

# Vermont Algebra 2 Step by Step

*Clear Methods, Worked Examples & Practice*

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# Methods Made Visible

Numbered Steps • Worked Examples • Guided Practice • Answers with Explanations

*Algebra 2 connects equations, functions, graphs, tables, and models. This step-by-step guide covers the same major course ideas as the study guide: foundations, linear systems, functions, quadratics, complex numbers, polynomials, rational and radical expressions, exponential and logarithmic models, sequences, trigonometry, conics, statistics, probability, and financial applications.*

*Each topic is built for students who want the method broken into visible moves. Read the concept, follow the numbered steps, trace the worked example, try the practice, then use the answer explanations to correct your work.*

## **Steps First**

*Each lesson turns a skill into clear actions you can repeat.*

## **Worked Examples**

*Examples show the exact steps before you practice.*

## **Focused Practice**

*Practice sets move from direct skill checks to common traps.*

## **Answer Support**

*Explanations name the reason, not just the final number.*

# How to Use This Step-by-Step Guide

A practical loop for learning methods, correcting mistakes, and preparing for tests.

1

## Start with the Meaning

Before using a procedure, read the short concept paragraph. Algebra 2 methods work best when you know what the expression, graph, table, or model is representing.

2

## Follow the Numbered Steps

Each lesson breaks the method into observable moves. Say what each step is doing: choose a form, isolate a term, factor, check a restriction, read a graph feature, or interpret a parameter.

3

## Trace the Worked Example

Cover part of the solution and predict the next line. Then compare your move to the example. This turns the example into practice instead of just something to read.

4

## Practice and Correct by Step

Try the practice immediately. If an answer is wrong, use the explanation to find the first step where the work changed direction, then redo a similar problem.

### Study Plan Ideas

- **Quick review:** Do one topic: concept, steps, example, practice.
- **Chapter review:** Rework examples from the topics that felt hardest.
- **Before a test:** Use the chapter mini TOC to target weak topics.

### For Parents & Teachers

- Ask students to name the step they are using before calculating.
- Match topic names to classroom lessons, homework, or state standards.
- Keep a short error log: setup, algebra, graph reading, or restrictions.

 **Suggested pace:** one topic in 20–30 minutes. For a difficult skill, read the study-guide explanation first, then return here and work through the numbered method.



# Algebra 2 Reference Sheet



High-yield formulas for quick review before each practice test

## Functions

Domain = allowed inputs; range = outputs.

Average rate:  $\frac{f(b) - f(a)}{b - a}$

$f(x) + k$ : up/down;  $f(x - h)$ : right/left

$a f(x)$ : vertical stretch/reflection

$f(bx)$ : horizontal change

Inverse:  $f^{-1}(f(x)) = x$

## Linear

Slope:  $m = \frac{y_2 - y_1}{x_2 - x_1}$

Point-slope:  $y - y_1 = m(x - x_1)$

Slope-intercept:  $y = mx + b$

Standard:  $Ax + By = C$

Parallel: same  $m$ ; perpendicular:  $m_1 m_2 = -1$

## Systems

Solutions are intersections.

Substitution: solve one equation, plug in.

Elimination: align terms, add/subtract.

No solution: parallel lines.

Infinitely many: same line.

## Quadratics

Standard:  $y = ax^2 + bx + c$

Vertex:  $y = a(x - h)^2 + k$

Factored:  $y = a(x - r_1)(x - r_2)$

Axis:  $x = -\frac{b}{2a}$

Formula:  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Discriminant:  $b^2 - 4ac$

Roots:  $r_1 + r_2 = -\frac{b}{a}$ ,  $r_1 r_2 = \frac{c}{a}$

## Polynomials

Remainder: divide by  $x - a$ , remainder  $f(a)$ .

Factor:  $x - a$  factor iff  $f(a) = 0$ .

Zeros and factors:  $x = r \leftrightarrow (x - r)$

Even degree: same end behavior

Odd degree: opposite end behavior

Even multiplicity touches; odd crosses.

## Complex Numbers

$i^2 = -1$ ,  $i^3 = -i$ ,  $i^4 = 1$

$(a + bi) + (c + di) = (a + c) + (b + d)i$

$(a + bi)(c + di) = (ac - bd) + (ad + bc)i$

Conjugates:  $a + bi$ ,  $a - bi$

Real polynomials have conjugate complex roots.

## Rational

Excluded values come from original denominator.

Factor first; cancel common factors.

Vertical asymptotes: uncanceled denominator zeros.

Holes: canceled denominator zeros.

Horizontal asymptote compares degrees.

Rational inequality: use sign chart.

## Radicals

$a^{m/n} = \sqrt[n]{a^m} = (\sqrt[n]{a})^m$

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

$\frac{a^m}{a^n} = a^{m-n}$

Power function:  $f(x) = ax^p$

Radical equations: isolate, power, check

Even roots need nonnegative radicands.

## Exponential

Model:  $y = ab^x$

Growth:  $b > 1$ ; decay:  $0 < b < 1$

Compound:  $A = P(1 + \frac{r}{n})^{nt}$

Continuous:  $A = Pe^{rt}$

Half-life/decay:  $A = A_0(1 - r)^t$

## Logarithms

$\log_b(x) = y \leftrightarrow b^y = x$

$\log_b(MN) = \log_b M + \log_b N$

$\log_b(M/N) = \log_b M - \log_b N$

$\log_b(M^p) = p \log_b M$

Change base:  $\log_b x = \frac{\log x}{\log b}$

Log domain: argument  $> 0$ .

## Sequences

Arithmetic:  $a_n = a_1 + (n - 1)d$

Arithmetic recursive:  $a_n = a_{n-1} + d$

Arithmetic sum:  $S_n = \frac{n(a_1 + a_n)}{2}$

Geometric:  $a_n = a_1 r^{n-1}$

Geometric recursive:  $a_n = r a_{n-1}$

Finite sum:  $S_n = \frac{a_1(1 - r^n)}{1 - r}$

Infinite sum:  $S = \frac{a_1}{1 - r}$ ,  $|r| < 1$

## Matrices

Matrix size: rows  $\times$  columns.

Add/subtract only same dimensions.

Multiply  $A_{m \times n} B_{n \times p} = C_{m \times p}$ .

Identity:  $AI = IA = A$

For  $2 \times 2$ , determinant  $ad - bc$ .



# Algebra 2 Reference Sheet



Trig, conics, data, probability, and modeling reminders

## Trigonometry

Unit point:  $(\cos \theta, \sin \theta)$

$$\sin^2 \theta + \cos^2 \theta = 1$$

$$1 + \tan^2 \theta = \sec^2 \theta$$

$$\sin = \frac{\text{opp}}{\text{hyp}}, \cos = \frac{\text{adj}}{\text{hyp}}, \tan = \frac{\text{opp}}{\text{adj}}$$

$$\text{Sine/cosine period: } \frac{2\pi}{|b|}$$

$$\text{Tangent period: } \frac{\pi}{|b|}$$

$$\text{Law of Sines: } \frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$\text{Law of Cosines: } c^2 = a^2 + b^2 - 2ab \cos C$$

## Trig Graphs

$$y = A \sin(B(x - C)) + D$$

Amplitude:  $|A|$

Period:  $\frac{2\pi}{|B|}$  for sine/cosine

Period:  $\frac{\pi}{|B|}$  for tangent

Phase shift:  $C$

Midline:  $y = D$

Max/min:  $D \pm |A|$

## Special Angles

$$30^\circ = \frac{\pi}{6}, 45^\circ = \frac{\pi}{4}, 60^\circ = \frac{\pi}{3}$$

$$\sin 30^\circ = \frac{1}{2}, \cos 30^\circ = \frac{\sqrt{3}}{2}$$

$$\sin 45^\circ = \cos 45^\circ = \frac{\sqrt{2}}{2}$$

$$\sin 60^\circ = \frac{\sqrt{3}}{2}, \cos 60^\circ = \frac{1}{2}$$

Quadrant signs: ASTC.

## Conics

$$\text{Circle: } (x - h)^2 + (y - k)^2 = r^2$$

$$\text{Parabola: } (x - h)^2 = 4p(y - k)$$

$$\text{or } (y - k)^2 = 4p(x - h)$$

$$\text{Ellipse: } \frac{(x - h)^2}{a^2} + \frac{(y - k)^2}{b^2} = 1$$

$$\text{Hyperbola: } \frac{(x - h)^2}{a^2} - \frac{(y - k)^2}{b^2} = 1$$

## Conic Details

Circle center  $(h, k)$ , radius  $r$ .

Parabola vertex  $(h, k)$ , focus is  $|p|$  away.

Ellipse: larger denominator gives major axis.

$$\text{Ellipse: } c^2 = a^2 - b^2$$

$$\text{Hyperbola: } c^2 = a^2 + b^2$$

Asymptotes guide hyperbola branches.

## Statistics

$$\text{Mean: } \bar{x} = \frac{\sum x}{n}$$

$$z = \frac{x - \mu}{\sigma}$$

Residual = actual - predicted

Correlation  $r$  is between  $-1$  and  $1$ .

Normal: about 68%, 95%, 99.7% within 1, 2, 3 SDs.

## Data Displays

$$\text{IQR: } Q_3 - Q_1$$

$$\text{Outlier fence: } Q_1 - 1.5(\text{IQR}), Q_3 + 1.5(\text{IQR})$$

Median resists outliers.

Mean is pulled by outliers.

Standard deviation measures typical distance from mean.

## Regression

Residual: actual - predicted.

Positive  $r$ : as  $x$  rises,  $y$  tends to rise.

Negative  $r$ : as  $x$  rises,  $y$  tends to fall.

Strong linear fit:  $|r|$  close to  $1$ .

$R^2$  is percent of variation explained.

## Probability

$$P(A | B) = \frac{P(A \cap B)}{P(B)}$$

Independent:  $P(A \cap B) = P(A)P(B)$

Either/or:  $P(A \cup B) = P(A) + P(B) - P(A \cap B)$

$$\text{Permutations: } {}_n P_r = \frac{n!}{(n-r)!}$$

$$\text{Combinations: } {}_n C_r = \frac{n!}{r!(n-r)!}$$

$$\text{Binomial: } {}_n C_r p^r (1-p)^{n-r}$$

## Counting

Fundamental counting principle: multiply choices.

Permutation: order matters.

Combination: order does not matter.

With replacement: choices stay the same.

Without replacement: choices decrease.

## Finance

Simple interest:  $I = Prt$

Future amount:  $A = P + I$

Compound:  $A = P(1 + \frac{r}{n})^{nt}$

Continuous:  $A = Pe^{rt}$

Depreciation:  $A = P(1 - r)^t$

Percent change:  $\frac{\text{new} - \text{old}}{\text{old}}$

## Modeling Checks

Linear: constant first differences.

Quadratic: constant second differences.

Exponential: constant ratios.

Domain should match the context.

Round only at the end unless directed.

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CHAPTER

1

# Algebra 2 Foundations

★ What's Inside ★

1.1	Real Number System and Set Notation .....	2
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## 1.1 Real Number System and Set Notation

Real numbers are organized by sets. Some sets sit inside larger sets, so one number can belong to several groups:

$$\text{natural} \subset \text{whole} \subset \text{integers} \subset \text{rational} \subset \text{real}.$$

A rational number can be written as a fraction and has a terminating or repeating decimal. An irrational number is real, but its decimal never terminates or repeats.

For sets of values, set-builder notation gives a rule, such as  $\{x \mid x \geq -2\}$ . Interval notation shows endpoints: brackets include endpoints, parentheses exclude endpoints, and  $\infty$  always uses a parenthesis.

### How to Classify and Write Number Sets

- 1 Simplify the number first, especially roots and fractions.
- 2 Use the smallest accurate set: natural, whole, integer, rational, or irrational.
- 3 For intervals, identify the left endpoint, right endpoint, and whether each endpoint is included.
- 4 Use brackets for included endpoints and parentheses for excluded endpoints.

### Example

**Problem:** Classify  $\sqrt{49}$  and write  $\{x \mid -3 < x \leq 2\}$  in interval notation.

**Step 1** Simplify the root:  $\sqrt{49} = 7$ .

**Step 2** The smallest accurate set for 7 is **natural**.

**Step 3** The set starts at  $-3$  and ends at  $2$ . Since  $-3$  is excluded and  $2$  is included, use  $($  on the left and  $]$  on the right.

**Answer:**  $\sqrt{49}$  is natural, and  $\{x \mid -3 < x \leq 2\} = (-3, 2]$ .

### Practice

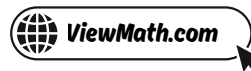
1. Classify  $-8$  by its smallest accurate set. \_\_\_\_\_
2. Classify  $0.2\bar{7}$  as rational or irrational. \_\_\_\_\_
3. Classify  $\sqrt{18}$  as rational or irrational. \_\_\_\_\_
4. Write  $\{x \mid x < 6\}$  in interval notation. \_\_\_\_\_
5. Write  $[-2, 5)$  as an inequality. \_\_\_\_\_



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CHAPTER

3

# *Functions, Transformations, and Inverses*

★ *What's Inside* ★

<b>3.1</b>	<b><i>Function Notation and Evaluation</i></b> .....	<b>4</b>
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## 3.1 Function Notation and Evaluation

Function notation names an output. The statement  $f(3) = 10$  means the input is 3 and the output is 10, so the graph contains the point (3, 10).

To evaluate a function, replace every  $x$  with the input expression. Parentheses matter, especially when the input is negative or more than one term.

### How to Evaluate a Function

- 1 Identify the input inside the parentheses of the function notation.
- 2 Replace every variable in the rule with that input.
- 3 Use parentheses around the substituted input.
- 4 Simplify using the order of operations.
- 5 Interpret the result as an output value or as a point on the graph.

### Example

**Problem:** For  $f(x) = x^2 - 4x + 1$ , find  $f(-3)$ .

**Step 1** The input is  $-3$ , so replace every  $x$  with  $(-3)$ .

$$f(-3) = (-3)^2 - 4(-3) + 1.$$

**Step 2** Simplify powers and products first:  $9 + 12 + 1$ .

**Step 3** Add to get 22.

**Answer:**  $f(-3) = 22$

### Practice

1. If  $g(x) = 3x - 7$ , find  $g(5)$ . \_\_\_\_\_
2. If  $h(t) = 2t^2 + 1$ , find  $h(-4)$ . \_\_\_\_\_
3. If  $f(6) = -2$ , what point is on the graph of  $f$ ? \_\_\_\_\_
4. For  $p(x) = x^2 + 3x$ , find  $p(a)$ . \_\_\_\_\_
5. If  $C(n) = 12n + 40$ , what does  $C(8)$  represent in a cost model? \_\_\_\_\_



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# *Answer Key*



 Chapter 1

## Section 1.1 Real Number System and Set Notation

 Answer Key

## Answers

1

integer

2

rational

3

irrational

4

 $(-\infty, 6)$ 

5

 $-2 \leq x < 5$  Explanations

- 1 Start by asking whether the number has any fraction or decimal part. Since  $-8$  is a negative whole-number value, it belongs to the integers, and integer is the smallest accurate set.
- 2 A bar over the digits means the same block repeats forever. Repeating decimals can always be written as fractions, so  $0.\overline{27}$  is rational.
- 3 Check whether the number under the radical is a perfect square. Since 18 is not,  $\sqrt{18}$  does not simplify to a rational number, so it is irrational.
- 4 The inequality  $x < 6$  means all numbers less than 6, so the interval stretches left forever. Use a parenthesis at 6 because 6 is not included.
- 5 Read the endpoints from left to right. The bracket includes  $-2$ , giving  $-2 \leq x$ , while the parenthesis excludes 5, giving  $x < 5$ .

 Chapter 3Find more at  
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## Section 3.1 Function Notation and Evaluation

 Answer Key

## Answers

1

8

2

33

3

 $(6, -2)$ 

4

 $a^2 + 3a$ 

5

the cost when  $n = 8$  Explanations

1

Substitute 5 for  $x$ :  $g(5) = 3(5) - 7$ . The result is  $15 - 7 = 8$ .

2

Use parentheses for the negative input:  $h(-4) = 2(-4)^2 + 1$ . Since  $(-4)^2 = 16$ , the output is  $32 + 1 = 33$ .

3

Function notation gives an input-output pair. The input becomes the  $x$ -coordinate and the output becomes the  $y$ -coordinate.

4

The input is the expression  $a$ . Replace every  $x$  with  $a$  and keep the same operations in the rule.

5

The notation asks for the output of the cost function at input 8. In context, that means the total cost for 8 units, trips, months, or whatever  $n$  represents.



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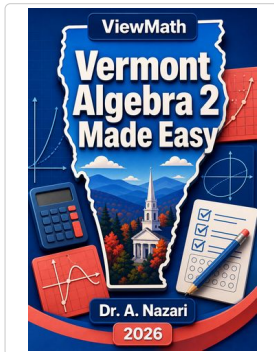


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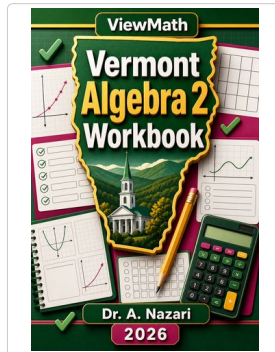
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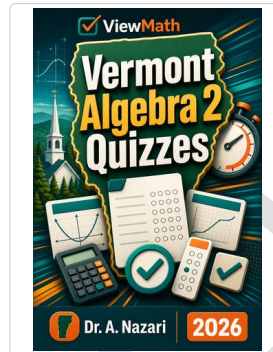
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Workbook



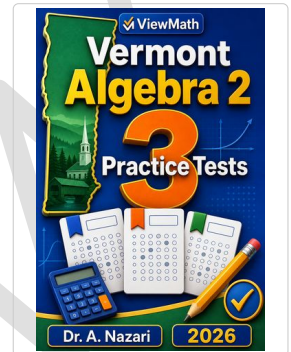
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Quizzes



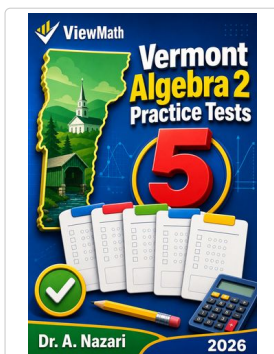
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3 Practice Tests



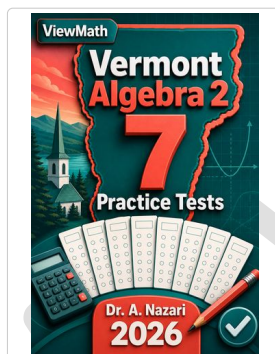
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5 Practice Tests



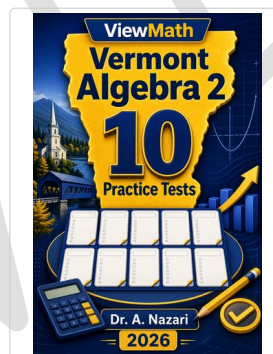
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7 Practice Tests



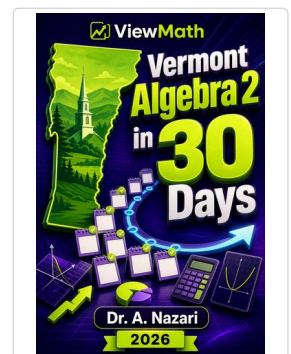
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10 Practice Tests



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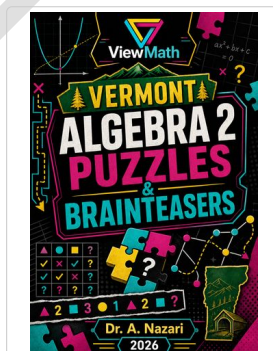
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Math in 10 Days



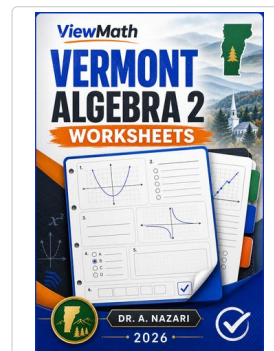
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