



# College Algebra

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Knewton College Algebra was developed to meet the scope and sequence of a typical one semester college algebra course . To develop the course, Knewton used three main sources of content: Openstax, videos created by a Math Professor we have partnered with, and a team of Subject Matter Experts (SMEs). The SMEs come from diverse backgrounds and are all accomplished academics in the field of Mathematics.

Knewton College Algebra has two instructional sequences for every learning objective, giving students multiple opportunities to learn new concepts. Between our OpenStax text content, instructional videos, and Knewton SMEs, we were able to solicit ideas from math instructors and students. Knewton College Algebra covers the typical breadth of college algebra topics and also provides the necessary depth to ensure the course is manageable and engaging for instructors and students alike.

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## College Algebra I Table of Contents

### Chapter 1: Prerequisites

#### Algebra Essentials

- Properties of Real Numbers and Order of Operations
  - Distinguish between natural numbers, whole numbers, and integers
  - Distinguish between rational and irrational numbers
  - Perform calculations using order of operations
  - Use the following properties of real numbers: inverse and identity
  - Use the following properties of real numbers: commutative, associative, and distributive
- Evaluate and Simplify Algebraic Expressions
  - Evaluate algebraic expressions with a single variable
  - Evaluate algebraic expressions with two variables
  - Identify constants and variables
  - Use a formula
  - Simplify algebraic expressions

#### Exponents and Scientific Notation

- Properties of Exponents
  - Understand exponent notation
  - Use the product rule of exponents
  - Use the quotient rule of exponents
  - Use the power rule of exponents
- Advanced Properties of Exponents
  - Use the negative and zero exponent rule
  - Find the power of a product
  - Find the power of a quotient
  - Simplify exponential expressions
- Scientific Notation
  - Convert between standard and scientific notation
  - Multiply and divide numbers in scientific notation

#### Radicals and Rational Exponents

- Simplify Radicals
    - Evaluate square roots
    - Use the product rule to simplify square roots
    - Use the quotient rule to simplify square roots
  - Operations with Radicals
    - Add and subtract square roots
    - Rationalize denominators with a monomial denominator
    - Rationalize denominators using the conjugate
  - Rational Exponents and Higher Order Radicals
    - Simplify  $n$ th roots
    - Operations with  $n$ th roots
    - Switch between radical and rational exponent form
    - Evaluate expressions with rational exponents
-



## Polynomials

- Properties of Polynomials
  - Identify the degree and leading coefficient of a polynomial
  - Identify monomials, binomials, and trinomials
- Operations on Polynomials
  - Add and subtract polynomials
  - Multiply binomials together
  - Multiply polynomials together
  - Perform operations with polynomials of several variables

## Factoring Polynomials

- Factor Quadratics
  - Factor the greatest common factor of a polynomial
  - Factor a trinomial
  - Factor a trinomial by grouping
  - Factor a perfect square trinomial
  - Factor a difference of squares
- Other Factoring Techniques
  - Factor a cubic by grouping
  - Factor the sum and difference of cubes
  - Factor expressions using fractional or negative exponents
  - Factor expressions using greatest common factor and other technique

## Rational Expressions

- Operations on Rational Expressions
  - Simplify rational expressions
  - Multiply rational expressions
  - Divide rational expressions
  - Add and subtract rational expressions
  - Simplify complex rational expressions

## **Chapter 2: Equations and Inequalities**

### The Rectangular Coordinate Systems and Graphs

- Cartesian Coordinates and Distances
  - Plot ordered pairs in a Cartesian coordinate system
  - Graph equations by plotting points
  - Use the distance formula, given two points
  - Use the midpoint formula

### Linear and Rational Equations in One Variable

- Solve Linear Equations in One Variable
    - Identify identity, conditional, and inconsistent equations
    - Solve equations in one variable algebraically, variable just on one side
    - Solve equations in one variable algebraically, variable on both sides
  - Solve Rational Equations
    - Solve a rational equation, monomials in denominator
    - Solve a rational equation, binomials in denominator
    - Solve a rational equation, requires factoring to find least common denominator
-



- Identify Slopes and Intercepts
  - Find the slope of a line given two points
  - Understand the relationship between the slope and y-intercept of a line and its equation
  - Find x -intercepts and y -intercepts
- Find Linear Equations
  - Find equation of a line, in slope-intercept form, given slope and one point (point-slope formula)
  - Find equation, in slope-intercept form, of a line passing through two given points
  - Given slope and intercept, find the equation of a line and write it in standard form
  - Find the equation of vertical and horizontal lines
- Parallel and Perpendicular Lines
  - Given the equations of two lines, determine whether their graphs are parallel or perpendicular
  - Write the equation of a line parallel to a given line
  - Write the equation of a line perpendicular to a given line

#### Models and Applications

- Word Problems with Linear Equations
  - Set up a linear equation to solve a real-world application
  - Translate verbal expressions into mathematical expressions
  - Use a formula to solve a real-world application

#### Complex Numbers

- Basics of Complex Numbers
  - Express the square root of a negative number as a multiple of  $i$
  - Simplify powers of  $i$
- Operations on Complex Numbers
  - Add and subtract complex numbers
  - Multiply a complex number by a real number
  - Multiply two complex numbers
  - Divide two complex numbers

#### Quadratic Equations

- Solve Quadratic Equations by Factoring
  - Solve quadratic equations by factoring, leading coefficient 1
  - Solve quadratic equations by factoring, leading coefficient  $> 1$
- Complete the Square
  - Solve quadratic equations by the square root property
  - Solve quadratic equations by completing the square
- Quadratic Formula
  - Use the discriminant to classify the solutions of a quadratic equation
  - Solve quadratic equations by using the quadratic formula

#### Other Types of Equations

- Solve Higher Order Equations with Factoring
    - Solve equations by factoring out the greatest common factor
    - Solve equations by factoring with grouping
    - Solve fourth-degree equation in quadratic form
    - Solve quadratic with binomial
-



- Solve Other Types of Equations
  - Solve equations using reciprocal exponents
  - Solve equations involving rational exponents by factoring out the greatest common factor
  - Solve radical equations with a single radical
  - Solve radical equations with two radicals
  - Solve rational equation which leads to a quadratic

#### Linear Inequalities and Absolute Value Inequalities

- Interval Notation and Inequalities
  - Use interval notation
  - Use properties of inequalities
  - Solve simple inequalities in one variable algebraically
- Compound and Absolute Value Inequalities
  - Solve compound inequalities in one variable algebraically
  - Solve absolute value inequalities

#### Inequalities Requiring Factoring

- Rational and Quadratic Inequalities
  - Solve quadratic inequalities in one variable, graph the solution set, and express the solution set using interval notation
  - Solve inequalities that involve rational expressions, graph the solution sets, and express the solution set using interval notation

### Chapter 3: Functions

#### Functions and Function Notation

- Relations and Functions
  - Identify domain and range from a set of ordered pairs
  - Determine whether a relation represents a function
  - Determine whether a function is one-to-one
  - Use the vertical line test to identify functions
  - Use the horizontal line test to identify one-to-one functions
- Function Notation
  - Evaluate a function using function notation
  - Solve a function using function notation
  - Evaluate or solve a function from a table
  - Evaluate or solve a function from a graph

#### Domain and Range

- Domain and Piecewise Functions
  - Find the domain of a function defined by an equation
  - Find the domain and range of a function defined by a graph
  - Graph piecewise-defined functions
  - Evaluate piecewise-defined functions

#### Rates of Change and Behavior of Graphs

- Graphical Properties of Functions
    - Find the average rate of change of a function
    - Use a graph to determine intervals of increase and decrease and local extrema
    - Use a graph to locate the absolute maximum and absolute minimum
-

- Difference Quotients
  - Determine the difference quotient

#### Composition of Functions

- Combinations of Functions
  - Combine functions using algebraic operations
  - Create a new function by composition of functions
  - Evaluate composite functions given a table of values
  - Evaluate composite functions given the graph of functions
  - Evaluate composite functions given explicit functions
- Properties of Composite Functions
  - Find the domain of a composite function
  - Decompose a composite function into its component functions

#### Function Graphs and Transformations

- Transformations of Functions
  - Graph functions using vertical and horizontal shifts
  - Graph functions using reflections about the x-axis and the y-axis
  - Graph functions using compressions and stretches
  - Combine transformations
- Even and Odd Functions
  - Determine whether a function is even, odd, or neither from its graph
  - Determine whether a function is even, odd, or neither given algebraically

#### Absolute Value Functions

- Graph and Solve Absolute Value Functions
  - Graph an absolute value function
  - Solve absolute value equations

#### Inverse Functions

- Inverse Function Values
  - Verify inverse function ordered pairs
  - Given graph of a function, find value of inverse function
  - Given table of values of a function, find value of inverse function
- Find Inverse Functions
  - Verify inverse function pairs algebraically
  - Determine the domain and range of an inverse function, and restrict the domain of a function to make it one-to-one
  - Given function, find the inverse function
  - Use the graph of a one-to-one function to graph its inverse function on the same axes

### **Chapter 4: Linear Functions and Modeling**

#### Linear Functions

- Interpretations of Linear Functions
    - Represent a linear function in table form
    - Determine whether a linear function is increasing, decreasing, or constant
    - Interpret slope as a rate of change
    - Represent a real-world application as a linear function
    - Graph linear functions
-



## Modeling with Linear Functions

- Application of Linear Functions
  - Build linear models from verbal descriptions, given a y-intercept
  - Build linear models from verbal descriptions, given inputs and outputs
  - Use a diagram to build a model
  - Model a set of data with a linear function

## Fitting Linear Models to Data

- Scatter Diagrams and Lines of Best Fit
  - Draw and interpret scatter diagrams
  - Distinguish between linear and nonlinear relations

## Chapter 5: Polynomial and Rational Functions

### Quadratic Functions

- Characteristics of Parabolas
  - Determine axis of symmetry and vertex of parabolas from a graph
  - Determine x- and y-intercepts of parabolas from a graph
- Graphs of Quadratic Functions
  - Find the direction a parabola opens and its axis of symmetry and vertex from the general form of its equation
  - Identify the axis of symmetry and vertex of a parabola from its equation in standard form
  - Write the equation of a quadratic function given vertex and a point on a graph
  - Write the equation of a quadratic function given intercepts on a graph
  - Write the equation of a quadratic function in standard form given the equation in general form
- Applications of Quadratic Functions
  - Find the domain and range of a quadratic function
  - Determine the maximum and minimum values of quadratic functions
  - Find the x- and y-intercepts of a quadratic function
  - Use a quadratic function to model projectile motion

### Graphs of Polynomial and Power Functions

- End Behavior of Polynomial Functions
    - Identify power functions and polynomial functions
    - Identify if a graph is a polynomial function
    - Determine end behavior
  - Local Behavior of Polynomial Functions
    - Identify intercepts of polynomial functions in factored form
    - Understand the relationship between degree, turning points, and x-intercepts
    - Understand the intermediate value theorem
    - Use factoring to find zeros of polynomial functions
    - Identify zeros and their multiplicities from an equation or a graph
  - Write and Graph Polynomial Functions
    - Draw conclusions about a polynomial function from a graph
    - Graph polynomial functions
    - Write a formula for a polynomial function from a graph
    - Determine equation of a polynomial given key information
-





### Dividing Polynomials

- Long Division of Polynomials
  - Use long division to divide polynomials
  - Use polynomial division to solve application problems
- Synthetic Division and Remainder Theorem
  - Use synthetic division to divide polynomials
  - Evaluate a polynomial using the remainder theorem

### Zeros of Polynomial Functions

- Rational Zeros of Polynomial Functions
  - Use the factor theorem to solve a polynomial equation
  - Use the rational zero theorem to find rational zeros
  - Solve real-world applications of polynomial equations
- Complex Zeros of Polynomial Functions
  - Find zeros of polynomial functions with complex zeros
  - Use the linear factorization theorem to find polynomials with given zeros
  - Use Descartes' rule of signs

### Rational Functions

- Asymptotic Behavior of Rational Functions
  - Use arrow notation to describe local behavior and end behavior of rational functions
  - Identify vertical asymptotes and removable discontinuities of rational functions
  - Identify horizontal and slant asymptotes of rational functions
- Graphs and Applications of Rational Functions
  - Solve applied problems involving rational functions
  - Find the intercepts of a rational function
  - Graph rational functions
  - Find the equation of a rational function from a graph

### Inverses and Radical Functions

- Inverses of Polynomial Functions
  - Find the inverse of an invertible polynomial function
  - Restrict the domain to find the inverse of a polynomial function
  - Solve an application with the inverse of a function
- Inverses of Radical and Rational Functions
  - Find the inverse of a radical function
  - Find the domain of a radical function composed with a rational function
  - Find the inverse of a rational function

### Modeling Using Variation

- Direct and Inverse Variation
    - Solve direct variation problems
    - Solve inverse variation problems
    - Solve problems involving joint variation
-



## Circles

- Graphs of Circles
  - Given the equation of a circle not in standard form, determine the standard form by completing the square
  - Determine the center and radius of a circle from the standard equation of a circle and sketch its graph

## Chapter 6: Exponential and Logarithmic Functions

### Exponential Functions

- Evaluate and Write Exponential Functions
  - Identify exponential functions
  - Evaluate exponential functions
  - Find the equation of an exponential function given the initial value and a point
  - Find the equation of an exponential function when the initial value is not known
- Applications of Exponential Functions and Base  $e$ 
  - Find the equation of an exponential function in a word problem context
  - Calculate compound interest
  - Evaluate exponential functions with base  $e$
  - Calculate continuous growth and decay

### Graphs of Exponential Functions

- Exponential Function Graphs
  - Graph exponential functions
  - Graph exponential functions using transformations
  - Find the equation of an exponential function given a graph
  - Write an exponential function from a description

### Logarithmic Functions

- Relate Logarithms and Exponents
  - Convert from logarithmic to exponential form
  - Convert from exponential to logarithmic form
- Evaluate Logarithmic Expressions
  - Evaluate logarithms with positive integer solutions
  - Evaluate logarithms with negative integer solutions
  - Use common logarithms
  - Use natural logarithms

### Graphs of Logarithmic Functions

- Logarithmic Function Graphs
    - Identify the domain of a logarithmic function
    - Graph logarithmic functions
    - Graph transformations of logarithmic functions
    - Write a logarithmic function from a description
-



## Logarithmic Properties

- Basic Properties of Logarithms
  - Understand the basic properties of logarithms
  - Use the product rule for logarithms
  - Use the quotient rule for logarithms
  - Use the power rule for logarithms
- Rewrite Logarithmic Expressions Using Properties
  - Expand logarithmic expressions
  - Condense logarithmic expressions
  - Use the change-of-base formula for logarithms

## Exponential and Logarithmic Equations

- Solve Exponential Equations
  - Use like bases to solve exponential equations
  - Rewrite equations so all powers have the same base and solve exponential equations
  - Use logarithms to solve exponential equations
  - Solve an equation with a base  $e$  using natural logarithms
- Solve Logarithmic Equations
  - Use the definition of a logarithm to solve logarithmic equations
  - Use logarithm properties and the definition of the logarithm to solve logarithmic equations
  - Use the one-to-one property of logarithms to solve logarithmic equations

## Exponential and Logarithmic Models

- Applications of Exponential and Logarithmic Functions
  - Model exponential growth
  - Model exponential decay
  - Applied logarithmic models
  - Choose an appropriate model for data
  - Express an exponential model in base  $e$

## Chapter 7: Systems of Equations and Inequalities

### Systems of Linear Equations in Two Variables

- Systems of Two Linear Equations
    - Determine whether an ordered pair is a solution to a system of equations
    - Solve systems of equations in two variables by graphing
    - Solve systems of equations in two variables by substitution
    - Solve systems of equations in two variables by addition
    - Identify inconsistent and dependent systems of equations containing two variables, and express the solution of dependent equations
  - Applications of Systems of Linear Equations
    - Use systems of equations to investigate profits
    - Write and solve a system of equations in two variables from a word problem
  - Linear Inequalities in Two Variables
    - Solve a linear inequality in two variables by graphing
    - Solve a linear system of inequalities by graphing
-



### Systems of Linear Equations in Three Variables

- Systems of Linear Equations in Three Variables
  - Determine whether an ordered triple is a solution to a system
  - Solve systems of three equations in three variables
  - Identify inconsistent and dependent systems of equations containing three variables, and express the solution of a system of dependent equations

### Systems of Nonlinear Equations in Two Variables

- Systems of Two Nonlinear Equations
  - Solve a system of nonlinear equations representing a parabola and a line
  - Solve a system of nonlinear equations representing a circle and a line
  - Solve a system of nonlinear equations in two variables using elimination
- Graphing Nonlinear Inequalities and Systems of Inequalities
  - Graph a nonlinear inequality
  - Graph a system of nonlinear inequalities

### Partial Fractions

- Partial Fraction Decomposition with Linear Factors
  - Decompose a rational expression where the denominator has only nonrepeated linear factors
  - Decompose a rational expression where the denominator has repeated linear factors
- Partial Fraction Decomposition with Quadratic Factors
  - Decompose a rational expression where the denominator has a nonrepeated irreducible quadratic factor
  - Decompose a rational expression where the denominator has a repeated irreducible quadratic factor

### Matrices and Matrix Operations

- Introduction to Matrices
  - Determine the order of a matrix and describe elements within a matrix
  - Add or subtract matrices
- Matrix Multiplication
  - Multiply a matrix by a scalar
  - Find the sum or difference of scalar multiples
  - Multiply two matrices

### Augmented Matrices and Gaussian Elimination

- Solving Systems with Gaussian Eliminations
  - Convert between a system of equations and its corresponding augmented matrix
  - Use row operations to solve a system of linear equations in two variables
  - Use row operations to solve a system of linear equations in three variables
  - Use matrices to solve applications of systems of linear equations

### Determinants or Matrices

- Finding Determinants of Matrices
    - Find the determinant of a 2x2 matrix
    - Find the determinant of a 3x3 matrix
-

### The Inverse Matrix

- Inverse and Identity Matrices
  - Understand the identity matrix and how it relates to the inverse matrix
  - Determine if a matrix is invertible using the determinant
  - Find the inverse of a 2x2 matrix
  - Find the inverse of a 3x3 matrix
- Solving Systems with Inverses
  - Solve a system of linear equations using the inverse of a 2x2 matrix
  - Solve a system of linear equations using the inverse of a 3x3 matrix

### Cramer's Rule

- Solving Systems with Cramer's Rule
  - Use Cramer's rule to solve a system of two equations in two variables
  - Use Cramer's rule to solve a system of three equations in three variables
  - Use Cramer's rule to solve inconsistent or dependent systems

## Chapter 8: Conic Sections

### Ellipses

- Ellipses Centered at the Origin
  - Identify key points and axes of ellipses from a graph
  - Identify key points and axes of ellipses from an equation
  - Write the equation in standard form of an ellipse centered at the origin
  - Graph an ellipse centered at the origin from an equation in standard form
- Ellipses Not Centered at the Origin
  - Identify key points and axes of ellipses not centered at the origin
  - Write the equation in standard form of an ellipse not centered at the origin
  - Graph an ellipse not centered at the origin
- Ellipses Not in Standard Form and Applications of Ellipses
  - Convert an equation of an ellipse into standard form
  - Graph an ellipse where the equation is not given in standard form
  - Use ellipses in applications

### Hyperbolas

- Hyperbolas Centered at the Origin
    - Locate the vertices and foci of a hyperbola from a graph
    - Identify vertices, foci, and asymptotes of a hyperbola from an equation
    - Write the equation of a hyperbola centered at the origin in standard form
    - Graph a hyperbola centered at the origin from an equation in standard form
  - Hyperbolas Not Centered at the Origin
    - Identify vertices, foci, and asymptotes of a hyperbola not centered at the origin
    - Write the equation of a hyperbola not centered at the origin
    - Graph a hyperbola not centered at the origin from an equation in standard form
  - Hyperbolas Not in Standard Form and Applications of Hyperbolas
    - Convert an equation of a hyperbola into standard form
    - Graph a hyperbola from an equation given in general form
    - Use hyperbolas in applications
-

## Parabolas

- Parabolas Centered at the Origin
  - Identify key components of a parabola from a graph
  - Identify key components of a parabola from an equation
  - Graph a parabola centered at the origin
  - Write the equation of a parabola centered at the origin in standard form
- Parabolas Not Centered at the Origin
  - Identify key components of a parabola not centered at the origin
  - Graph a parabola not centered at the origin
  - Write the equation of a parabola not centered at the origin in standard form
- Parabolas Not in Standard Form and Applications of Parabolas
  - Convert an equation of a parabola into standard form
  - Graph a parabola from an equation given in general form
  - Use parabolas in applications

## Chapter 9: Sequences and Series

### Sequences

- Introduction to Sequences and Recursive Sequences
  - Write the terms of a sequence defined by an explicit formula
  - Write the terms of a sequence defined by a piecewise explicit formula
  - Write the terms of a sequence defined by a recursive formula
  - Write the terms of a sequence defined by a recursive formula with more than one initial term
- Arithmetic Sequences
  - Find the common difference of an arithmetic sequence
  - Write terms of an arithmetic sequence
  - Write a recursive formula for an arithmetic sequence
  - Write an explicit formula for an arithmetic sequence
- Geometric Sequences
  - Find the common ratio of a geometric sequence
  - Write terms of a geometric sequence
  - Write a recursive formula for a geometric sequence
  - Write an explicit formula for a geometric sequence
- Applications of Sequences
  - Write an explicit formula for the  $n$ th term of a sequence
  - Find specific terms of an arithmetic sequence given other terms
  - Solve application problems with arithmetic sequences
  - Solve application problems with geometric sequences
  - Solve geometric sequence problems

### Series

- Summation Notation and Arithmetic Series
    - Evaluate expressions using summation notation
    - Find the sum of a finite arithmetic series
-

- Finite and Infinite Geometric Series
  - Find the sum of a finite geometric series
  - Determine if the sum of an infinite series is defined
  - Find the sum of an infinite geometric series
- Applications of Series
  - Solve application problems with arithmetic series
  - Solve application problems with geometric series
  - Find the equivalent fraction for a repeating decimal
  - Solve an annuity problem

## **Chapter 10: Probability and Counting Theory**

### Counting Theory

- The Addition and Multiplication Principles
  - Solve counting problems using the addition principle
  - Solve counting problems using the multiplication principle
  - Evaluate an expression with factorials
- Permutations and Combinations
  - Find the number of permutations of  $n$  distinct objects using the multiplication principle
  - Find the number of permutations of  $n$  distinct objects using a formula
  - Find the number of combinations using the formula
  - Find the number of subsets of a set
  - Find the number of permutations of  $n$  non-distinct objects

### Binomial Theorem

- Binomial Expansion
  - Find a binomial coefficient
  - Expand a binomial using the binomial theorem
  - Use the binomial theorem to find a single term

### Probability

- Basic Probability
    - Compute the probability of equally likely outcomes
    - Compute the probability of the union of two events
    - Use the complement rule to compute probabilities
    - Compute probability using counting theory
-