \neq 0$ .
<b>Inequality rule</b>	If multiplying or dividing by a negative number, flip the inequality symbol.

### Tutor's Note

Solving means keeping the equation balanced while isolating the variable. Whatever you do to one side, do to the other side.

Solve  $3x + 5 = 20$ . Subtract 5:  $3x = 15$ . Divide by 3:  $x = 5$ .

**Example**

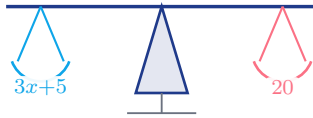




CHECK

A solution should make the original equation true. For inequalities, test a number in the solution region if you are unsure.

**An equation is a balance scale** Whatever you do to one side, do to the other, and the scale stays level until  $x$  is alone.



Solve  $3x + 5 = 20$ :

1. Subtract 5 from *both* sides:  $3x = 15$ .
2. Divide *both* sides by 3:  $x = 5$ .
3. Check:  $3(5) + 5 = 20$ . ✓

## 8 Exponents, Roots & Scientific Notation

### Powers and roots

**Exponent meaning**

$a^n$  means multiply  $a$  by itself  $n$  times for positive integer  $n$ .

**Product of powers**

$$a^m \cdot a^n = a^{m+n}$$

**Power of a power**

$$(a^m)^n = a^{mn}$$

**Power of a product**

$$(ab)^n = a^n b^n$$

**Power of a quotient**

$$\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n} \text{ when } b \neq 0.$$

**Quotient of powers**

$$\frac{a^m}{a^n} = a^{m-n} \text{ when } a \neq 0.$$

**Zero exponent**

$$a^0 = 1 \text{ when } a \neq 0.$$

**Negative exponent**

$$a^{-n} = \frac{1}{a^n} \text{ when } a \neq 0.$$

**Square root**

$$\sqrt{x} = a \text{ means } a^2 = x \text{ and } a \geq 0.$$

**Cube root**

$$\sqrt[3]{x} = a \text{ means } a^3 = x.$$

**Perfect squares**

1, 4, 9, 16, 25, 36, 49, 64, 81, 100, ... are squares of whole numbers.

**Perfect cubes**

1, 8, 27, 64, 125, 216, 343, 512, 729, 1000, ... are cubes of whole numbers.

**Scientific notation**

$a \times 10^n$ , where  $1 \leq a < 10$  and  $n$  is an integer.

**Powers of ten**

Multiplying by  $10^n$  moves the decimal  $n$  places right if  $n > 0$  and left if  $n < 0$ .



**Tutor's Note**

Scientific notation keeps very large and very small numbers readable. The exponent on 10 tells how many places the decimal moved.

$0.00042 = 4.2 \times 10^{-4}$  because the decimal moves 4 places right to make 4.2.

**Example**



ROOTS

The square root symbol means the principal, nonnegative square root. So  $\sqrt{49} = 7$ , not  $\pm 7$ .

**Exponents & scientific notation** The exponent counts how many times the base is multiplied. Scientific notation moves the decimal so one nonzero digit sits in front.

base  $\rightarrow$  2 3 exponent  
 $= 2 \cdot 2 \cdot 2 = 8$

$4200 = 4.2 \times 10^3$   
 3 places left

$0.0042 = 4.2 \times 10^{-3}$   
 3 places right

**Power checkpoint** Before graphing, make exponents automatic.

**Same base**  
 $2^3 \cdot 2^4 = 2^7 = 128$ . Add exponents when multiplying.

**Square roots**  
 $\sqrt{64} = 8$  because  $8^2 = 64$ . Use the principal root.

**Power of a power**  
 $(x^2)^5 = x^{10}$ . Multiply the exponents.

**Perfect squares**  
 Know  $1^2$  through  $15^2$ ; they make roots and geometry faster.

**Scientific form**  
 $0.0063 = 6.3 \times 10^{-3}$ . Small decimals use negative powers.

**Fast check**  
 If the answer gets huge, the exponent should usually be positive. If it gets tiny, negative.



## 9 Coordinate Plane & Linear Patterns

### Graphing basics

#### Ordered pair

$(x, y)$  gives horizontal movement first, vertical movement second.

#### Quadrants

I: (+, +), II: (-, +), III: (-, -), IV: (+, -).

#### Slope

$$m = \frac{\text{change in } y}{\text{change in } x} = \frac{y_2 - y_1}{x_2 - x_1}, \text{ with } x_2 \neq x_1.$$

#### Rate of change

Another name for slope: how much  $y$  changes for each 1 unit of  $x$ .

#### $y$ -intercept

The point where a graph crosses the  $y$ -axis.

#### $x$ -intercept

The point where a graph crosses the  $x$ -axis.

#### Linear pattern

$y = mx + b$ , where  $m$  is slope and  $b$  is the  $y$ -intercept.

#### Direct variation

$y = kx$  is a proportional linear pattern through the origin.

#### Horizontal line

$y = c$  has slope 0.

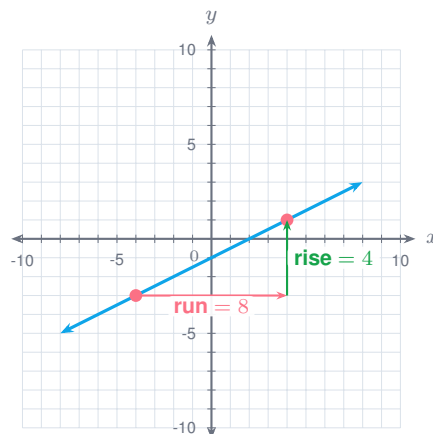
#### Vertical line

$x = c$  has undefined slope.

### Tutor's Note

The coordinate plane is a map. The  $x$ -axis moves left and right; the  $y$ -axis moves down and up. Slope tells how much  $y$  changes for each 1 step in  $x$ .

### Visual: slope is rise over run

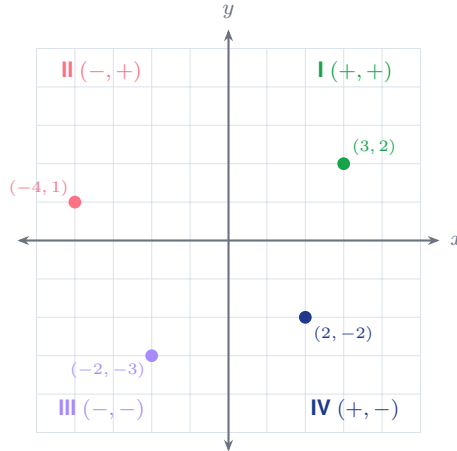




GRAPH

A vertical line fails the function test because one input has many outputs.

**The coordinate plane: quadrants & plotting** An ordered pair  $(x, y)$  moves right/left first, then up/down. The signs tell you the quadrant.



**Graphing checkpoint** Read the plane like a map: horizontal first, vertical second.

**Ordered pair**

$(-4, 3)$  means left 4, then up 3. The  $x$ -move comes first.

**Intercepts**

$y$ -intercept: where the graph crosses the  $y$ -axis.  $x$ -intercept: where it crosses the  $x$ -axis.

**Quadrant signs**

I  $(+, +)$ , II  $(-, +)$ , III  $(-, -)$ , IV  $(+, -)$ .

**Line patterns**

$y = mx + b$  shows slope  $m$  and starting value  $b$ .

**Slope**

$m = \frac{\text{rise}}{\text{run}}$ . Up/right is positive; down/right is negative.

**Fast check**

A vertical line has undefined slope because its run is 0.

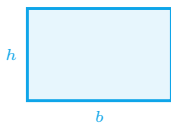


## 10 Geometry & Measurement

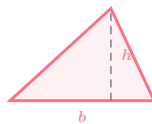
### Plane geometry

<b>Rectangle perimeter</b>	$P = 2l + 2w.$
<b>Rectangle area</b>	$A = lw.$
<b>Square perimeter / area</b>	$P = 4s$ and $A = s^2.$
<b>Triangle area</b>	$A = \frac{1}{2}bh.$
<b>Parallelogram area</b>	$A = bh.$
<b>Trapezoid area</b>	$A = \frac{1}{2}(b_1 + b_2)h.$
<b>Circle circumference</b>	$C = 2\pi r = \pi d.$
<b>Circle area</b>	$A = \pi r^2.$
<b>Pythagorean theorem</b>	$a^2 + b^2 = c^2$ for right triangles, where $c$ is the hypotenuse.

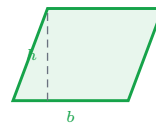
**Area formulas you can see** Area is the flat space inside a figure; the height is always perpendicular to the base.



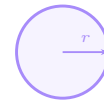
**Rectangle**  
 $A = bh$



**Triangle**  
 $A = \frac{1}{2}bh$



**Parallelogram**  
 $A = bh$



**Circle**  
 $A = \pi r^2$

**Geometry checkpoint** Name the measurement before choosing a formula.

**Perimeter**

Add side lengths around the outside. Units stay linear.

**Circles**

$C = 2\pi r = \pi d$  and  $A = \pi r^2$ . Diameter is twice the radius.

**Area**

Covering a flat region uses square units. Rectangle:  $A = lw$ .

**Pythagorean check**

Use  $a^2 + b^2 = c^2$  only for right triangles;  $c$  is the hypotenuse.

**Triangle area**

$A = \frac{1}{2}bh$ . The height must be perpendicular to the base.

**Fast check**

Area and volume answers should include square or cubic units.



## Solid geometry: volume &amp; surface area

## Rectangular prism

$$V = lwh; \text{ surface area } SA = 2lw + 2lh + 2wh.$$

## Cube

$$V = s^3; \text{ surface area } SA = 6s^2.$$

## Cylinder

$$V = \pi r^2 h; \text{ surface area } SA = 2\pi r^2 + 2\pi rh.$$

## Triangular prism

$$V = \left(\frac{1}{2}bh\right)L; \text{ SA} = \text{two triangle ends} + \text{three rectangle faces.}$$

## Cone

$$V = \frac{1}{3}\pi r^2 h.$$

## Pyramid

$$V = \frac{1}{3}(\text{base area})h.$$

## Sphere

$$V = \frac{4}{3}\pi r^3; \text{ surface area } SA = 4\pi r^2.$$

## Surface area idea

Add the areas of every outside face or curved surface; nets help organize the faces.

## Tutor's Note

Area is measured in square units because it covers a flat region. Volume is measured in cubic units because it fills space. Make sure all measurements use the same unit before using a formula.

## Example

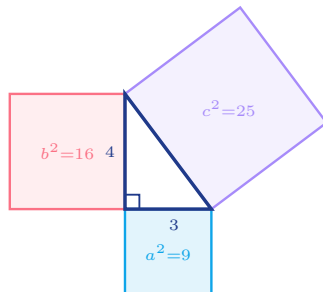
A triangle with base 10 cm and height 7 cm has area  $A = \frac{1}{2}(10)(7) = 35$  square centimeters.



## GEOMETRY

For the Pythagorean theorem,  $c$  is always the longest side, across from the right angle.

**The Pythagorean theorem:**  $a^2 + b^2 = c^2$  For a right triangle, the square built on the hypotenuse equals the two squares on the legs added together.



The legs are  $a = 3$  and  $b = 4$ , so  
 $c^2 = a^2 + b^2 = 9 + 16 = 25$ ,  
 which gives  $c = \sqrt{25} = 5$ .

The hypotenuse  $c$  is always the longest side, opposite the right angle.



## 11 Measurement & Unit Conversions

### Customary (U.S.) units

**Length**

12 in = 1 ft; 3 ft = 1 yd; 5280 ft = 1 mi.

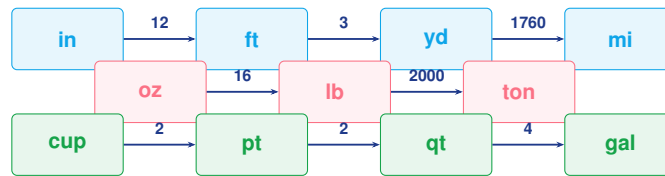
**Weight**

16 oz = 1 lb; 2000 lb = 1 ton.

**Capacity**

8 fl oz = 1 cup; 2 cups = 1 pt; 2 pt = 1 qt; 4 qt = 1 gal.

**Unit conversion checkpoint** Write the unit you want to cancel on the bottom.



**Length path**

1 yd = 3 ft and 1 ft = 12 in, so  
2 yd = 72 in.

**Fraction setup**

$5 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}}$ : feet cancel.

**Weight path**

1 lb = 16 oz; multiply pounds by 16 to  
get ounces.

**Reasonableness**

Smaller units make larger numbers;  
larger units make smaller numbers.

**Capacity path**

1 gal = 4 qt = 8 pt = 16 cups.

**Fast check**

Keep units attached until the final  
answer. They show whether the setup  
is right.

**Try it** 4 ft = 48 in   3 lb = 48 oz   2 gal = 8 qt = 32 cups   Smaller units make the number larger.



**Metric units & time**

**Metric length**

10 mm = 1 cm; 100 cm = 1 m; 1000 m = 1 km.

**Metric mass**

1000 mg = 1 g; 1000 g = 1 kg.

**Metric capacity**

1000 mL = 1 L.

**Metric prefixes**

kilo = 1000, hecto = 100, deca = 10, deci =  $\frac{1}{10}$ , centi =  $\frac{1}{100}$ , milli =  $\frac{1}{1000}$ .

**Time**

60 s = 1 min; 60 min = 1 hr; 24 hr = 1 day; 7 days = 1 wk.

**Temperature**

$F = \frac{9}{5}C + 32$  and  $C = \frac{5}{9}(F - 32)$ .

**Converting units: multiply by a fraction equal to 1** Write the conversion so the *old* unit cancels and the *new* unit is left.

$$5 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \Rightarrow 60 \text{ in}$$

the "ft" units cancel, leaving inches

**Tutor's Note**

To convert, multiply by a fraction that equals 1 (the same amount written two ways). Put the unit you want to cancel on the bottom and the unit you want to keep on top.

**Example**

Convert 3 yards to inches:  $3 \text{ yd} \times \frac{3 \text{ ft}}{1 \text{ yd}} \times \frac{12 \text{ in}}{1 \text{ ft}} = 108 \text{ in}$ .



Metric prefixes move the decimal by powers of 10: from km to m multiply by 1000; from m to cm multiply by 100.

**12 Angles, Lines & Polygons**

**Types of angles** Angles are measured in degrees. A right angle is exactly  $90^\circ$ ; a straight angle is  $180^\circ$ .



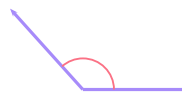
**Acute**

less than  $90^\circ$



**Right**

exactly  $90^\circ$



**Obtuse**

between  $90^\circ$  and  $180^\circ$



**Straight**

exactly  $180^\circ$



**Angle & figure facts**

**Right / straight angle**

A right angle is  $90^\circ$ ; a straight angle is  $180^\circ$ ; a full turn is  $360^\circ$ .

**Complementary angles**

Two angles whose measures add to  $90^\circ$ .

**Supplementary angles**

Two angles whose measures add to  $180^\circ$  (a straight line).

**Vertical angles**

When two lines cross, opposite angles are equal.

**Triangle angle sum**

The three interior angles of a triangle add to  $180^\circ$ .

**Quadrilateral angle sum**

The four interior angles of a quadrilateral add to  $360^\circ$ .

**Polygon angle sum**

For  $n$  sides, interior angles add to  $(n - 2) \cdot 180^\circ$ .

**Regular polygon angle**

Each interior angle is  $\frac{(n-2)180^\circ}{n}$ .

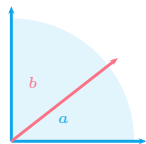
**Exterior angles**

One exterior angle at each vertex adds to  $360^\circ$ ; regular exterior angle is  $\frac{360^\circ}{n}$ .

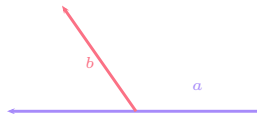
**Parallel lines**

Lines in a plane that never meet; a crossing line makes equal matching angles.

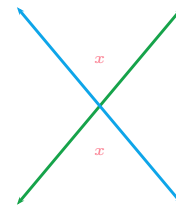
**Angle pairs** Complementary angles add to  $90^\circ$ , supplementary angles add to  $180^\circ$ , and vertical angles (across an X) are equal.



**Complementary**  
 $a + b = 90^\circ$



**Supplementary**  
 $a + b = 180^\circ$



**Vertical**  
opposite angles equal

**Tutor's Note**

Most angle problems are just addition. If two angles form a right angle, they are complementary; if they form a straight line, they are supplementary. Set the known sum equal to the parts and solve.

If one angle of a complementary pair is  $35^\circ$ , the other is  $90^\circ - 35^\circ = 55^\circ$ .

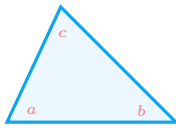
**Example**



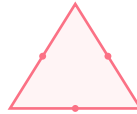
The angles of a triangle always total  $180^\circ$ , so two angles determine the third:  
 $c = 180^\circ - a - b$ .



**Triangle angle sum & figure types** The three angles of any triangle add to  $180^\circ$ ; the four angles of any quadrilateral add to  $360^\circ$ .



$a + b + c = 180^\circ$



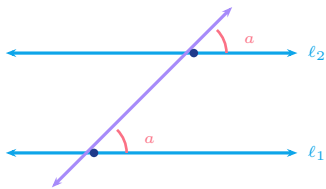
equilateral: all sides =



rectangle

4 right angles

**Parallel lines cut by a transversal** A line crossing two parallel lines makes equal matching angles.



**Corresponding angles** (same position at each crossing) are **equal**.

**Alternate interior angles** (opposite sides, between the lines) are **equal**.

**Co-interior angles** (same side, between the lines) are **supplementary** — they add to  $180^\circ$ .

**Interior angle sums:**  $(n - 2) \times 180^\circ$  Every extra side adds another  $180^\circ$  to the total.



Triangle

3 sides =  $180^\circ$



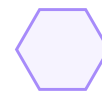
Quadrilateral

4 sides =  $360^\circ$



Pentagon

5 sides =  $540^\circ$



Hexagon

6 sides =  $720^\circ$

**Angle checkpoint** Most angle questions are sum facts plus simple equations.

**Pairs**

$a + b = 90^\circ$  for complementary;  
 $a + b = 180^\circ$  for supplementary.

**Triangles**

$a + b + c = 180^\circ$ . Two angles determine the third.

**Quadrilaterals**

Four interior angles add to  $360^\circ$ .

**Polygons**

Interior sum =  $(n - 2)180^\circ$ . Divide by  $n$  only for regular polygons.

**Parallel lines**

Corresponding and alternate interior angles match; same-side interior angles add to  $180^\circ$ .

**Fast check**

A straight line is  $180^\circ$  and a full turn is  $360^\circ$ .



## 13 Data, Statistics & Probability

### Statistics formulas

<b>Mean</b>	$\bar{x} = \frac{\text{sum of values}}{\text{number of values}}$
<b>Median</b>	The middle value after the data are ordered.
<b>Mode</b>	The value or values that occur most often.
<b>Range</b>	Maximum minus minimum.
<b>Quartiles</b>	$Q_1$ , median, $Q_3$ split ordered data into four equal parts.
<b>Interquartile range</b>	$IQR = Q_3 - Q_1$ , the spread of the middle half.
<b>Mean absolute deviation</b>	$MAD = \frac{\sum  x - \bar{x} }{n}$ , the average distance from the mean.
<b>Probability</b>	$P(\text{event}) = \frac{\text{favorable outcomes}}{\text{total equally likely outcomes}}$
<b>Experimental probability</b>	$\frac{\text{times event occurs}}{\text{number of trials}}$
<b>Complement</b>	$P(\text{not } A) = 1 - P(A)$ .
<b>Simple counting principle</b>	If one choice has $m$ options and another has $n$ options, together there are $mn$ outcomes.

### Tutor's Note

Statistics summarize data. Probability predicts chance. Both depend on reading the question carefully: are the outcomes equally likely, and what exactly counts as a success?

For data 4, 5, 6, 9, the mean is  $\frac{4+5+6+9}{4} = 6$  and the range is  $9 - 4 = 5$ .

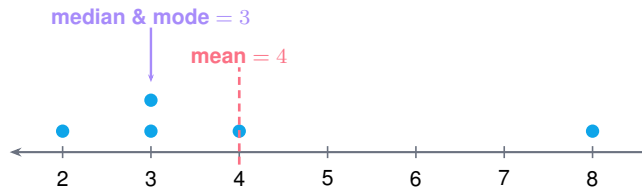
**Example**



Outliers can pull the mean more than the median. If one value is far away from the rest, compare both measures.

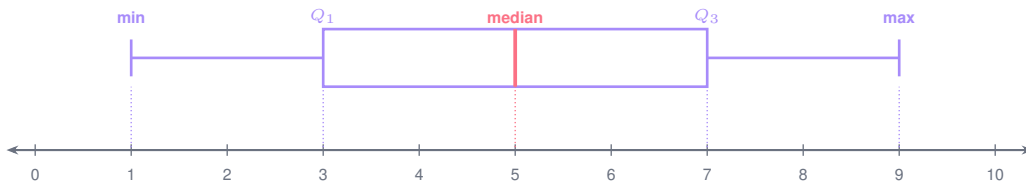


**Mean, median & mode on a dot plot** Stack a dot for each value, then read the center three ways. The mean balances the data; the median is the middle; the mode is the most common.



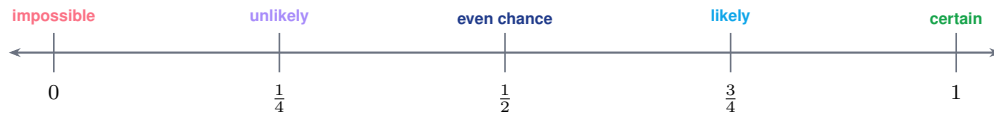
Data 2, 3, 3, 4, 8: mean  $\frac{20}{5} = 4$ , median 3, mode 3, range  $8 - 2 = 6$ .

**The five-number summary & box plot** Order the data, then mark the minimum, first quartile  $Q_1$ , median, third quartile  $Q_3$ , and maximum.



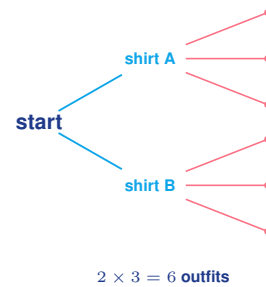
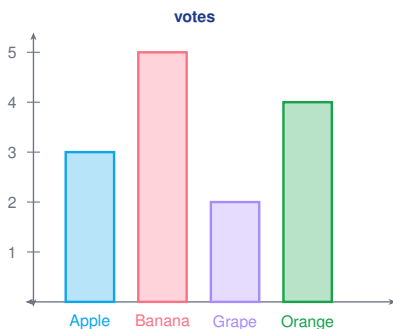
The box holds the middle half of the data; its width ( $Q_3 - Q_1$ ) is the interquartile range (IQR).

**The probability scale** Every probability is a number from 0 (impossible) to 1 (certain). Half-way is an even chance.



0% to 100% — e.g. one head on a fair coin flip is  $\frac{1}{2} = 50\%$ .

**Reading data & counting outcomes** A bar graph compares categories; the counting principle multiplies the choices at each stage.



# Quick Reference Tables

Memorize these to speed up everything

## Fraction = Decimal = Percent

Fraction	Decimal	Percent
$\frac{1}{2}$	0.5	50%
$\frac{1}{3}$	$0.\bar{3}$	$33\frac{1}{3}\%$
$\frac{2}{3}$	$0.\bar{6}$	$66\frac{2}{3}\%$
$\frac{1}{4}$	0.25	25%
$\frac{3}{4}$	0.75	75%
$\frac{1}{5}$	0.2	20%
$\frac{2}{5}$	0.4	40%
$\frac{1}{6}$	$0.1\bar{6}$	$16\frac{2}{3}\%$
$\frac{1}{8}$	0.125	12.5%
$\frac{1}{9}$	$0.\bar{1}$	$11\frac{1}{9}\%$
$\frac{1}{10}$	0.1	10%
$\frac{1}{20}$	0.05	5%
$\frac{1}{100}$	0.01	1%

## Perfect squares

$n$	$n^2$	$n$	$n^2$
1	1	9	81
2	4	10	100
3	9	11	121
4	16	12	144
5	25	13	169
6	36	14	196
7	49	15	225
8	64	20	400

## Divisibility rules

- By** The number is divisible if...
- 2 it is even (ends in 0, 2, 4, 6, 8).
  - 3 the digit sum is divisible by 3.
  - 4 the last two digits form a multiple of 4.
  - 5 it ends in 0 or 5.
  - 6 it is divisible by both 2 and 3.
  - 9 the digit sum is divisible by 9.
  - 10 it ends in 0.

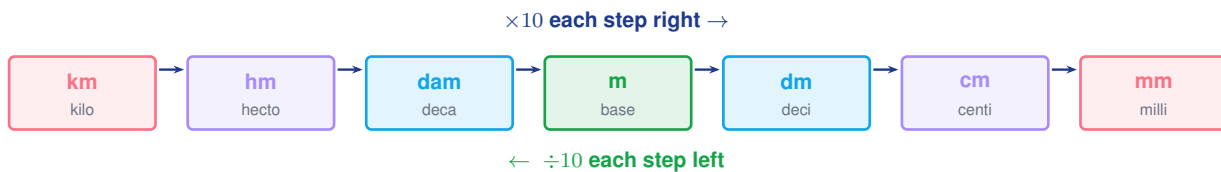
## Perfect cubes

$n$	$n^3$	$n$	$n^3$
1	1	6	216
2	8	7	343
3	27	8	512
4	64	9	729
5	125	10	1000

## Powers of ten

Power	Value
$10^0, 10^1, 10^2, 10^3$	1, 10, 100, 1000
$10^4, 10^5, 10^6$	10,000, 100,000, 1,000,000
$10^{-1}, 10^{-2}, 10^{-3}$	0.1, 0.01, 0.001

**The metric staircase** Each step is a power of 10. Moving *right* to a smaller unit multiplies by 10 (decimal moves right); moving *left* divides by 10.



# Pre-Algebra Symbols Cheat Sheet

Symbol • Meaning • Example

## Operations & Comparisons

Symbol	Meaning	Example
=	equals	$x = 5$
$\neq$	not equal	$x \neq 0$
<	less than	$x < 7$
>	greater than	$x > 2$
$\leq$	at most	$x \leq 10$
$\geq$	at least	$x \geq 0$
+	add / positive	$3 + 4 = 7$
-	subtract / negative	$5 - 8 = -3$
$\times, \cdot$	multiply	$4 \cdot x = 4x$
$\div, /$	divide	$12 \div 3 = 4$

## Graphs & Geometry

Symbol	Meaning	Example
$(x, y)$	ordered pair	$(3, -2)$
$x$ -axis	horizontal axis	left/right
$y$ -axis	vertical axis	up/down
$m$	slope	rise/run
$b$	$y$ -intercept	$y = mx + b$
$k$	constant of proportionality	$y = kx$
$P$	perimeter	distance around
$A$	area	square units
$V$	volume	cubic units
$r, d$	radius, diameter	$d = 2r$

## Fractions, Powers & Roots

Symbol	Meaning	Example
$\frac{a}{b}$	fraction / quotient	$\frac{3}{4}$
%	percent	$25\% = 0.25$
:	ratio	$2 : 3$
$\frac{b}{a}$	reciprocal of $\frac{a}{b}$	divide fractions
$x^2$	square	$6^2 = 36$
$x^3$	cube	$2^3 = 8$
$\sqrt{x}$	square root	$\sqrt{49} = 7$
$\sqrt[3]{x}$	cube root	$\sqrt[3]{8} = 2$
$ x $	absolute value	$ -5  = 5$
$\pi$	circle constant	$C = 2\pi r$

## Data & Probability

Symbol	Meaning	Example
$\bar{x}$	mean	$\bar{x} = 6$
$n$	number of values	$n = 12$
$P(A)$	probability	$P(A) = \frac{1}{4}$
$A'$	not event $A$	complement
$\approx$	approximately	$\pi \approx 3.14$
$\infty$	continues without end	repeating decimal
$\Rightarrow$	leads to	$x + 2 = 5 \Rightarrow x = 3$
$\therefore$	therefore	final conclusion

**Symbol check** Equation symbols compare values; operation symbols change values; graph symbols name location and slope; data symbols summarize a set. Always read the symbol in context before substituting numbers.



# Pre-Algebra Vocabulary Bank

## Numbers & Operations

**Digit** — one symbol in a number, such as 0 through 9.  
**Place value** — the value of a digit based on its position.  
**Factor** — a number that divides another number evenly.  
**Multiple** — a product of a number and a whole number.  
**Prime** — a whole number greater than 1 with exactly two factors.  
**Composite** — a whole number greater than 1 with more than two factors.  
**GCF** — the greatest common factor.  
**LCM** — the least common multiple.  
**Rational number** — a number that can be written as  $\frac{a}{b}$ , with  $b \neq 0$ .  
**Absolute value** — distance from zero on a number line.

## Fractions, Decimals & Percents

**Numerator** — the top number in a fraction.  
**Denominator** — the bottom number in a fraction; it cannot be zero.  
**Equivalent fractions** — fractions with the same value.  
**Mixed number** — a whole number plus a fraction.  
**Improper fraction** — a fraction with numerator at least as large as denominator.  
**Reciprocal** — a fraction flipped upside down; used to divide fractions.  
**Percent** — per hundred.  
**Unit rate** — a rate per one unit.  
**Proportion** — two equal ratios.  
**Proportional relationship** — a relationship that can be written as  $y = kx$ .  
**Scale factor** — the multiplier from one size to another.

## Algebra Readiness

**Variable** — a letter that represents a number.  
**Constant** — a number that does not change.  
**Coefficient** — a number multiplying a variable.  
**Expression** — numbers, variables, and operations without an equals sign.  
**Equation** — a statement that two expressions are equal.  
**Solution** — a value that makes an equation or inequality true.  
**Like terms** — terms with the same variable part.  
**Distribute** — multiply a factor by each term inside parentheses.  
**Inequality** — a comparison using  $<$ ,  $>$ ,  $\leq$ , or  $\geq$ .  
**Scientific notation** — a number written as  $a \times 10^n$ , where  $1 \leq a < 10$ .  
**Unit conversion** — rewriting a measurement with an equivalent unit.

## Graphs, Geometry & Data

**Coordinate plane** — a grid formed by the  $x$ -axis and  $y$ -axis.  
**Ordered pair** — a point written as  $(x, y)$ .  
**Slope** — change in  $y$  divided by change in  $x$ .  
**Perimeter** — distance around a figure.  
**Area** — space inside a flat figure.  
**Volume** — space inside a solid figure.  
**Mean** — the average of a data set.  
**Median** — the middle value after ordering.  
**Outlier** — a data value far from most of the data.  
**IQR** — interquartile range; the spread of the middle half.  
**Probability** — a number that describes how likely an event is.



VOCAB

Translate the action word first: evaluate plugs in a number, simplify cleans an expression, solve finds a value, and graph shows the relationship visually.

**Vocabulary check** Say the word, name the action, then write a tiny example. If a definition includes a restriction such as  $b \neq 0$  or  $a \geq 0$ , keep that restriction with the formula.



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TOOLS

#### Quick references

Use formula sheets and topic pages when memory needs support.

Best loop: learn the rule, practice the foundation skill, then move toward Algebra 1. [EffortlessMath.com/pre-algebra](https://EffortlessMath.com/pre-algebra)