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# **Elementary Algebra Review Topics**

Professor Tim Busken

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# **Mathematical Theorems**

## Definition

A <u>theorem</u> is a statement that has been proven on the basis of previously established statements.

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## Definition

A set is a collection of objects or numbers. We use braces { } to denote a set.

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# **Basic Set Definitions**

## Definition

A set is a collection of objects or numbers. We use braces { } to denote a set.

## Example 1

{ 1,2,3,4} denotes a set containing the four numbers 1, 2, 3 and 4.

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## Definition

The <u>union</u> of two sets A and B, written  $A \cup B$ , is the set of all elements (numbers) that are either in A or in B or both. The  $\cup$  symbol means the word "or."

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**Example 2** Suppose A =  $\{1,2,3\}$  and B =  $\{4,5,6\}$ . Then A  $\cup$  B is equal to what set?

 $A \cup B =$ 

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 $A \cup B = \{1,2,3,4,5,6\}$ 

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## Definition

The <u>intersection</u> of two sets A and B, written  $A \cap B$ , is the set of all elements (numbers) that are in both A and B. The  $\cap$  symbol means the word "and."

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# **Basic Set Definitions**

## Definition

The <u>intersection</u> of two sets A and B, written  $A \cap B$ , is the set of all elements (numbers) that are in both A and B. The  $\cap$  symbol means the word "and."

**Example 3** Suppose  $A = \{1,2,3,4\}$  and  $B = \{2,4,20\}$ . Then  $A \cap B$  is equal to what set?

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# **Basic Set Definitions**

## Definition

The <u>intersection</u> of two sets A and B, written  $A \cap B$ , is the set of all elements (numbers) that are in both A and B. The  $\cap$  symbol means the word "and."

**Example 3** Suppose  $A = \{1,2,3,4\}$  and  $B = \{2,4,20\}$ . Then  $A \cap B$  is equal to what set?

 $A \cap B = \{2,4\}$ 

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# **Number Types**

## Definition

The natural numbers,

$$\mathbb{N} = \{1, 2, 3, 4, \dots\}$$

consists of the counting numbers, where the ellipsis (...) indicates that the set goes on to infinity, or that there is no upper bound (largest number) in the set.

# **Number Types**

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## Definition

The set of whole numbers,

$$\mathbb{W} = \{0, 1, 2, 3, 4, \dots\}$$

is the set of natural numbers unioned with zero, written  $\mathbb{W} = \mathbb{N} \cup \{0\}$ .

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## Definition

The set of integers,

$$\mathbb{Z} = \{\dots, -4, -3, -2, -1, 0, 1, 2, 3, 4, \dots\}$$

is also known as all the positive and negative whole numbers.

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# Number Types

## Definition

A rational number is any number that can be written as a fraction where both the numerator and denominator are integers (and the denominator is not zero). The set of rational numbers is written symbolically as

$$\mathbb{Q} = \left\{ \begin{array}{c} \frac{a}{b} \mid \text{a and b are any integers, and } b \neq 0 \end{array} \right\}$$

Note that any integer "a" is a rational number since  $a = \frac{a}{4}$ .

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# **Number Types**

<u>HUGE note</u>: When a rational number (fraction) is represented as a decimal number, then

1 it has a finite number of digits to the right of the decimal point; for example,  $\frac{5}{4} = 1.25$ , OR

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<u>HUGE note</u>: When a rational number (fraction) is represented as a decimal number, then

- 1 it has a finite number of digits to the right of the decimal point; for example,  $\frac{5}{4} = 1.25$ , OR
- 2 it has an infinite number of digits to the right of the decimal point *AND* and those digits have a repeating pattern, for example  $\frac{1}{3} = 0.\overline{3}$  and  $\frac{2}{37} = 0.054054054\cdots = 0.\overline{054}$ .

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# **Number Types**

## Definition

Real numbers that are not rational, for example,  $\sqrt{2}$ ,  $\sqrt[3]{3}$ , and  $\pi$  are called <u>irrational numbers</u>. The set of irrational numbers is denoted  $\mathbb{I}$ .

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<u>HUGE note</u>: When an irrational number is represented as a decimal number, then

- 1 it has an infinite number of digits to the right of the decimal point,
- 2 and those digits do not have a repeating pattern.



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# **Number Types**

## Definition

The <u>set of real numbers</u>, denoted  $\mathbb{R}$ , is the set  $\mathbb{R}=\mathbb{Q}\cup\mathbb{I}$ , that is the set of rationals unioned with the irrationals. Each real number can be uniquely represented as a decimal, and we associate each real number with a distinct point on a coordinate (number) line.

### Tim Busken

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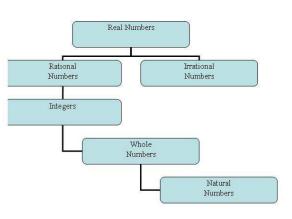
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**Opposites** 

## Theorem

Every real number has an opposite. The sum of a real number and its opposite is zero. Opposites are often called additive inverses.

Example The opposite of 5 is -5, and 5 + (-5) = 0 Properties of Re Numbers

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Every non-zero real number has a <u>reciprocal</u>. The product of a real number and its reciprocal is one. Reciprocals are often called multiplicative inverses.

Reciprocals

**Example** The multiplicative inverse of 5 is  $\frac{1}{5}$ , and  $5 \cdot \frac{1}{5} = 1$ 

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# Absolute value

## Definition (Absolute Value)

The absolute value of a real number is its distance from 0 on the number line. If |x| represents the absolute value of x, then

$$|x| = \begin{cases} x, & \text{if } x \ge 0; \\ -x, & \text{if } x < 0. \end{cases}$$

The absolute value of a real number is never negative.

**Example** 
$$|5| = 5$$
 and  $|-5| = 5$ .

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# Theorem (Properties of Absolute value)

For any real numbers a and b:

- **1** |a| ≥ 0
- | a | = |a|
- $|a \cdot b| = |a| \cdot |b|$
- $\left|\frac{a}{b}\right| = \frac{|a|}{|b|}$  provided  $b \neq 0$

# Addition

## To add two real numbers with the same sign:

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# Addition

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## To add two real numbers with the same sign:

Add the absolute values and use the common sign.

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## To add two real numbers with the same sign:

Add the absolute values and use the common sign.

# **Examples**

$$7 + 5 = 12$$

$$-7 + (-5) = -12$$

# Addition

## To add two real numbers with different signs:

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# Addition

## To add two real numbers with different signs:

 Subtract the smaller absolute value from the larger absolute value. The answer has the same sign as the number with the larger absolute value.

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# Addition

## To add two real numbers with different signs:

 Subtract the smaller absolute value from the larger absolute value. The answer has the same sign as the number with the larger absolute value.

## **Examples**

$$7 + (-5) = 2$$

$$-7 + 5 = -2$$

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We use addition to define subtraction.

## Definition

Suppose a and b represent any two real numbers. Then

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

To subtract *b*, add the opposite of *b*.

# Multiplication

## To multiply two real numbers:

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# Multiplication

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## To multiply two real numbers:

simply multiply their absolute values.

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# Multiplication

## To multiply two real numbers:

· simply multiply their absolute values.

Like signs give a positive answer. For example,

$$7 \cdot 5 = 35$$

$$(-7) \cdot (-5) = 35$$

Like signs give a positive answer. For example,

$$7 \cdot 5 = 35$$

$$(-7) \cdot (-5) = 35$$

Unlike signs give a negative answer. For example,

$$-7\cdot 5=-35$$

$$7\cdot(-5)=-35$$

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Multiplication

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We use multiplication to define division.

### Definition

Suppose a and b represent any two real numbers, and that  $b \neq 0$ . Then

$$\frac{a}{b} = a \cdot \frac{1}{b}$$

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We use multiplication to define division.

### Definition

Suppose a and b represent any two real numbers, and that  $b \neq 0$ . Then

$$\frac{a}{b} = a \cdot \frac{1}{b}$$

### Example

$$\frac{3}{4} = 3 \cdot \frac{1}{4}$$

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# **Properties of Real Numbers**

### Closure

Suppose a and b represent any real numbers, then a + b and  $a \cdot b$  are real numbers too.

	For Addition	For Multiplication
Commutative	a+b=b+a	$a \cdot b = b \cdot a$
Associative	a+(b+c)=(a+b)+c	$a \cdot (b \cdot c) = (a \cdot b) \cdot c$
Identity	0+a=a	$1 \cdot a = a$
Inverse	a+(-a)=0	$a \cdot \left(\frac{1}{a}\right) = 1$
Mult. Prop of Zero	$0 \cdot a = 0$	

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# The Distributive Property

Theorem (Distributive Property of Multiplication ) *Multiplication distributes over addition. For example,* 

$$(a \cdot (b + c)) = a \cdot b + a \cdot c$$

# The Distributive Property

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# The Distributive Property

The distributive property says that multiplication distributes over addition.

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# The Distributive Property

The distributive property says that multiplication distributes over addition. For example, notice that  $3\cdot(2+5)$  simplifies to the same number as  $3\cdot2+3\cdot5$ .

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The distributive property says that multiplication distributes over addition. For example, notice that  $3 \cdot (2+5)$  simplifies to the same number as  $3 \cdot 2 + 3 \cdot 5$ .

$$3 \cdot \underbrace{(2+5)}_{} = 3(7) = 21$$

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$$3 \cdot (2+5) = 3(7) = 21$$

and

$$3 \cdot 2 + 3 \cdot 5 = 6 + 15 = 21$$

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The distributive property says that multiplication distributes over addition. For example, notice that  $3 \cdot (2+5)$  simplifies to the same number as  $3 \cdot 2 + 3 \cdot 5$ .

$$3 \cdot \underbrace{(2+5)}_{} = 3(7) = 21$$

and

$$3 \cdot 2 + 3 \cdot 5 = 6 + 15 = 21$$

Therefore,

$$\widehat{3(2+5)}=3\cdot 2+3\cdot 5$$

Notice in the expression  $3 \cdot (2+5)$  that each number inside the parenthesis is multiplied by 3.

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# The Distributive Property

**Example** Use the Distributive Property on the algebraic expression,  $3 \cdot (x - 1)$ . Assume x represents a real number.

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# The Distributive Property

**Example** Use the Distributive Property on the algebraic expression,  $3 \cdot (x - 1)$ . Assume x represents a real number.

### Solution:

$$3 \cdot (x-1) = 3 \cdot \left(x + (-1)\right)$$
 Definition of Subtraction
$$= 3 \cdot x + 3 \cdot (-1)$$
 Distributive Property
$$= 3x + (-3)$$

$$= 3x - 3$$
 Definition of Subtraction



 $-\frac{a}{b} = \frac{-a}{b}$  and  $-\frac{a}{b} = \frac{a}{-b}$ 

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# **Exponential Notation**

Recall the following terminology related to multiplication.

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# **Exponential Notation**

Recall the following terminology related to multiplication.

The numbers we are multiplying are called factors.

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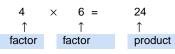
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# **Exponential Notation**

Recall the following terminology related to multiplication.



The result of multiplying the factors is called the **product**.

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#### **Review Topics**

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#### Exponential Notation

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# **Exponential Notation**

In the product  $2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$ , notice that 2 is a factor several times.

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```
\underbrace{2 \cdot 2 \cdot 2 \cdot 2}_{2 \text{ is a factor 5 times}} \text{ can be written as } 2^{5}.  (Read as "two to the fifth power.")
```

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```
\underbrace{2 \cdot 2 \cdot 2 \cdot 2 \cdot 2}_{2 \text{ is a factor 5 times}} \text{ can be written as } 2^5.  (Read as "two to the fifth power.")
```

This is called **exponential notation**. The **exponent**, 5, indicates how many times the **base**, 2, is a factor.

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# **Exponential Expressions**

## **Helpful Hint**

An exponent applies only to its base. For example,  $4 \cdot 2^3$  means  $4 \cdot 2 \cdot 2 \cdot 2$ 

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# **Exponential Expressions**

## **Helpful Hint**

An exponent applies only to its base. For example,  $4\cdot 2^3$  means  $4\cdot 2\cdot 2\cdot 2$ 

### **Helpful Hint**

Dont forget that  $2^4$ , for example is not  $2 \cdot 4$ . The expression  $2^4$  means repeated multiplication of the same factor.

$$2^4 = 2 \cdot 2 \cdot 2 \cdot 2 = 16$$
 whereas  $2 \cdot 4 = 8$ 

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#### **Review Topics**

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## The Order of Operations

Example: Simplify  $6 + 2 \cdot 30$ . Do you multiply or add first?

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#### **Review Topics**

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# The Order of Operations

When evaluating a mathematical expression, we will perform the operations in the following order:

Begin with the expression in the innermost parenthesis or brackets and work our way out.

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# The Order of Operations

When evaluating a mathematical expression, we will perform the operations in the following order:

- Begin with the expression in the innermost parenthesis or brackets and work our way out.
- 2 Change exponential expressions into repeated multiplication.
- Multiply or divide in order from left to right.

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# The Order of Operations

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- Begin with the expression in the innermost parenthesis or brackets and work our way out.
- 2 Change exponential expressions into repeated multiplication.
- Multiply or divide in order from left to right.
- 4 Add or subtract in order from left to right.

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# The Order of Operations

When evaluating or simplifying an algebraic or arithmetic expression, we always use the ORDER OF OPERATIONS. In other words we evaluate the expression in the following order:

P-Parenthesis

E-Exponents

M-Multiplication

D-Division

A-Addition

S-Subtraction

The operations  $+, -, \times, \div$  must be performed from left to right! The acronym

PEMDAS helps us to recall the ORDER OF OPERATIONS.

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# Example

**Example** Recall that for any real number a, it is always true that  $-a = (-1) \cdot a$ . Use the Order of Operations and  $-a = (-1) \cdot a$  to simplify the arithmetic expression  $5 - 10^2$ .

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# Example

**Example** Recall that for any real number a, it is always true that  $-a = (-1) \cdot a$ . Use the Order of Operations and  $-a = (-1) \cdot a$  to simplify the arithmetic expression  $5 - 10^2$ .

### Solution:

$$5 - 10^2 = 5 + (-10^2)$$
 Definition of Subtraction
$$= 5 + ((-1) \cdot 10^2)$$
 Since  $-a = (-1) \cdot a$ 

$$= 5 + ((-1) \cdot 10 \cdot 10)$$
 Since  $10^2 = 10 \cdot 10$ 

$$= 5 + (-100) = -95$$

#### Tim Busken

#### **Review Topics**

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- An equation is a statement (or sentence) indicating that two algebraic expressions are equal.
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  a ≠ 0. A linear equation in one variable is an equation of the form
  ax + b = 0.

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- Ex: How do you solve 2x 4 = 0 for x?

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- An equation can be an classified as
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  - 2 a CONDITIONAL EQUATION,
  - **3** or a CONTRADICTION.

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- A **CONTRADICTION** is a false equation, such as 4 = 9.

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## **Solving Linear Equations**

#### Definition

A linear equation in one variable is any equation that can be put in the form

$$a \cdot x + b = c$$

where a, b and c are constants (numbers) and  $a \neq 0$ .

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A linear equation in one variable is any equation that can be put in the form

$$a \cdot x + b = c$$

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For example,  $2 \cdot x + 3 = -1$  is a linear equation in one variable.

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2x, 3 and -1 are called the **terms** of the equation.

Linear Equations

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2x, 3 and -1 are called the **terms** of the equation.

2x is a variable term and 3 and -1 are constant terms.

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#### Definition

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The solution set for an equation is the set of all numbers that when used in place of the variable make the equation a true statement.

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#### **Review Topics**

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The solution set for an equation is the set of all numbers that when used in place of the variable make the equation a true statement.

**Example** The solution set for 4x - 2 = 10 is {3} since replacing x with 3 makes the equation a true statement.

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**Example** The solution set for 4x - 2 = 10 is {3} since replacing x with 3 makes the equation a true statement.

#### Solution:

$$4x - 2 = 10$$

$$4 \cdot (x) - 2 = 10$$

Associative Property of Multiplication

$$4 \cdot (3) - 2 = 10$$

Replace x with 3

$$12 - 2 = 10$$

The Order of Operations says that we multiply before subtracting.

#### Tim Busken

#### Definition

Two or more equations with the same solution set are called equivalent equations.

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#### Definition

Two or more equations with the same solution set are called equivalent equations.

**Example** 2x + 3 = -1, x = -2, 2x = -4, and x + 2 = 0 are all equivalent equations since the solution set for each is  $\{-2\}$ .

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## **Properties of Equality**

### **Addition Property of Equality**

For any three algebraic expressions A, B and C,

If 
$$A = B$$

then 
$$A + C = B + C$$

In words: Adding the same quantity to both sides of an equation will not change the solution set.

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## **Properties of Equality**

### **Multiplication Property of Equality**

For any three algebraic expressions A, B and C, where  $C \neq 0$ ,

If 
$$A = B$$
,

then 
$$A \cdot C = B \cdot C$$

In words: Multiplying both sides of an equation by the same non-zero quantity will not change the solution set.

## Classroom Examples: Solve the following equations for x.

$$\frac{2}{3}x + 4 = -8$$

$$3x - 3 = -5x + 9$$

$$-x = 1$$

$$4 \quad \frac{3}{5}x + \frac{1}{3} = -\frac{5}{6}$$

## **Solving Linear Equations in One Variable**

#### **Review Topics**

Set Definitions

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Absolute Value

Operations

Properties of Real Numbers

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The Order of

Operations

Linear Equation

#### Linear Equations

Linear Inequalities

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Factoring Polynomia

Polynomials GCF

ac-grouping method

**Step 1: a.** Use the Distributive Property to separate terms, if necessary.

Linear Equations

Combining Like

Binomial

ac-grouping method

## **Solving Linear Equations in One Variable**

Step 1: a. Use the Distributive Property to separate terms, if necessary.

**b.** If fractions are present, consider multiplying both sides the LCD to eliminate the fractions. by

#### Linear Equations

Combining Like

Binomial

## **Solving Linear Equations in One Variable**

Step 1: a. Use the Distributive Property to separate terms, if necessary.

**b.** If fractions are present, consider multiplying both sides the LCD to eliminate the fractions. If decimals are bν present consider multiplying both sides by a power of 10 to clear the

equation of decimals.

#### Linear Equations

Combining Like

Binomial

## **Solving Linear Equations in One Variable**

Step 1: a. Use the Distributive Property to separate terms, if necessary.

**b.** If fractions are present, consider multiplying both sides the LCD to eliminate the fractions. If decimals are by present consider multiplying both sides by a power of 10 to clear the

equation of decimals.

**c.** Combine similar terms on each side of an equation.

Linear Equations

Combining Like

Binomial

## **Solving Linear Equations in One Variable**

a. Use the Distributive Property to Step 1: separate terms, if necessary,

**b.** If fractions are present, consider multiplying both sides the LCD to eliminate the fractions. If decimals are bν consider multiplying both sides by a power of 10 present to clear the

equation of decimals.

**c.** Combine similar terms on each side of an equation.

Step 2: Use the Addition Property of Equality to get all variable terms

on one side of the equation and all constant terms on the

side.

other

### **Solving Linear Equations in One Variable**

#### Review Topics

Linear Equations

Combining Like

a. Use the Distributive Property to Step 1: separate terms, if necessary,

**b.** If fractions are present, consider multiplying both sides the LCD to eliminate the fractions. If decimals are bν consider multiplying both sides by a power of 10 present to clear the

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Step 2: Use the Addition Property of Equality to get all variable terms

on one side of the equation and all constant terms on the

side.

other

Step 3: Use the Multiplication Property of Equality to get the variable by

itself on one side of the equation.

## Solving Linear Equations in One Variable

**Review Topics** 

Set Definitions

Opposites Absolute Value

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Operations
Linear Equations

Linear Equations

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**Step 1: a.** Use the Distributive Property to separate terms, if necessary.

b. If fractions are present, consider multiplying both sides
by the LCD to eliminate the fractions. If decimals are
present consider multiplying both sides by a power of 10
to clear the

equation of decimals.

**c.** Combine similar terms on each side of an equation.

**Step 2:** Use the Addition Property of Equality to get all variable terms

on one side of the equation and all constant terms on the

side.

other

side.

**Step 3:** Use the Multiplication Property of Equality to get the variable by

itself on one side of the equation.

**Step 4:** Check your solution in the original equation to be sure that you

have not made a mistake in the solution process.



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Multiplying Poly

Binomial Factoring

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Factor By Groupin

ac-grouping method
Rational Expressions

## Classroom Examples: Solve the following equations for *x*.

$$6 - 2(5x - 1) + 4x = 20$$

2 
$$3(5x+1) = 10 + 15x$$
 Special Case 1

3 
$$-4 + 8x = 2(4x - 2)$$
 Special Case 2

Set Definitions

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## Linear Inequalities in One Variable

 An equation states that two algebraic expressions are equal, while an inequality is a statement that indicates two algebraic expressions are not equal in a particular way. Properties of Rea Numbers

Exponential Notation

The Order of Operations

Linear Equations

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Multiplying Poly

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ac-grouping method

## Linear Inequalities in One Variable

- An equation states that two algebraic expressions are equal, while an inequality is a statement that indicates two algebraic expressions are not equal in a particular way.
- Inequalities are stated using one the following symbols:
  - 1 less than <,</p>
  - ② less than or equal to ≤,
  - 3 greater than >,
  - 4 or greater than or equal to  $\geq$ .

Properties of Rea Numbers

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The Order of Operations

Linear Equations

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ac-grouping method Rational Expressions

## Linear Inequalities in One Variable

#### Definition

Replacing the equal sign in the general linear equation  $a \cdot x + b = c$  by any of the symbols  $<, \le, >$  or  $\ge$  gives a **linear inequality in one variable**.

**For example**,  $2 \cdot x - 1 \le 0$  and 3x + 5 > 8 are two different linear inequalities in a single variable, x.

Number Types

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Linear Inequalities

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ac-grouping method

## Solving Linear Inequalities

#### Definition

The solution to any linear inequality is a <u>SET</u> of real numbers.

#### Linear Inequalities

Combining Like

Binomial

ac-grouping method

## **Solving Linear Inequalities**

#### Definition

The solution to any linear inequality is a SET of real numbers.

**For example,**  $\{x \mid x < -2\}$  is shorthand notation for the set of real numbers less than -2.

$$\begin{cases} x \mid x < -2 \end{cases}$$

x such that x is any real number less than -2

#### Tim Busken

**Review Topics** 

#### Linear Inequalities

Combining Like

ac-grouping method

## Addition Property for Inequalities

For any three algebraic expressions A, B and C,

If 
$$A < B$$

then 
$$A + C < B + C$$

In words: Adding the same quantity to both sides of an inequality will not change the solution set.

We can use the Addn. Prop. to write **equivalent inequalities**.

Set Definitions

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**Example 1** Solve the inequality, 5x + 4 < 4x + 2, then graph the solution.

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ac-grouping method
Rational Expressions

# **Example 1** Solve the inequality, 5x + 4 < 4x + 2, then graph the solution.

**Solution:** Try to get the variable terms on the left-hand side of the inequality, and the constant terms on the right-hand side.

Set Definitions

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## **Example 1** Solve the inequality, 5x + 4 < 4x + 2, then graph the solution.

**Solution:** Try to get the variable terms on the left-hand side of the inequality, and the constant terms on the right-hand side.

$$5x + 4 < 4x + 2$$
  
 $5x + 4 + (-4) < 4x + 2 + (-4)$ 

Addition Prop. of Inequalities

$$5x + \left(4 + \left(-4\right)\right) < 4x + \left(2 + \left(-4\right)\right)$$

Associative Prop. of Addition

$$5x + 0 < 4x + (-2)$$

Additive Inverse & Closure Props.

$$5x < 4x - 2$$

Additive Identity & the Defn. of Subtraction

Set Definitions

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ac-grouping method

## **Example 1** Solve the inequality, 5x + 4 < 4x + 2, then graph the solution.

#### Solution:

$$5x < 4x - 2$$

$$5x + (-4x) < 4x - 2 + (-4x)$$

$$5x + (-4x) < 4x + (-4x) - 2$$

$$\left(5x+\left(-4x\right)\right)<\left(4x+\left(-4x\right)\right)-2$$

$$(5-4) \cdot x < 0-2$$

$$1 \cdot x < -2$$

$$x < -2$$

Addition Prop. of Inequalities

Commutative Prop. of Addn.

Associative Prop. of Addn.

Distributive & Additive
Inverse Props.
Closure & Additive
Identity Props.

Multiplicative Identity Prop.

Set Definitions

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**Example 1** Solve the inequality, 5x + 4 < 4x + 2, then graph the solution.

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ac-grouping method
Rational Expressions

## **Example 1** Solve the inequality, 5x + 4 < 4x + 2, then graph the solution.

**Conclusion:** The solution set of the given inequality is  $\{x \mid x < -2\}$ . This is called writing the solution using **set notation** (or set-builder notation).

Set Definitions

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ac-grouping method

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**Graph:** We can shade the number line to the left of -2 to give a graphical description of the solution set.



Set Definitions

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**Conclusion:** The solution set of the given inequality is  $\{x \mid x < -2\}$ . This is called writing the solution using **set notation** (or set-builder notation).

**Graph:** We can shade the number line to the left of -2 to give a graphical description of the solution set.



We use a left-opening parenthesis at -2 to indicate that -2 is not part of the solution set.

Set Definitions

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Rational Expressions

## **Example 1** Solve the inequality, 5x + 4 < 4x + 2, then graph the solution.

An alternate and more compact way of writing the solution set is

$$\left(-\infty,-2\right)$$

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Factor By Grouping

**Example 1** Solve the inequality, 5x + 4 < 4x + 2, then graph the solution.

An alternate and more compact way of writing the solution set is

$$\left(-\infty,-2\right)$$

This gives us 3 equivalent representations of the solution set to the original inequality:

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An alternate and more compact way of writing the solution set is

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This gives us 3 equivalent representations of the solution set to the original inequality:

Set Notation

$$\{x\mid x<-2\}$$

Set Definitions

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An alternate and more compact way of writing the solution set is

$$\left(-\infty,-2\right)$$

This gives us 3 equivalent representations of the solution set to the original inequality:

Set Notation

$$\{x\mid x<-2\}$$

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ac-grouping method

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An alternate and more compact way of writing the solution set is

$$\left(-\infty,-2\right)$$

This gives us 3 equivalent representations of the solution set to the original inequality:

Set Notation

 $\{x\mid x<-2\}$ 





Interval Notation

$$(-\infty, -2)$$

Set Definitions Number Types

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ac-grouping method

### Properties of Inequalities

### **Multiplication Property of Inequalities**

For any three algebraic expressions A, B and C, where  $C \neq 0$ ,

If 
$$A < B$$
,

then 
$$A \cdot C < B \cdot C$$

$$A \cdot C > B \cdot C$$

if 
$$C$$
 is positive ( $C > 0$ )

if 
$$C$$
 is negative  $(C < 0)$ 

Set Definitions

Opposites

Absolute Value

Properties of Rea

Distributive Prop

The Order of Operations Linear Equations

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Factor By Grouping ac-grouping method

## Properties of Inequalities

### Multiplication Property of Inequalities

For any three algebraic expressions A, B and C, where  $C \neq 0$ ,

If A < B,

then  $A \cdot C < B \cdot C$ 

if C is positive (C > 0)

or  $A \cdot C > B \cdot C$ 

if C is negative (C < 0)

<u>In words</u>: Multiplying both sides of an inequality by a positive quantity always produces an equivalent inequality. Multiplying both sides of an inequality by a negative number produces an equivalent inequality BUT it reverses the direction of the inequality symbol.

Set Definitions

Number Type

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#### Linear Inequalities

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Factor By Groupin

ac-grouping method

## **Example 2** Determine what set is the solution to -2x - 3 < 3

Linear Inequalities

Combining Like

Binomial

ac-grouping method

## Example 2

## Determine what set is the solution to

$$-2x - 3 \le 3$$

#### Solution:

$$-2x-3\leq 3$$

$$-2x-3+3 < 3+3$$

$$-2x \leq 6$$

$$\left(-\frac{1}{2}\right)\cdot\left(-2x\right) \geq \left(-\frac{1}{2}\right)\cdot 6$$

$$x \ge -3$$

Addition Prop. of Inequalities

Additive Inverse & Identity Props

Multiplication Prop. of Inequalities

Closure

#### Linear Inequalities

Combining Like

ac-grouping method

## Example 2

## Determine what set is the solution to

$$-2x - 3 \le 3$$

#### Solution:

$$-2x - 3 \le 3$$
$$-2x - 3 + 3 < 3 + 3$$

$$-2x \leq 6$$

$$\left(-\frac{1}{2}\right)\cdot\left(-2x\right) \geq \left(-\frac{1}{2}\right)\cdot 6$$

$$x \ge -3$$

Addition Prop. of Inequalities

Additive Inverse & Identity Props

Multiplication Prop. of Inequalities

Closure

#### Set Notation

$$\{x\mid x\geq -3\}$$

Set Definitions

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## **Example 2**

Determine what set is the solution to

$$-2x - 3 \le 3$$

#### Solution:

$$-2x-3\leq 3$$

$$-2x-3+3 < 3+3$$

$$-2x \leq 6$$

Addition Prop. of Inequalities

Additive Inverse & Identity Props

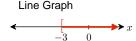
$$\left(-\frac{1}{2}\right)\cdot\left(-2x\right) \ge \left(-\frac{1}{2}\right)\cdot 6$$

Multiplication Prop. of Inequalities

$$x \ge -3$$

Closure

Set Notation  $\{x \mid x \ge -3\}$ 





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## Example 2 Deter

Determine what set is the solution to

 $-2x - 3 \le 3$ 

#### Solution:

$$-2x-3\leq 3$$

$$-2x-3+3<3+3$$

$$-2x \leq 6$$

Addition Prop. of Inequalities

Additive Inverse & Identity Props

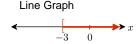
$$\left(-\frac{1}{2}\right)\cdot\left(-2x\right) \geq \left(-\frac{1}{2}\right)\cdot 6$$

Multiplication Prop. of Inequalities

$$x \ge -3$$

Closure

Set Notation  $\{x \mid x \geq -3\}$ 



Interval Notation  $[-3, \infty)$ 

Set Definitions Number Types

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ac-grouping method Rational Expression

### Interval Notation and Graphing

## Inequality Notation x < -2

Interval Notation  $(-\infty, -2)$ 

Graph Using Parenthesis/Brackets



Graph using open and closed circles



Linear Inequalities

Combining Like

Binomial

ac-grouping method

### Interval Notation and Graphing



x < -2

x < -2

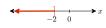
Interval Notation  $(-\infty, -2)$  **Graph Using** Parenthesis/Brackets



Graph using open and closed circles









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### Interval Notation and Graphing

Inequality
Notation x < -2

Notation  $(-\infty, -2)$ 

Interval

Graph Using Parenthesis/Brackets

 $\begin{array}{cccc} & & & & & \\ & & & & \\ & -2 & & 0 & & \end{array}$ 

Graph using open and closed circles





$$(-\infty, -2]$$

$$\begin{array}{c|c} & & & \\ \hline & -2 & 0 \end{array}$$

$$x \ge -3$$

$$[-3,\infty)$$



## Interval Notation and Graphing

#### **Review Topics**

Properties of Real

#### Linear Inequalities

Combining Like

Binomial

ac-grouping method

Inequality Notation  $(-\infty, -2)$ x < -2

Interval Notation

Graph Using Parenthesis/Brackets

Graph using open and closed circles



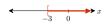
x < -2

$$(-\infty, -2]$$



$$\begin{array}{c|c} & & & & \\ & & & \\ \hline & -2 & 0 & \end{array}$$

x > -3 $[-3, \infty)$ 



$$\leftarrow \longrightarrow x$$

$$x > -3 \qquad \qquad \left(-3, \infty\right)$$





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Factor By Grouping ac-grouping method

Linear Inequalities in One Variable

Classroom Example: Solve the following inequality.

 $3(2x+5) \leq -3x$ 

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#### Linear Inequalities

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## Linear Inequalities in One Variable

**Classroom Examples:** Take the next five minutes to work these 6 problems. Graph the solution set to the given inequality, then write the solution set using interval notation.

- x ≤ −6
- x > 5
- $x \ge -1$
- x > 10

**Classroom Examples:** Solve each inequality. Graph the solution set, then write the solution set using interval notation.

- 2x 1 < -6
- -3x < 2x 6

Set Definitions

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ac-grouping method Rational Expressions

## Linear Inequalities in One Variable

#### Definition

A compound inequality is two or more simple inequalities {sets} joined by the terms 'and' or 'or' .

For Example, the set  $\left\{ x \mid 3x - 6 \le -3 \text{ or } 3x - 6 \ge 3 \right\}$  is a compound inequality.

The inequality statement -7 < x < 7 is to be read "x is in between -7 and 7."

#### **Review Topics**

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The inequality statement -7 < x < 7 is to be read "x is in between -7 and 7." The statement -7 < x < 7 is called a composite inequality because it is composed of the intersection of the sets described by -7 < x AND x < 7.

**Review Topics** 

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## Linear Inequalities in One Variable

**Classroom Examples:** Solve the following compound inequalities. Graph the solution set on a number line, then write the solution set using interval notation.

- $-7 \le 2x + 1 \le 7$
- 3x 6 < -3 or 3x 6 > 3

Properties of Real

#### Linear Inequalities

Combining Like

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### Interval Notation and Graphing

#### Inequality Notation -4 < x < 3

Interval Notation (-4, 3)

**Graph Using** Parenthesis/Brackets



Graph using open and closed circles



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### Interval Notation and Graphing

Inequality Notation

Notation -4 < x < 3

-4 < x < 3

4 < x < 3 (-4,3)

Interval Notation

[-4, 3]

Graph Using Parenthesis/Brackets



Graph using open and closed circles







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## Interval Notation and Graphing

## Inequality Notation -4 < x < 3

Interval Notation (-4, 3) Graph Using Parenthesis/Brackets



Graph using open and closed circles



$$-4 \le x \le 3$$

$$[-4, 3]$$

$$\leftarrow$$
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 $3$ 

$$-4 < x \le 3$$
  $(-4,3]$ 





### Interval Notation and Graphing

#### **Review Topics**

Properties of Real

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Inequality

Notation -4 < x < 3 Interval

Notation (-4, 3)

**Graph Using** Parenthesis/Brackets

Graph using open and closed circles

-4 < x < 3

$$[-4, 3]$$



-4 < x < 3(-4, 3]



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$$-4 \le x < 3 \qquad \qquad [-4,3)$$

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# **Ordered Pairs**

We now turn our attention to equations containing two variables, x and y. Paired data plays an important role in these type of equations.

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# Ordered Pairs

# Definition

A pair of numbers enclosed in parenthesis and separated by a comma, such as (-2, 1), is called an ordered pair of numbers. The first number in the pair is called the x-coordinate of the ordered pair; the second number is called the y-coordinate. For the ordered pair (-2,1), the x-coordinate is -2 and the v-coordinate is 1.

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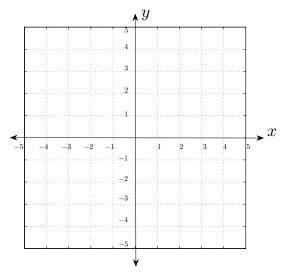
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We use a rectangular coordinate system to visualize ordered pairs.



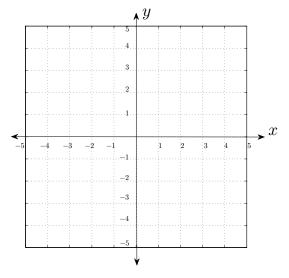
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A rectangular coordinate system is made by drawing two real number lines at right angles to each other.



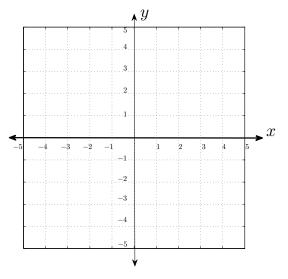
### **Review Topics**

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A rectangular coordinate system is made by drawing two real number lines at right angles to each other.



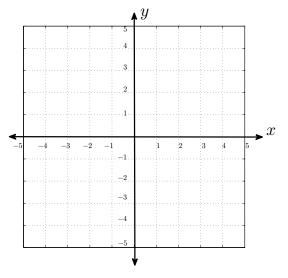
### **Review Topics**

Coordinate System

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A rectangular coordinate system is made by drawing two real number lines at right angles to each other.



Two number lines, called axes, cross each other at zero.

## **Review Topics**

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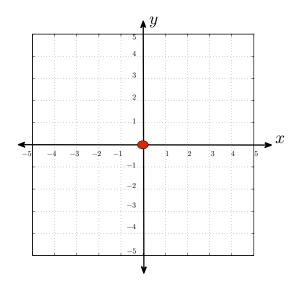
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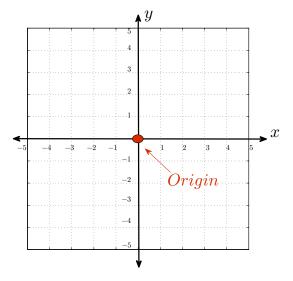
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Two number lines, called axes, cross each other at zero. This point is called the origin.



Relative to the origin, positive directions are to the right and up.

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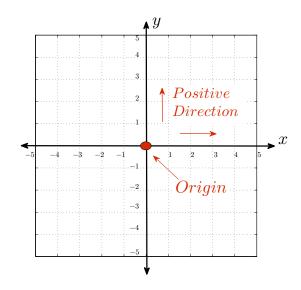
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Negative directions are to the left and down.

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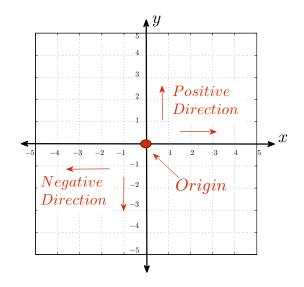
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# The horizontal number line is called the x-axis

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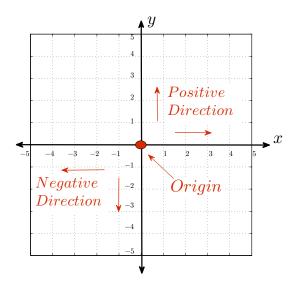
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# The horizontal number line is called the x-axis

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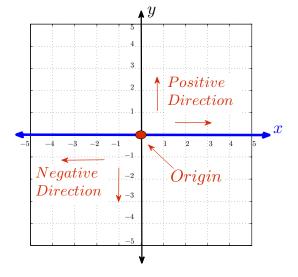
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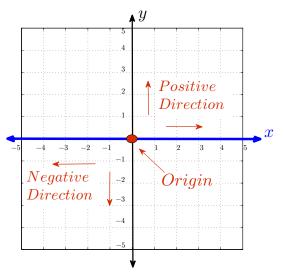
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The horizontal number line is called the x-axis and the vertical number line is called the y-axis.



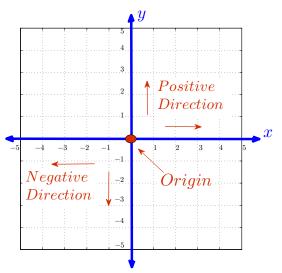
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The horizontal number line is called the x-axis and the vertical number line is called the y-axis.



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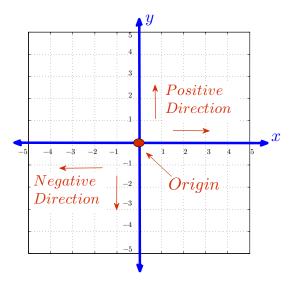
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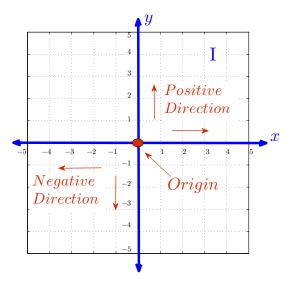
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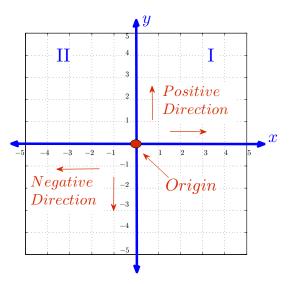
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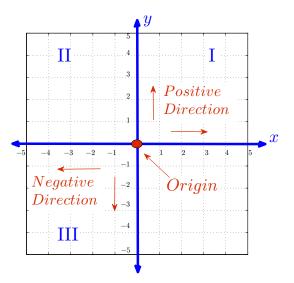
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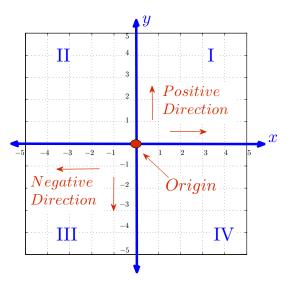
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# **Graphing Ordered Pairs**

# Algorithm

To graph the ordered pair (a, b) on the rectangular coordinate system, we:

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# **Graphing Ordered Pairs**

# **Algorithm**

To graph the ordered pair (a, b) on the rectangular coordinate system, we:

1 begin at the origin and move along the x-axis a units right or a units left (right if a is positive and left if a is negative).

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# **Graphing Ordered Pairs**

# Algorithm

To graph the ordered pair (a, b) on the rectangular coordinate system, we:

- 1 begin at the origin and move along the x-axis a units right or a units left (right if a is positive and left if a is negative).
- 2 From that point we move *b* units up or down (up if *b* is positive and down if *b* is negative).
- 3 The point where we end up is the graph of the ordered pair.

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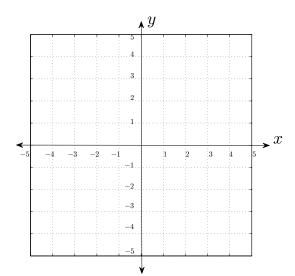
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# Example 1: Plot (graph) the following ordered pairs:

$$(2,3),\; (-2,3),\; (-2,-3),\; (2,-3),\;$$



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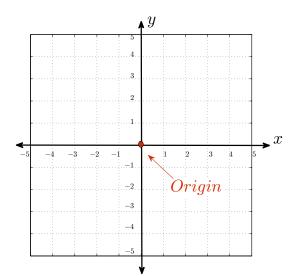
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ac-grouping method

# Example 1: Plot (graph) the following ordered pairs:

$$(2,3), (-2,3), (-2,-3), (2,-3),$$

To plot (2,3), begin at the origin.



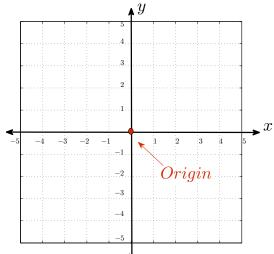
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# Example 1: Plot (graph) the following ordered pairs:

(2,3), (-2,3), (-2,-3), (2,-3), To plot (2,3), begin at the origin. Travel along the *x*-axis 2 units right



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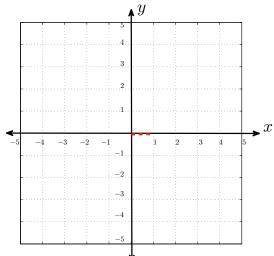
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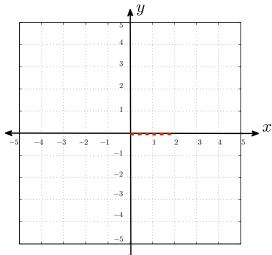
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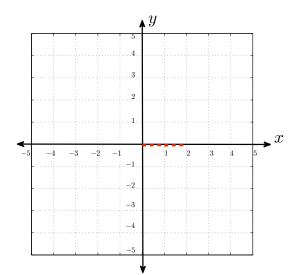
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Example 1: Plot (graph) the following ordered pairs:



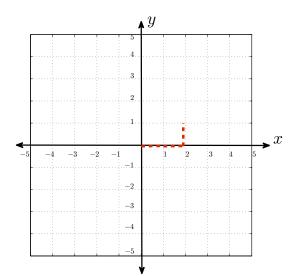
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# Example 1: Plot (graph) the following ordered pairs:

(2,3), (-2,3), (2,-3), From that point, move in the upwards (positive y) direction 3 units.



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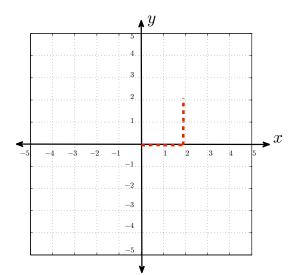
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# Example 1: Plot (graph) the following ordered pairs:



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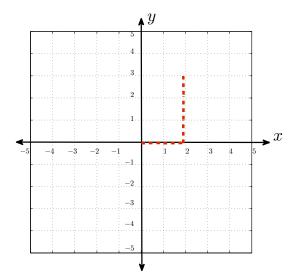
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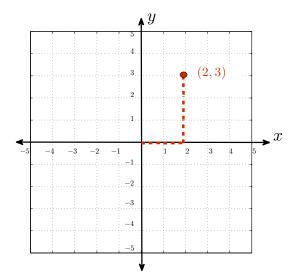
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# Example 1: Plot (graph) the following ordered pairs:



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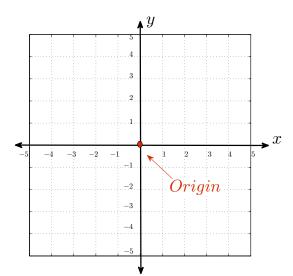
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Example 1: Plot (graph) the following ordered pairs:

$$(2,3), (-2,3), (-2,-3), (2,-3),$$

To plot (-2,3), begin at the origin.



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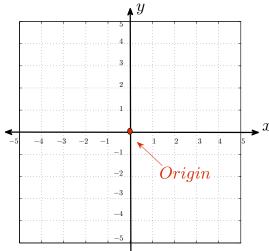
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ac-grouping method

# Example 1: Plot (graph) the following ordered pairs:

$$(2,3), (-2,3), (-2,-3), (2,-3),$$

To plot (-2,3), begin at the origin. Travel along the x-axis 2 units left (in the negative direction).



## Coordinate System

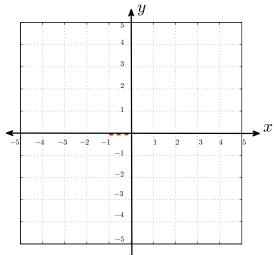
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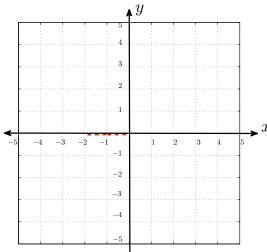
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$$(2,3), (-2,3), (-2,-3), (2,-3),$$

To plot (-2,3), begin at the origin. Travel along the x-axis 2 units left (in the negative direction).



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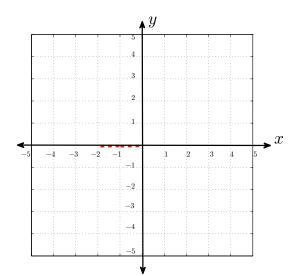
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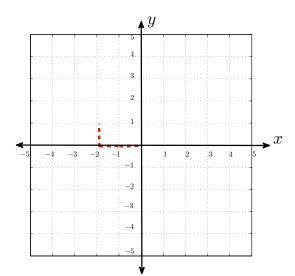
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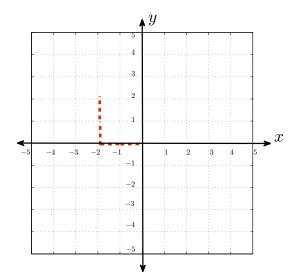
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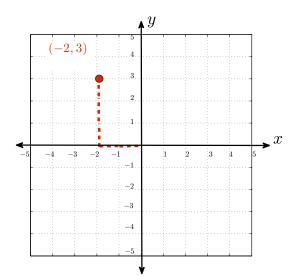
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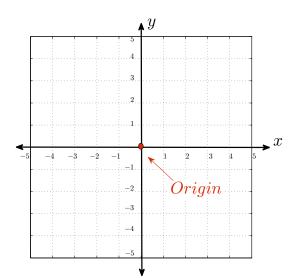
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# Example 1: Plot (graph) the following ordered pairs:

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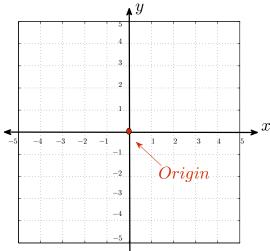
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### Example 1: Plot (graph) the following ordered pairs:

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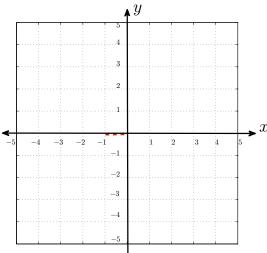
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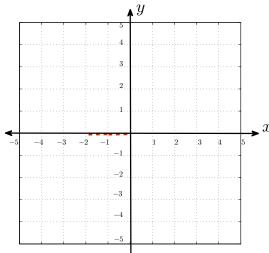
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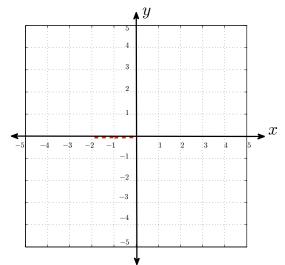
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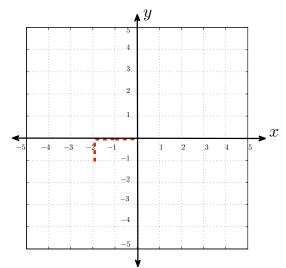
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Example 1: Plot (graph) the following ordered pairs:

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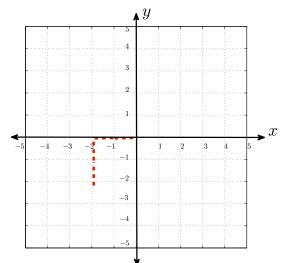
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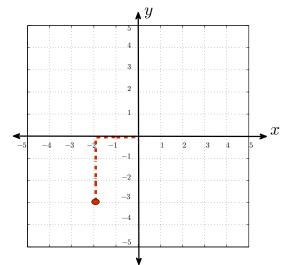
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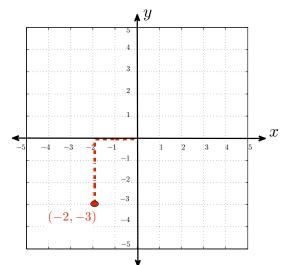
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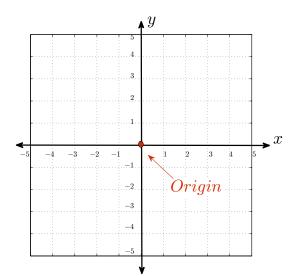
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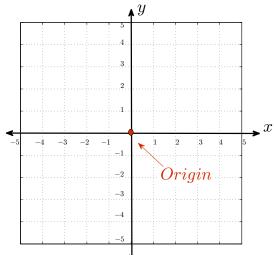
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### Example 1: Plot (graph) the following ordered pairs:

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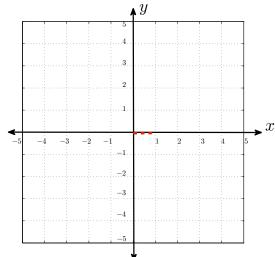
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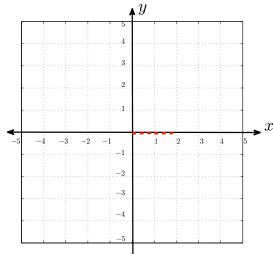
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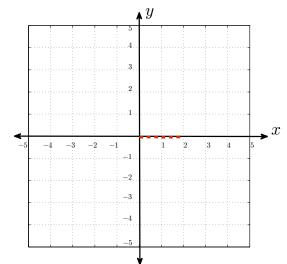
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# Example 1: Plot (graph) the following ordered pairs:

(2,3), (-2,3), (-2,-3), (2,-3), From that point, move in the downwards (negative y) direction 3 units.



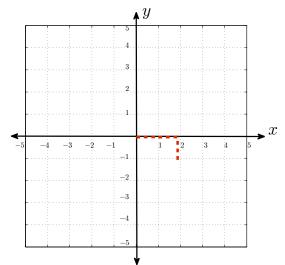
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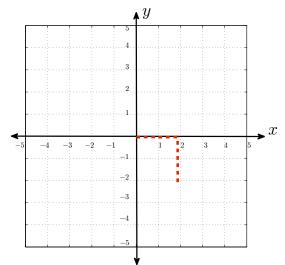
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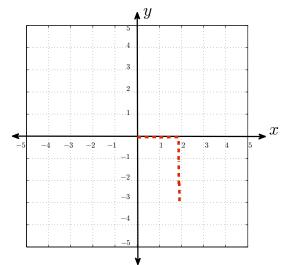
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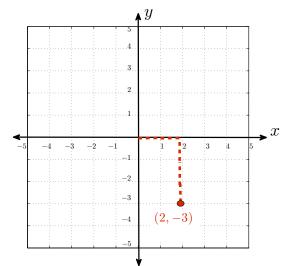
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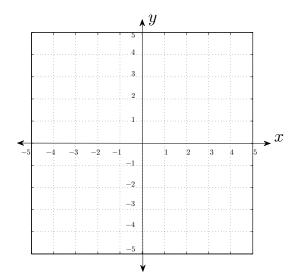
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# Example 2: Plot (graph) the following ordered pairs:

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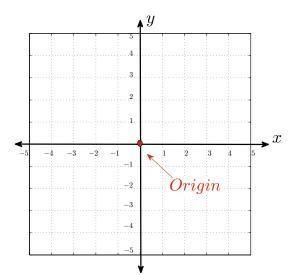
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# Example 2: Plot (graph) the following ordered pairs:

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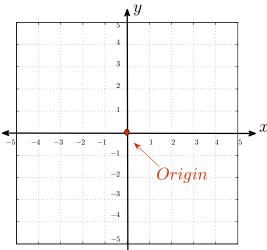
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### Example 2: Plot (graph) the following ordered pairs:

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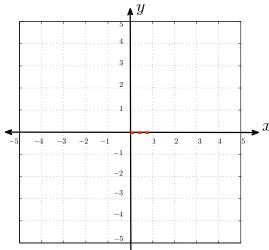
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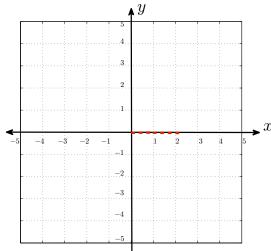
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## Example 2: Plot (graph) the following ordered pairs:

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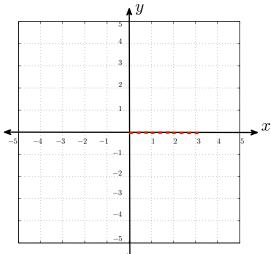
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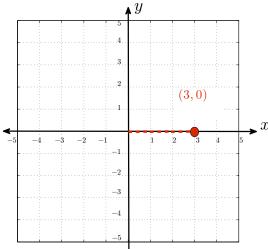
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### Example 2: Plot (graph) the following ordered pairs:

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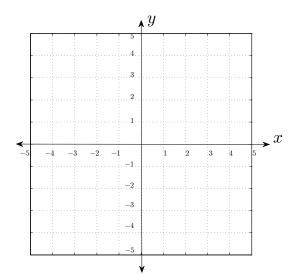
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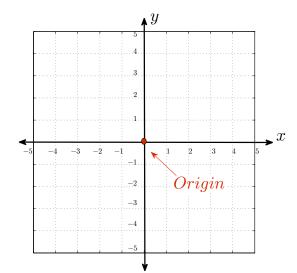
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### Example 2: Plot (graph) the following ordered pairs:

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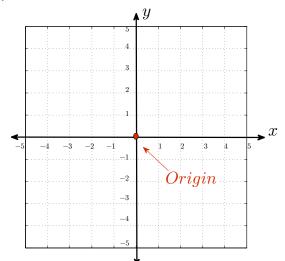


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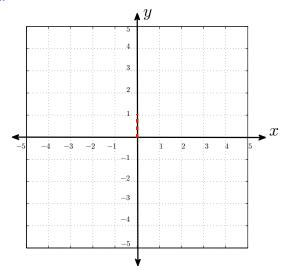


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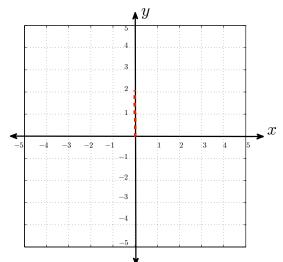


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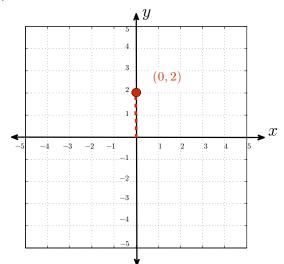


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# Example 2: Plot (graph) the following ordered pairs:



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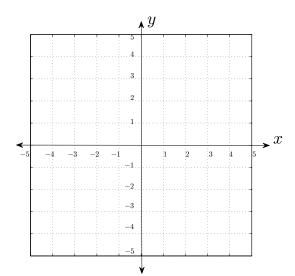
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# Example 2: Plot (graph) the following ordered pairs:

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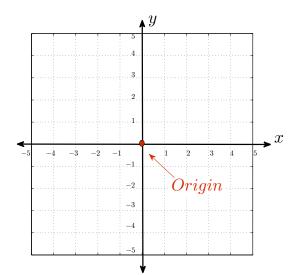
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## Example 2: Plot (graph) the following ordered pairs:

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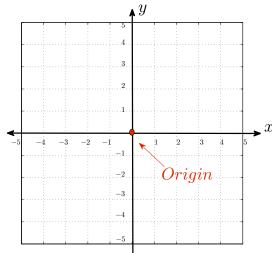
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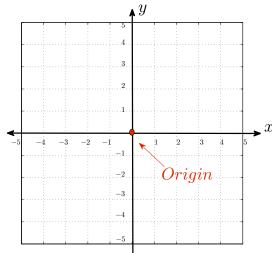
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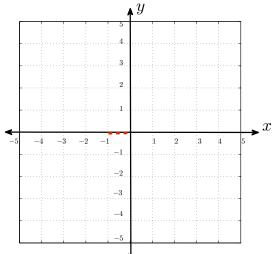
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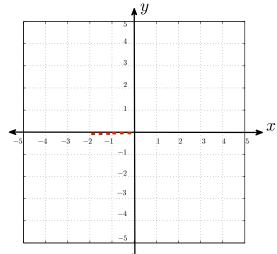
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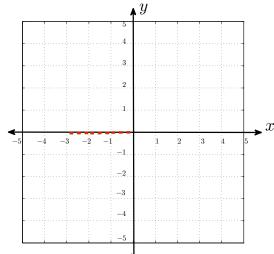
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Rational Expressions

## Example 2: Plot (graph) the following ordered pairs:

$$(3,0), (0,2), (-3,0), (0,-2),$$



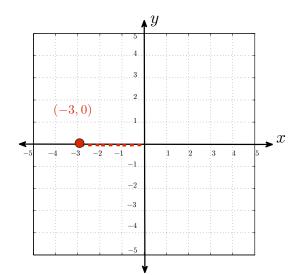
Coordinate System

Combining Like

ac-grouping method

Example 2: Plot (graph) the following ordered pairs:

From that point (the origin), move up 0 spaces in the y direction.



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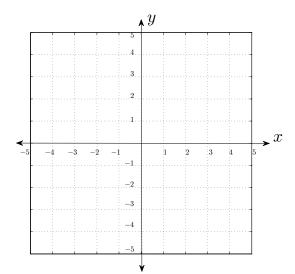
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$$(3,0), (0,2), (-3,0), (0,-2),$$



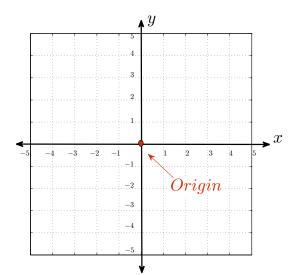
### Coordinate System

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Example 2: Plot (graph) the following ordered pairs:

(3,0), (0,2), (-3,0), (0,-2), To plot (0,-2), begin at the origin. Travel along the *x*-axis 0 units.



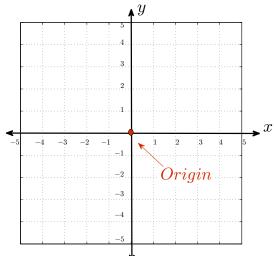
Coordinate System

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ac-grouping method

## Example 2: Plot (graph) the following ordered pairs:

(3,0), (0,2), (-3,0), (0,-2), From that point (the origin), move up 2 spaces in the negative ydirection (downwards).



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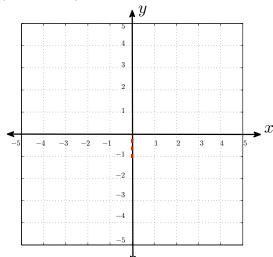
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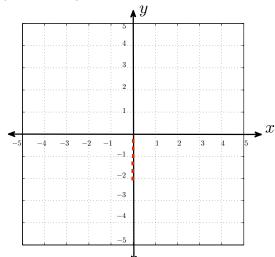
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From that point (the origin), move up 2 spaces in the negative y direction (downwards).



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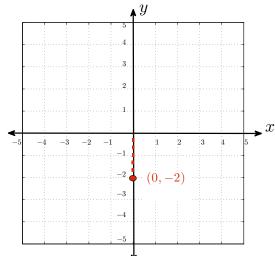
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From that point (the origin), move up 2 spaces in the negative y direction (downwards).



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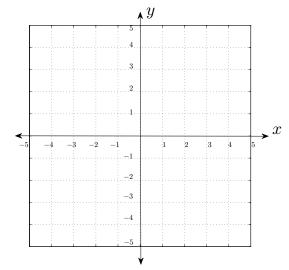
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Factor By Group

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Plot (graph) (3,4), (-4,3), (-1,-4) and (5,-4)

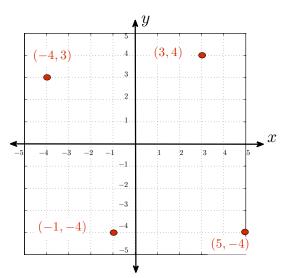


Review Topics
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Absolute Value

## Concept Check

Plot (graph) (3,4), (-4,3), (-1,-4) and (5,-4)

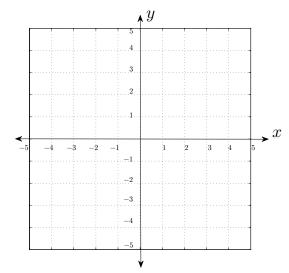


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## Concept Check

Plot (graph) (4,0), (0,-3), (-1,0), and (0,5)



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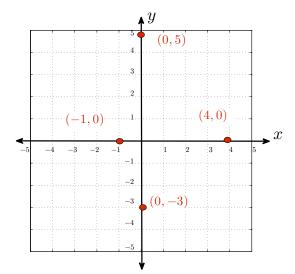
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## Concept Check

Plot (graph) (4,0), (0,-3), (-1,0), and (0,5)



**Review Topics** 

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## Definition

Suppose A, B and C represent any real numbers. A linear equation in two variables is an equation having the form

$$A x + B y = C,$$

For example, 2x + 3y = 1 is a linear equation in the two variables x and y.

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Rational Expressions

# Solutions of a linear equation in two variables

Any linear equation in two variables always has in infinite number of solutions, and solutions come in the form of ordered pairs.

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# Solutions of a linear equation in two variables

Any linear equation in two variables always has in infinite number of solutions, and solutions come in the form of ordered pairs.

Terminology	Definition	Illustration
<b>Solution</b> of an equation in <i>x</i> and <i>y</i>	An ordered pair $(a, b)$ that yields a true statement if $x = a$ and $y = b$	(1,4) is a solution of $y = 5 x - 1$ , since substituting x=1 and $y = 4$ renders the LHS = 4 and the RHS = $5(1) - 1 = 4$

LHS is an abbreviation for "left-hand side" (of the equation)

RHS is an abbreviation for "right-hand side" (of the equation)

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GCF Factor By Groupin

ac-grouping method Rational Expressions

## **Equations and Graphs**

## Definition

For each ordered-pair solution, (a, b), of an equation in x and y there is a point (a, b) in a rectangular coordinate plane. The set of all such points is called a **graph of the equation**.

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GCF Factor By Grouping **Equations and Graphs** 

## Definition

For each ordered-pair solution, (a, b), of an equation in x and y there is a point (a, b) in a rectangular coordinate plane. The set of all such points is called a **graph of the equation**.

We can graph a linear equation by finding 3 ordered-pair solutions of the equation, plot the corresponding points on the rectangular grid, then draw a line between the three points.

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## **Equations and Graphs**

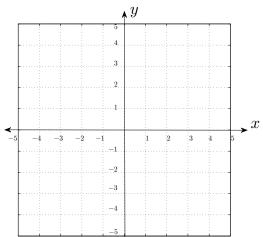
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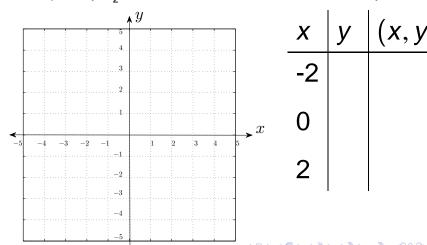
We use the third point for "insurance." If all three points line up in a straight we have not made a mistake!

# Example 3: Graph the linear equation $y = -\frac{1}{2}x - 3$

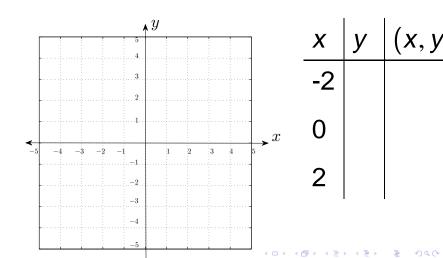




equation  $y = -\frac{1}{2}x - 3$ We begin by a making a table that summarizes x and y values. Since every value of x we substitute into the equation will be multiplied by  $-\frac{1}{2}$ , we use numbers for x that are divisible by 2.



equation  $y = -\frac{1}{2}x - 3$ That way, when we multiply by  $-\frac{1}{2}$ , the result will be an integer.



We let x = -2 in the equation to find the y-value of the ordered pa which is associated with x-coordinate -2.

X	y	(x, y)
-2		
0		
2		

We let x = -2 in the equation to find the y-value of the ordered pa which is associated with x-coordinate -2.

1		i	i
$y=-\frac{1}{2}\cdot(x)-3$	X	У	(x, y)
$=-\frac{1}{2}\cdot \textcolor{red}{(-2)}-3$	-2		
= 1 - 3	0		
= -2	2		

Upon simplification, we get the ordered pair solution (-2,-2)

$$y = -\frac{1}{2} \cdot (x) - 3$$

$$= -\frac{1}{2} \cdot (-2) - 3$$

$$= 1 - 3$$

$$= -2$$

$$2$$

$$x \quad y \quad (x, y)$$

$$-2 \quad -2 \quad (-2, -2)$$

$$0 \quad -2$$

Next, we let x = 0 in the equation to find the  $y^2$ -value of the ordered pair which is associated with x-coordinate 0.

1		•	
$y=-\frac{1}{2}\cdot (x)-3$	X	У	(x, y)
$=-\frac{1}{2}\cdot \textcolor{red}{(0)}-3$			(-2,-
= 0 - 3	0		
= -3	2		

This gives us the ordered pair solution  $y = -\frac{1}{2}x - 3$ 

$$y = -\frac{1}{2} \cdot (x) - 3$$

$$= -\frac{1}{2} \cdot (0) - 3$$

$$= 0 - 3$$

$$= -3$$

$$X$$

$$y$$

$$(x, y)$$

$$-2$$

$$-2$$

$$(-2, -3)$$

$$0$$

$$-3$$

$$(0, -3)$$

Afterwards, we let x = 2 in the equation.  $y = -\frac{1}{2}x - 3$ 

$$y = -\frac{1}{2} \cdot (x) - 3$$

$$= -\frac{1}{2} \cdot (2) - 3$$

$$= -1 - 3$$

$$= -4$$

$$X$$

$$y$$

$$(x, y)$$

$$-2$$

$$-2$$

$$(-2, -1)$$

$$0$$

$$-3$$

$$(0, -3)$$

Upon simplification, we get the ordered pair solution (2,-4)

$$y = -\frac{1}{2} \cdot (x) - 3$$

$$= -\frac{1}{2} \cdot (2) - 3$$

$$= -1 - 3$$

$$= -4$$

$$2 - 4$$

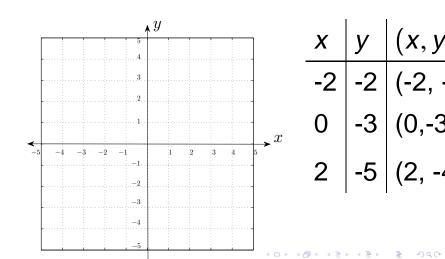
$$x y (x, y)$$

$$-2 - 2 (-2, -1)$$

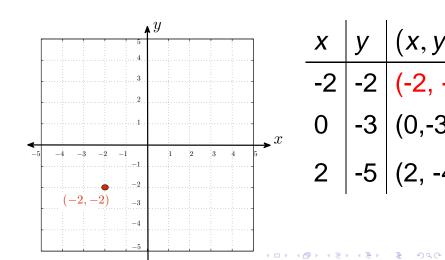
$$0 - 3 (0, -3)$$

$$2 - 4 (2, -4)$$

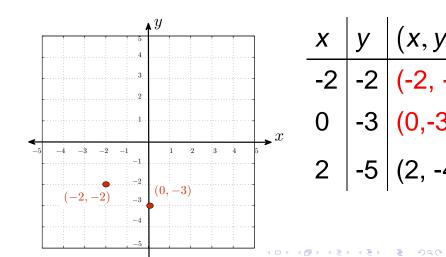
equation  $y = -\frac{1}{2}x - 3$  We now locate the three ordered pair solutions (points) on the rectangular coordinate grid, then draw a line through the solutions.



equation  $y = -\frac{1}{2}x - 3$ We now locate the three ordered pair solutions (points) on the rectangular coordinate grid, then draw a line through the solutions.

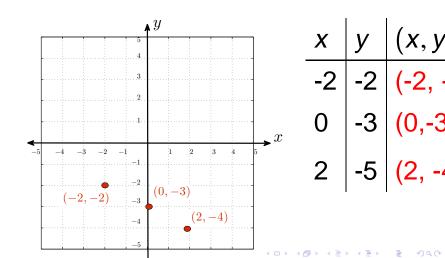


equation  $y = -\frac{1}{2}x - 3$  We now locate the three ordered pair solutions (points) on the rectangular coordinate grid, then draw a line through the solutions.



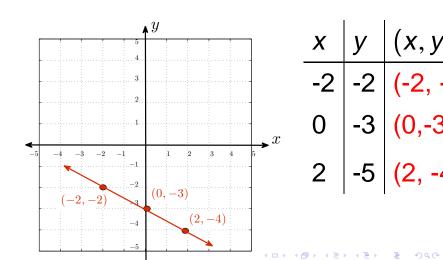
# Example 3: Graph the linear

equation  $y = -\frac{1}{2}x - 3$ We now locate the three ordered pair solutions (points) on the rectangular coordinate grid, then draw a line through the solutions.

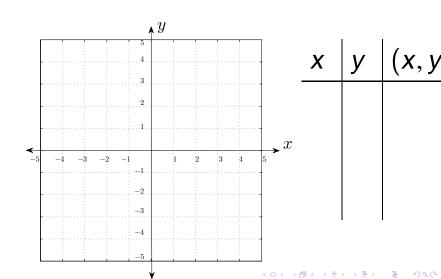


# Example 3: Graph the linear

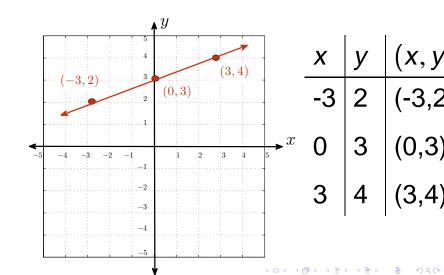
equation  $y = -\frac{1}{2}x - 3$ We now locate the three ordered pair solutions (points) on the rectangular coordinate grid, then draw a line through the solutions.



Concept Check: Graph 
$$y = \frac{1}{3}x + 3$$



Concept Check: Graph 
$$y = \frac{1}{3}x + 3$$



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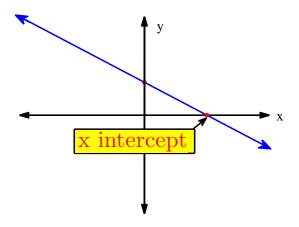
Factoring Polynomial

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#### Definition

The graph of an equation has an  $\underline{x\text{-intercept}}$  whenever the graph of the equation crosses the x axis. The x intercept always occurs when the value of y is equal to zero.



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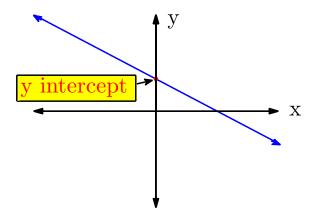
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The graph of an equation has an  $\underline{y}$ -intercept whenever the graph of the equation crosses the y axis. The y intercept always occurs when the value of x is equal to zero.



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ac-grouping method Rational Expression **Example 4** Find the x- and y-intercepts for 5x - 7y = -35, then graph the solution set.

#### **Review Topics**

#### Coordinate System

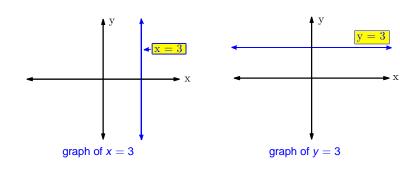
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### **Theorem**

Suppose a and b are real numbers. Graphs of linear equations of the form x = a are vertical lines and graphs of linear equations of the form y = b are horizontal lines.



Set Definitions

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# **More Classroom Examples**

Graph each of the following lines:

• 
$$y=\frac{1}{2}x$$

• 
$$x = -2$$

• 
$$y = -4$$

Absolute Value

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## **Definition**

The slope of a line is a measure of the steepness of the line.

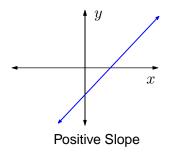
#### Lines

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# A line that rises from left to right has positive slope.



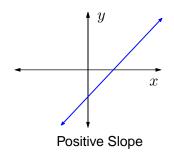
#### Lines

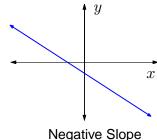
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A line that falls from left to right has negative slope.





Properties of Real

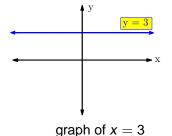
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# Horizontal lines have zero slope



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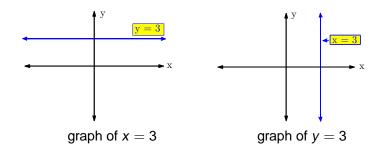
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# Horizontal lines have zero slope, and vertical lines have no slope.

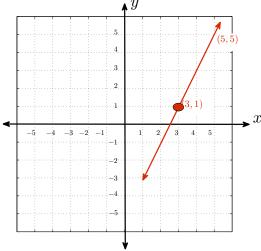


**Review Topics** 

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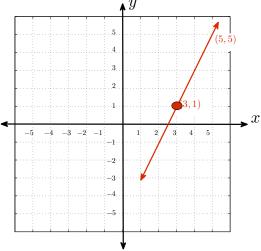


**Review Topics** 

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**Review Topics** 

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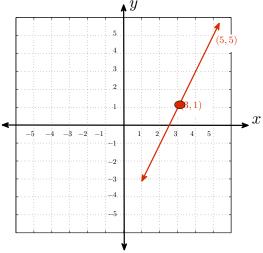
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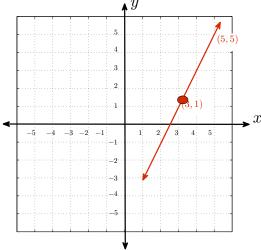


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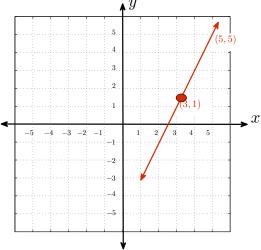


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**Review Topics** 

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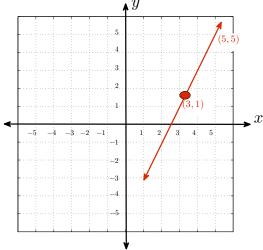
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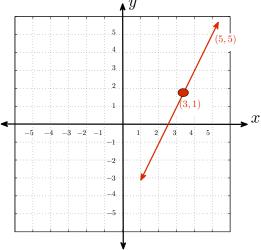


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**Review Topics** 

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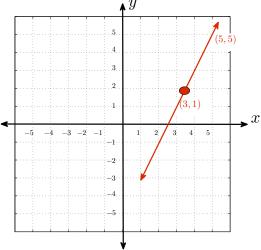
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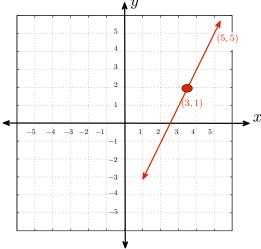


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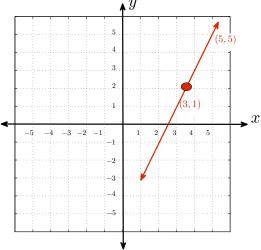


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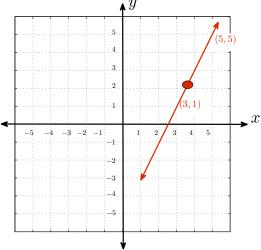


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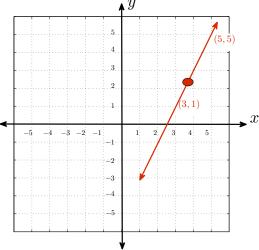


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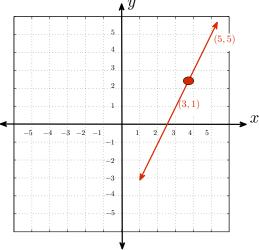


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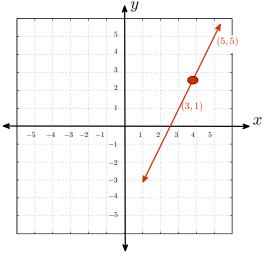


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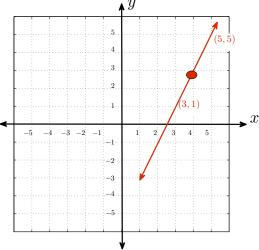


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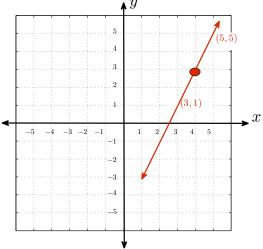


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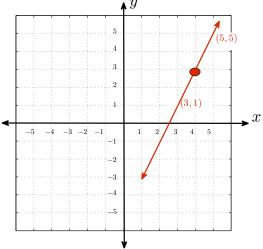


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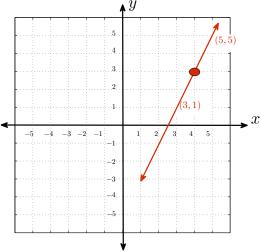


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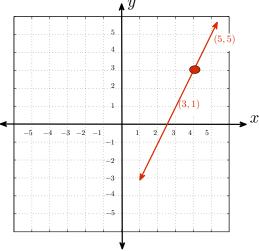


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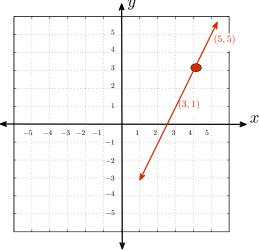


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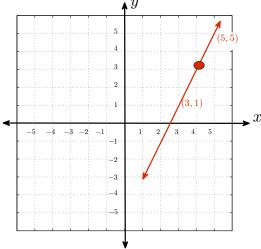


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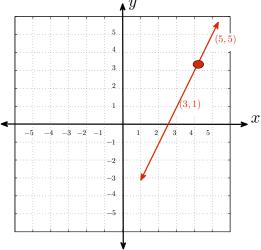
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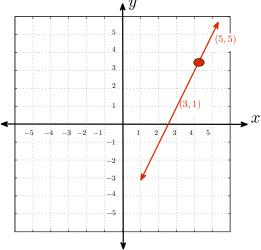


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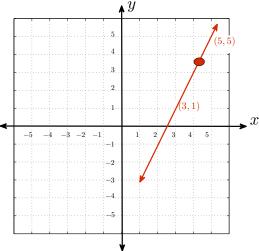


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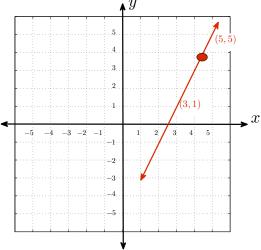
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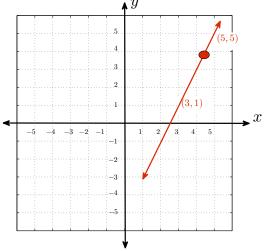


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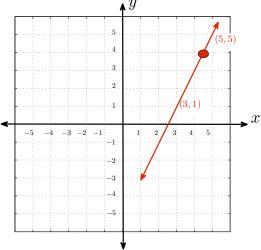


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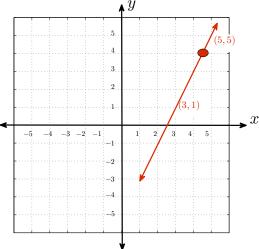
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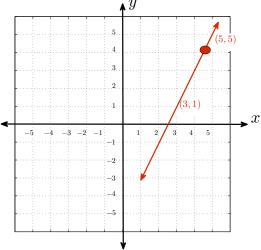
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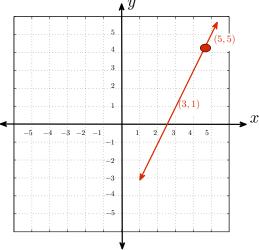


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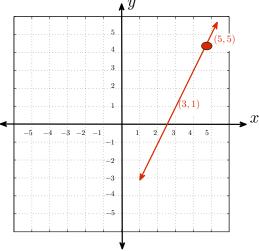


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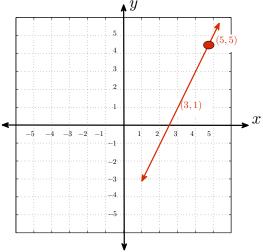


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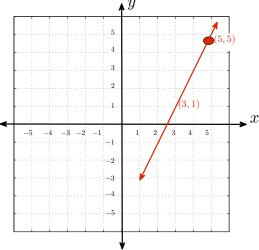


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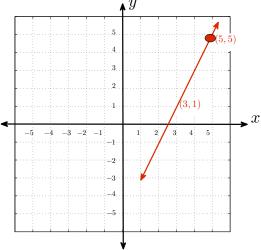


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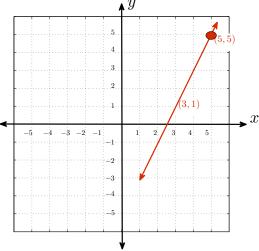


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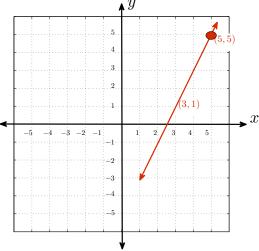


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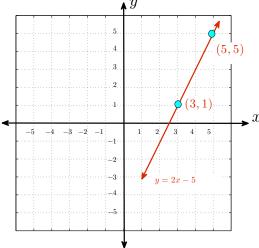


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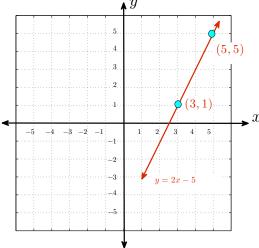


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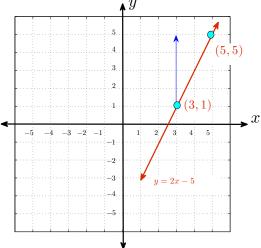


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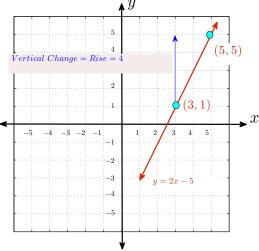


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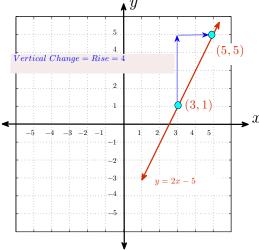


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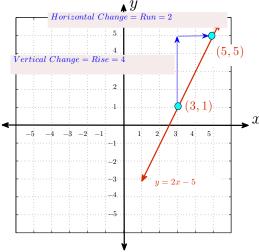


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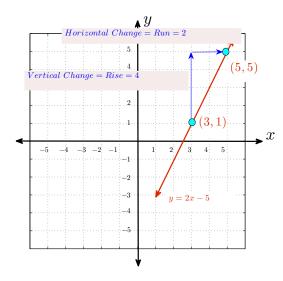
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$$slope = \frac{Rise}{Run} = \frac{4}{2} = 2$$



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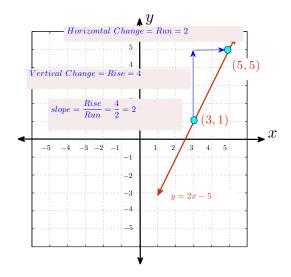
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Notice that the vertical change is measured by subtracting the y-coordinates of the two points, 5-1=4.



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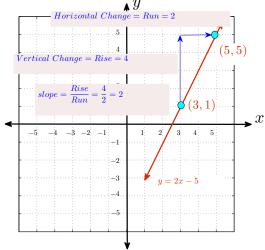
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Notice that the vertical change is measured by subtracting the y-coordinates of the two points, 5 - 1 = 4. The horizontal change is the difference between the x-coordinates, 5 - 3 = 2.



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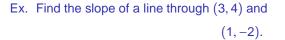
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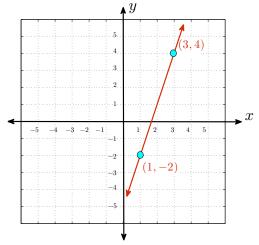
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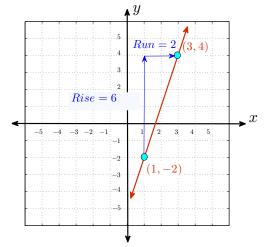
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# Ex. Find the slope of a line through (3,4) and

slope = 
$$\frac{Rise}{Run} = \frac{6}{2} = 3$$
 (1, -2).



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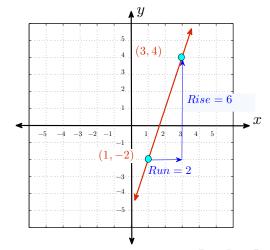
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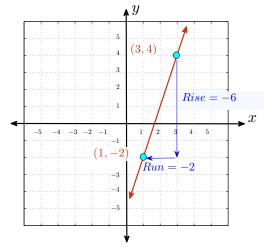
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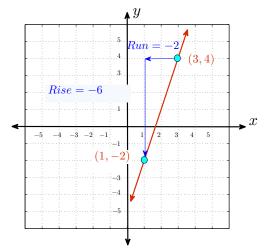
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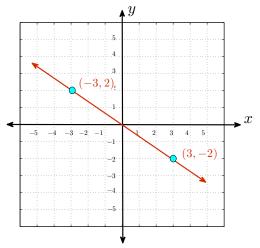
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# Ex. Find the slope of a line through (-3, 2) and (3, -2).



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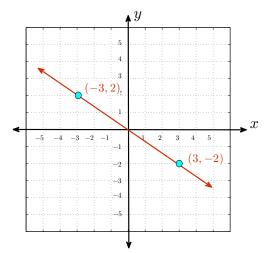
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# Ex. Find the slope of a line through (-3, 2) and

We expect a negative slope for the solution because the graph of the line <u>falls</u> from left to right.



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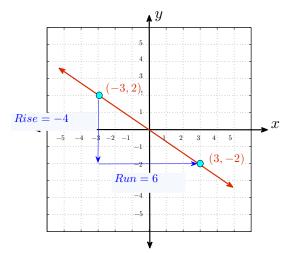
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Ex. Find the slope of a line through (-3, 2) and

slope = 
$$\frac{Rise}{Run} = \frac{-4}{6} = \frac{2 \cdot (-2)}{2 \cdot 3} = \frac{\cancel{2} \cdot (-\cancel{2})}{\cancel{2} \cdot 3} = -\frac{2}{3}$$



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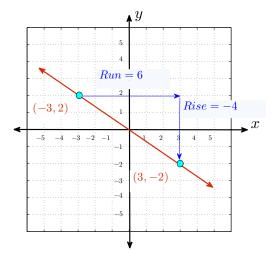
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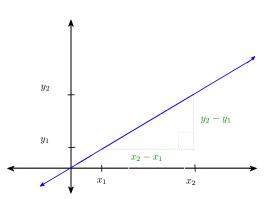
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Rational Expressions

## Definition

Let  $(x_1, y_1)$  and  $(x_2, y_2)$  be any two points on the rectangular coordinate plane. The **SLOPE** of a line which passes through the points  $(x_1, y_1)$  and  $(x_2, y_2)$  is m, where m is given by the formula:

$$m=\frac{(y_2-y_1)}{(x_2-x_1)}$$



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Classroom Examples: Take some time out to work these 2 problems.

Use the slope formula,  $m = \frac{(y_2 - y_1)}{(x_2 - x_1)}$ , to find the slope of a line containing the given points.

- (7, -4) and (4, 2)
- (2,-3) and (-1,-3)

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The Equation of a Line

Suppose, now, that line l has slope m and y-intercept b, then what is the equation for l? Because the y-intercept is b, we know that point (0, b) is on the line.

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# The Equation of a Line

Suppose, now, that line I has slope m and y-intercept b, then what is the equation for I? Because the y-intercept is b, we know that point (0,b) is on the line. If (x,y) is any other point on I, then using the definition for slope, we have

$$\frac{y-b}{x-0}=m$$

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## The Equation of a Line

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$$\frac{y-b}{x-0}=m$$

Multiplying both sides of this equation by x, then adding b to both sides gives

$$y = mx + b$$

#### Tim Busken

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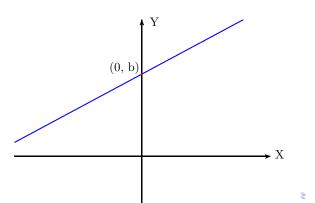
ac-grouping method

# Definition (The Equation of a Line: The Slope-Intercept Form )

Suppose *m* and *b* are real numbers (constants). Then another form for the equation of a line is

$$y = mx + b$$

where *m* represents the slope of the line and *b* represents the *y*-intercept.



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Classroom Examples: Take some time out to

work these 2 problems.

- Determine the slope and y-intercept for the line 4x - 5v = 7.
- Graph the line -3x + 2y = -6 using the slope-intercept form (y = mx + b).

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Suppose m and b represent particular, but arbitrarily chosen real numbers (fixed constants). A **linear function**, f(x), has the form

$$f(x) = m \cdot x + b$$

where m represents the slope of the line and b represents the y intercept.

Example: Suppose f(x) = 2x - 1

What is the slope of *f* and what is it's *y* intercept.

Explain the geometric interpretation of f(3).

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## Theorem (Point-Slope Equation of a line)

The line with slope m that passes through the point  $(x_1, y_1)$  is given by the equation:

$$y-y_1=m(x-x_1)$$

We call this the **Point-Slope Equation of a line**.

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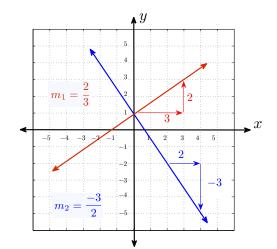
## Classroom Examples

- Find the equation of the line with slope 3 that contains the point (-1,2). Use the Point-Slope Form,  $y-y_1=m(x-x_1)$ .
- 8. Find the equation of the line through (2,5) and (6,-3).
- Find the equation of the line that goes through the point (3,2), and is perpendicular to the graph of 3y - y = 2.

## **Theorem**

If line  $L_1$  has slope  $m_1$  and line  $L_2$  has slope  $m_2$ , then

 $L_1$  is perpendicular to  $L_2$  if and only if  $m_1 \cdot m_2 = -1$  (or  $m_1 = -\frac{1}{m_2}$ 



#### **Review Topics**

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## Classroom Example

9. Find the equation of the line that goes through the point (3,2), and is perpendicular to the graph of 3y - y = 2.

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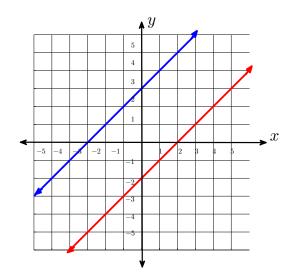
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## Theorem

Two lines have the same slope if and only if they are parallel.



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## Classroom Example

10. Find the equation of the line that goes through the point (3,2), and is parallel to the graph of 3y - y = 2.

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#### Perpendicular & Parallel Lines

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## Definition (The Equation of a Line: Standard Form)

Suppose *A*, *B* and *C* represent any real numbers. A **linear equation in two variables** is an equation having the *form* 

$$A x + B y = C,$$

For example, 2x + 3y = 1 is a linear equation in the two variables x and y which is written in standard form.

Determine whether or not the following equations are **linear equation in two variables**. If not, why?

$$y = 2x - 1$$

$$2y - x = 4$$

$$(3) 2x^2 + y = 1$$

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 In mathematics, a theorem is a statement that has been proven on the basis of previously established statements, such as other theorems, and previously accepted statements, such as axioms.

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- $+, -, \times, \div$  are called the **arithmetic operators**.

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- $+, -, \times, \div$  are called the **arithmetic operators**.
- When a letter represents any number from a set of numbers, it is called a variable.
- A **constant** is either a fixed number, such as 5, or a letter or symbol that represents a fixed number.

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#### **Review Topics**

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ac-grouping method

 An algebraic expression is any combination of variables, constants, grouping symbols, exponents and arithmetic operators.

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ac-grouping method

 An algebraic expression is any combination of variables, constants, grouping symbols, exponents and arithmetic operators. The terms contained in the given expression are t, 29, 5a<sup>2</sup>b, and2x/y.

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#### Algebraic Expressions

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ac-grouping method

- An algebraic expression is any combination of variables, constants, grouping symbols, exponents and arithmetic operators. The terms contained in the given expression are t, 29, 5a<sup>2</sup>b, and2x/y.
- To evaluate an algebraic expression, substitute a numerical value for each variable into the expression and simplify the result by applying the order of operations in a left to right fashion.

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## Definition

A **term** is either a single number or variable, or the product or quotient of several numbers or variables separated from another term by a plus or minus sign in an overall expression.

## Review Topics

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overall expression.

For example, the following algebraic expression

$$100 + 3x + 5yz^2w^3 - \frac{2}{3}x$$

has terms  $100, 3x, 5yz^2w^3$ , and  $\frac{2}{3}x$ .

## **Review Topics**

Polynomials

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## Definition

A term is either a single number or variable, or the product or quotient of several numbers or variables separated from another term by a plus or minus sign in an overall expression.

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The numerical factor of a term is a coefficient.

numbers or variables separated from another term by a plus or minus sign in an overall expression.

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For example, the aforementioned terms have coefficients 100, 3, 5, and  $\frac{2}{5}$ .

## Polynomials

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### Definition

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For example, the following algebraic expression

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#### Definition

The numerical factor of a term is a coefficient.

For example, the aforementioned terms have coefficients 100, 3, 5, and  $\frac{2}{5}$ .

### Definition

A constant is a single number, such as 8 or 9.

## Review Topics

Polynomials

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### en Definition

A monomial expression has the form

 $ax^n$ ,

where a is a constant that is any real number, x is a variable, and n is a whole number (0, 1, 2, ...).

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#### Definition

## A monomial expression has the form

ax<sup>n</sup>,

where a is a constant that is any real number, x is a variable, and n is a whole number (0, 1, 2, ...).

For instance,

3, 5x,  $7x^4$ , and  $9x^{200}$ 

are all examples of monomial functions.

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## Definition

We call *n* the **degree** of the monomial.

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#### Tim Busken

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We call *n* the **degree** of the monomial.

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### Polynomials

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The degree of a nonzero constant is zero. Because  $0 = 0x = 0x^2 = 0x^3 = \dots$ , we cannot assign a degree to the 0. Therefore, we say 0 has no degree.

Monomial	Coefficient	Degree
3	3	0
$-5x^{2}$	-5	2
x <sup>7</sup>	1	7
0	0	no degree

We call *n* the **degree** of the monomial.

**Review Topics** 

Polynomials Combining Like

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Monomial	Coefficient	Degree	
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and -3 is not a whole number.

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Monomial	Coefficient	Degree	
3	3	0	
$-5x^{2}$	-5	2	
$x^7$	1	7	
0	0	no degree	

- $\mathbb{D}$   $p(x) = 4x^{-3}$  is not a monomial because the exponent of the variable, x, is -3 and -3 is not a whole number.
- $p(x) = 2x^{1/3}$  is not a monomial because the exponent of the variable is 1/3, and 1/3 is not a whole number.

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#### ac-grouping method Rational Expressions

A polynomial of degree *n* is an expression of the form:

$$a_n x^n + a_{n-1} x^{n-1} + \cdots + a_3 x^3 + a_2 x^2 + a_1 x + a_0$$

where *n* is a non-negative integer and  $a_n \neq 0$ .

- The numbers  $a_n, a_{n-1}, \ldots, a_3, a_2, a_1, a_0$  are the <u>COEFFICIENTS</u> of the polynomial.
- $\square$   $a_0$  is called the <u>CONSTANT TERM</u>.
- $\square$   $a_n x^n$  is called the <u>LEADING TERM</u> of the polynomial.
- $\square$  a<sub>n</sub> is called the <u>LEADING COEFFICIENT</u> of the polynomial.
- n is called the <u>DEGREE</u> of the polynomial.

#### Tim Busken

#### **Review Topics**

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#### Definition

A **polynomial** is a monomial or a sum of monomials.

11 monomial

 $3x^4$  monomial

 $2x^2 + 1$  binomial

 $5x^3 + x - 1$  trinomial

 $x^{1/2} + 5$  is not a polynomial

 $\sqrt[5]{x+5}$  is not a polynomial

 $\frac{1}{x-1}$  is not a polynomial

#### Tim Busken

#### **Review Topics**

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### Definition

The **degree of polynomial expression** is the degree of the leading term (the term which has *x* raised to the largest power).

Polynomial	Degree	Leading	Leading	Constant
Function		Term	Coefficient	term
$-2x^4 - 3x - 5$	4	$-2x^{4}$	-2	-5
$x^5 - 3x^6 - 10x - 4$	6	$-3x^{6}$	-3	-4
$5x^{10} - 8x^3 - 10x + 5$	10	5 x <sup>10</sup>	5	5
17 <i>x</i> + 4	1	17 <i>x</i>	17	4
24	0	24	24	24

Polynomial addition and subtraction is as one would expect.

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#### Poly Add/Subtract Combining Like

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GCF Factor By Groupin ac-grouping metho Example Compute the difference  $(x^2 - 5x) - (3x^2 - 4x - 1)$ 

$$(x^2-5x)-(3x^2-4x-1)=$$

$$= (x^2 - 5x) - 1(3x^2 - 4x - 1)$$

$$=(x^2-5x)+(-1)(3x^2-4x-1)$$

$$=(x^2-5x)-3x^2+4x+1$$

$$= x^2 - 5x - 3x^2 + 4x + 1$$

$$=(x^2-3x^2)+(-5x+4x)+1$$

$$=$$
  $-2x^2 - x + 1$ 

since 
$$-a = (-1) \cdot a$$

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

Combining Like

Terms

## Definition (Like Terms)

Like terms are terms that contain the same variable(s) raised to the same power(s). Like terms can be combined or collected together.

Example Identify the like terms in  $4x^3 + 5x - 7x^2 + 2x^3 + x^2$ 

## Solution:

like terms:  $4x^3$  and  $2x^3$ 

same variable and exponent same variable and exponent

like terms:  $-7x^2$  and  $x^2$ 

Example Identify the like terms in  $8x^2y^2 + 4x - 6x^5 + 2x^2y^2$ 

Solution:

like terms:  $8x^2y^2$  and  $2x^2y^2$ 

same variables and exponents

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#### Multiplying Poly's

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# Multiplying Polynomials

Combining Like

#### Multiplying Poly's

The product of two binomials results in four terms before the like terms are combined. The acronym "Foil" stands for FIRST, OUTER, INNER, LAST, and should remind you how to compute the product of two binomials. Consider the following product:

$$(a+b)(c+d) = a(c+d) + b(c+d) = \underbrace{ac}_{F} + \underbrace{ad}_{O} + \underbrace{bc}_{O} + \underbrace{bd}_{O}$$

The product of the two binomials consists of four terms:

- the product of the FIRST term of each (ac),
- the product of the OUTER term of each (ad).
- the product of the INNER term of each (bc), and
- the product of the *LAST* term of each (bd).

## 2 Examples:

a.) 
$$(x+4) \cdot (2x-3)$$

b.) 
$$(3\sqrt{6}-2\sqrt{5})^2$$

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### Binomial

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## Solution

$$(x^{2} - 3x + 4) \cdot (2x - 3) =$$

$$= (2x - 3) \cdot (x^{2} - 3x + 4)$$
 comm prop ×
$$= 2x \cdot (x^{2} - 3x + 4) + (-3) \cdot (x^{2} - 3x + 4)$$
 distr. prop ×
$$= 2x^{3} - 6x^{2} + 8x - 3x^{2} + 9x - 12$$
 distr. prop ×
$$= 2x^{3} + (-6x^{2} - 3x^{2}) + (8x + 9x) - 12$$
 comm., assoc. +
$$= 2x^{3} - 9x^{2} + 17x - 12$$
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# #1 RULE: FACTOR OUT THE GCF

Factoring reverses multiplication. Consider the polynomial expression  $6x^2 - 3x$ , whose two terms have a greatest common factor, 3x.

$$6x^{2} - 3x = (3x) \cdot (2x) - (3x) \cdot (1)$$

$$= 3x \cdot (2x - 1) \qquad \text{since } a \cdot b - a \cdot c = a \cdot (b - c)$$

We can rewrite  $6x^2 - 3x$  as a difference of two products. Afterwards, we can rewrite an equivalent expression using the distributive property. We call this process **factoring out the gcf**.

## Definition (The #1 Rule of Factoring)

The first step to factoring any algebraic expression is to factor out the gcf (if there is one).

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GCF Factor By Grou ac-grouping me

### Definition

The **greatest common factor (GCF)** for a polynomial is the largest monomial that divides (is a factor of) each term of the polynomial.

**Example:** The greatest common factor for  $25x^5 + 20x^4 - 30x^3$  is  $5x^3$  since it is the largest monomial that is a factor of each term.

$$25x^5 + 20x^4 - 30x^3 = 5x^3 \cdot (5x^2) + 5x^3 \cdot (4x) - 5x^3 \cdot (6)$$
$$= 5x^3 \cdot (5x^2 + 4x - 6)$$

How to find the GCF of a polynomial

find the GCF of the coefficients of each variable factor.

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## How to find the GCF of a polynomial

- 1 Find the GCF of the coefficients of each variable factor.
- For each variable factor common to all the terms, determine the smallest exponent that the variable factor is raised to.

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ac-grouping method Rational Expressions

## How to find the GCF of a polynomial

- 1 Find the GCF of the coefficients of each variable factor.
- 2 For each variable factor common to all the terms, determine the smallest exponent that the variable factor is raised to.
- 3 Compute the product of the common factors found in Steps 1 and 2. This expression is the GCF of the polynomial.

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### ac-grouping method Rational Expressions

## How to find the GCF of a polynomial

- 1 Find the GCF of the coefficients of each variable factor.
- 2 For each variable factor common to all the terms, determine the smallest exponent that the variable factor is raised to.
- 3 Compute the product of the common factors found in Steps 1 and 2. This expression is the GCF of the polynomial.

## Factor the greatest common factor from each of the following.

- $8x^3 8x^2 48x$
- $15a^7 25a^5 + 30a^3$
- $12x^4y^5 9x^3y^4 15x^5y^3$
- $4(a+b)^4 + 6(a+b)^3 + 16(a+b)^2$
- x(x+7) + 2(x+7)

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## Factoring Trinomials with a Leading Coefficient of 1

Earlier in the chapter, we multiplied binomials.

$$(x+2)\cdot(x+8)=x^2+10x+16$$

$$(x+6)(x+3) = x^2 + 9x + 18$$

In each case, the product of the two binomials is a trinomial.

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## Factoring Trinomials with a Leading Coefficient of 1

### In general,

$$(x+a)\cdot(x+b)=x^2+ax+bx+a\cdot b$$

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=  $x^2 + (a + b)x + a \cdot b$ 

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In general,

$$(x+a)\cdot(x+b) = x^2 + ax + bx + a\cdot b$$
$$= x^2 + (a+b)x + a\cdot b$$

We can view this generalization as a factoring problem

$$x^2 + (a+b)x + a \cdot b = (x+a) \cdot (x+b)$$

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## Factoring Trinomials with a Leading Coefficient of 1

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We can view this generalization as a factoring problem

$$x^2 + (a+b)x + a \cdot b = (x+a) \cdot (x+b)$$

To factor a trinomial with a leading coefficient of 1, we simply find the two numbers *a* and *b* whose sum is the coefficient of the middle term, and whose product is the constant term.

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## Factoring Trinomials with a Leading Coefficient of 1

### Factor.

• 
$$x^2 + 5x + 4$$

• 
$$x^2 + 7x + 6$$

• 
$$x^2 + 9x + 14$$

• 
$$x^2 + 11x + 24$$

• 
$$x^2 + 19x + 34$$

• 
$$x^2 + 12x + 27$$

$$x^2 + 12x + 27$$

• 
$$x^2 + 20x + 64$$

• 
$$x^2 + 18x + 65$$

• 
$$x^2 - x + 5$$

• 
$$x^2 + 5xy + 4y^2$$

• 
$$x^2 + 5xy + 6y^2$$

• 
$$x^2 + 12xy + 27y^2$$

• 
$$m^2 + 19mn + 60n^2$$

• 
$$x^2 + 2x - 15$$

• 
$$x^2 - 7x - 18$$

• 
$$x^2 + x - 20$$

• 
$$x^2 + 10x - 24$$

Polynomials with four terms can sometimes be factored by grouping.

Example Factor  $x^4 - 2x^3 - 8x + 16$ 

Solution:

$$x^{4} - 2x^{3} - 8x + 16 = (x^{4} - 2x^{3}) + (-8x + 16) \quad (assoc. prop +)$$

$$= \left[x \cdot (x^{3}) + (-2) \cdot (x^{3})\right] + \left[(-8) \cdot x + (-8) \cdot (-2)\right]$$

$$= x^{3}(x - 2) - 8(x - 2) \quad (distr. prop.)$$

$$= x^{3}(x - 2) - 8(x - 2) \quad (identify common factor)$$

$$= \left[(x - 2)(x^{3} - 8)\right] \quad (distr. prop)$$

\*\*Technically we are not done. This is not the prime factorization of the given polynomial since  $x^3 - 8$  can be factored with the difference of cubes formula.

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Problem: Factor $ax^2 + bx + c$	Problem: Factor $10x^2 - 11x - 6$
(1) Multiply a times c.	(1) $a = 10$ , $b = -11$ , $c = -6$ , so clearly $a \cdot c = -60$
(2) List all possible pairs of numbers whose product is ac	$ \begin{array}{ccccc} -60 & -60 \\ & \swarrow & \swarrow & \\ -6 \cdot 10 & -1 \cdot 60 \\ 6 \cdot (-10) & 1 \cdot (-60) \\ 3 \cdot (-20) & -5 \cdot 12 \\ -3 \cdot 20 & 5 \cdot (-12) \\ \hline -15 \cdot 4 & 15 \cdot (-4) \end{array} $

(3) Box the pair whose sum is  $b \nearrow (3)$  b = -11, and -15 + 4 = -11

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ac-grouping method Rational Expression Problem: Factor  $ax^2 + bx + c$ 

(4) Replace *b* with the sum of the circled pair. Distribute *x* into this quantity

(4)  $10x^2 - 11x - 6$ =  $10x^2 + (-15x + 4x) - 6$ =  $10x^2 - 15x + 4x - 6$ 

Problem: Factor  $10x^2 - 11x - 6$ 

(5) Now factor by grouping: Use parenthesis to group the first two terms, and another () to group the second two terms.

(5) 
$$(10x^2 - 15x) + (4x - 6)$$
  
=  $5x(2x - 3) + 2(2x - 3)$   
=  $5x(2x - 3) + 2(2x - 3)$   
=  $(2x - 3) \cdot (5x + 2)$ 

## Recall: The Number Types

#### **Review Topics**

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Definition

The set of whole numbers,

$$\mathbb{W} = \{0,1,2,3,4,\dots\}$$

is the set of natural numbers unioned with zero, written  $\mathbb{W} = \mathbb{N} \cup \{0\}$ .

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### Definition

The set of integers,

$$\mathbb{Z} = \{\dots, -4, -3, -2, -1, 0, 1, 2, 3, 4, \dots\}$$

is also known as all the positive and negative whole numbers.

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## Recall: The Number Types

### Definition

A <u>rational number</u> is any number that can be expressed as the ratio of two integers. The <u>set of rational numbers</u> is written symbolically as

$$\mathbb{Q} = \left\{ \begin{array}{c} \frac{a}{b} \mid \text{a and b are any integers, and } b \neq 0 \end{array} \right\}$$

Note that any integer "a" is a rational number since  $a = \frac{a}{1}$ .

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## Rational expressions

A rational expression is defined similarly as any expression that can be written as the ratio of two polynomials.

**Definition (Rational Expressions)** 

rational expressions 
$$= \left\{ \left. \frac{p}{q} \, \right| \, \text{p and q are polynomials, } \, q \neq 0 \right\}$$

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**Definition (Rational Expressions)** 

rational expressions 
$$= \left\{ \left. \frac{p}{q} \; \right| \; \text{p and q are polynomials, } \; q \neq 0 \right\}$$

Some examples of rational expressions are

$$\frac{1}{x}$$
,  $\frac{2m-3}{6n-7}$ ,  $\frac{x^2-3x-1}{x^2-3x-5}$ ,  $\frac{x-y}{y-x}$ 

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### Rational Expressions

## Rational expressions

## **Basic Properties**

Multiplying (or dividing) the numerator and denominator by the same nonzero expression may change the form of the rational expression, but it will always produce an expression equivalent to the original one.

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Rational Expressions

## Rational expressions

## **Basic Properties**

Multiplying (or dividing) the numerator and denominator by the same nonzero expression may change the form of the rational expression, but it will always produce an expression equivalent to the original one.

We use this property to reduce fractions to lowest terms. For example,

$$\frac{6}{8} = \frac{3 \cdot \cancel{2}}{4 \cdot \cancel{2}} = \frac{3}{4}$$

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## Using Basic Properties

In a similar fashion, we reduce rational expressions to lowest terms by

- first factoring the numerator and denominator,
- 2 and then dividing both numerator and denominator by any factors they have in common.

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## **Using Basic Properties**

In a similar fashion, we reduce rational expressions to lowest terms by

- first factoring the numerator and denominator,
- and then dividing both numerator and denominator by any factors they have in common.

**Example:** Reduce  $\frac{x^2 - 25}{x - 5}$  to lowest terms.

$$\frac{x^2 - 25}{x^2 - 5}$$
 to 10

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### **Using Basic Properties**

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- first factoring the numerator and denominator,
- 2 and then dividing both numerator and denominator by any factors they have in common.

**Example:** Reduce  $\frac{x^2 - 25}{x - 5}$  to lowest terms.

### Solution:

$$\frac{x^2 - 25}{x - 5} = \frac{(x - 5) \cdot (x + 5)}{x - 5} = \frac{\cancel{(x - 5)} \cdot (x + 5)}{\cancel{(x - 5)}} = x + 5$$

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Factor By Grouping ac-grouping method **Using Basic Properties** 

We reduce rational expressions to lowest terms by

- first factoring the numerator and denominator,
- and then dividing both numerator and denominator by any factors they have in common.

**Try This One!** Reduce  $\frac{x-5}{x^2-10x+25}$  to lowest terms.

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## **Using Basic Properties**

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- first factoring the numerator and denominator,
- and then dividing both numerator and denominator by any factors they have in common.

**Try This One!** Reduce  $\frac{x-5}{x^2-10x+25}$  to lowest terms.

### Solution:

$$\frac{x-5}{x^2-10x+25} = \frac{x-5}{(x-5)^2} = \frac{1 \cdot (x-5)}{(x-5) \cdot (x-5)} = \frac{1 \cdot \cancel{(x-5)}}{(x-5)\cancel{(x-5)}} = \frac{1}{x-5}$$

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## **Using Basic Properties**

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**Try This One!** Reduce  $\frac{-3+5x}{25x^2-9}$  to lowest terms.

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### Rational Expressions

### **Using Basic Properties**

We reduce rational expressions to lowest terms by

- first factoring the numerator and denominator,
- 2 and then dividing both numerator and denominator by any factors they have in common.

**Try This One!** Reduce  $\frac{-3+5x}{25x^2-9}$  to lowest terms.

### Solution:

$$\frac{-3+5x}{25x^2-9} = \frac{5x-3}{(5x)^2-3^2} = \frac{1\cdot(5x-3)}{(5x+3)\cdot(5x-3)} = \frac{1\cdot\underbrace{(5x-3)}}{(5x+3)\underbrace{(5x-3)}} = \frac{1}{5x+3}$$

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Factor By Grouping ac-grouping method Rational Expressions **Try This One!** Reduce  $\frac{5x-3}{3-2x}$  to lowest terms.

**Try This One!** Reduce  $\frac{5x-3}{3-2x}$  to lowest terms.

Solution:

First degree polynomials have form ax + b for real numbers a and b with a not equal to zero. First degree polynomials are always prime, unless the numbers a and b have a greatest common factor. So, the given expression is prime (not factorable), since both first degree polynomials do not have a common constant that can be divided out of both numerator and denominator. Therefore, the given rational expression is in lowest terms.

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# **Try This One!** Reduce $\frac{16y^3 - 250}{12y^2 - 26y - 10}$ to lowest terms.

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**Try This One!** Reduce  $\frac{16y^3 - 250}{12v^2 - 26v - 10}$  to lowest terms.

$$\textbf{Solution:} \ \frac{16y^3-250}{12y^2-26y-10} = \frac{\cancel{2} \cdot (8y^3-125)}{\cancel{2} \cdot (6y^2-13y-5)} = \frac{(2y)^3-5^3}{6y^2+2y-15y-5}$$

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**Try This One!** Reduce  $\frac{16y^3 - 250}{12y^2 - 26y - 10}$  to lowest terms.

**Solution:** 
$$\frac{16y^3 - 250}{12y^2 - 26y - 10} = \frac{\cancel{2} \cdot (8y^3 - 125)}{\cancel{2} \cdot (6y^2 - 13y - 5)} = \frac{(2y)^3 - 5^3}{6y^2 + 2y - 15y - 5}$$

$$=\frac{(2y-5)(4y^2+10y+25)}{(6y^2+2y)+(-15y-5)}=\frac{(2y-5)(4y^2+10y+25)}{2y\cdot(3y+2)+(-5)\cdot(3y+2)}=\frac{(2y-5)(4y^2+10y+25)}{(3y+2)\cdot(2y-5)}$$

$$=\frac{(4y^2+10y+25)}{(3y+2)}$$

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**Try This One!** Reduce  $\frac{3a^3+3}{6a^2-6a+6}$  to lowest terms.

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**Try This One!** Reduce  $\frac{3a^3 + 3}{6a^2 - 6a + 6}$  to lowest terms.

Solution: 
$$\frac{3a^3 + 3}{6a^2 - 6a + 6} = \frac{3(a^3 + 1)}{6(a^2 - a + 1)} = \frac{3(a + 1)(a^2 - a + 1)}{6(a^2 - a + 1)}$$

$$=\frac{3(a+1)}{6}=\frac{3(a+1)}{3\cdot 2}=\frac{3(a+1)}{3\cdot 2}=\frac{(a+1)}{2}$$

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ac-grouping method Rational Expressions **Try This One!** Reduce  $\frac{x^2 - 3x + ax - 3a}{x^2 - ax - 3x + 3a}$  to lowest terms.

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**Try This One!** Reduce  $\frac{x^2 - 3x + ax - 3a}{x^2 - ax - 3x + 3a}$  to lowest terms.

### Solution:

$$\frac{x^2 - 3x + ax - 3a}{x^2 - ax - 3x + 3a} = \frac{(x^2 - 3x) + (ax - 3a)}{(x^2 - ax) + (-3x + 3a)} = \frac{x(x - 3) + a(x - 3)}{x(x - a) + (-3)(x - a)}$$

$$= \frac{(x+a)(x-3)}{(x-a)(x-3)} = \frac{(x+a)(x-3)}{(x-a)(x-3)} = \frac{(x+a)}{(x-a)}$$

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# **Try This One!** Reduce $\frac{a-b}{b-a}$ to lowest terms.

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Exponential Notati

The Order of

Operations

Linear Equation

Linear Equations

Coordinate System

....

Lines

Perpendicula

Parallel Lines

Algebraic Expression

Polynomials

Poly Add/Subtra

Combining Like

Multiplying Poly

Trinomial time Binomial

Factoring

Polynomials

Factor By Groupin

Rational Expressions

# **Try This One!** Reduce $\frac{a-b}{b-a}$ to lowest terms.