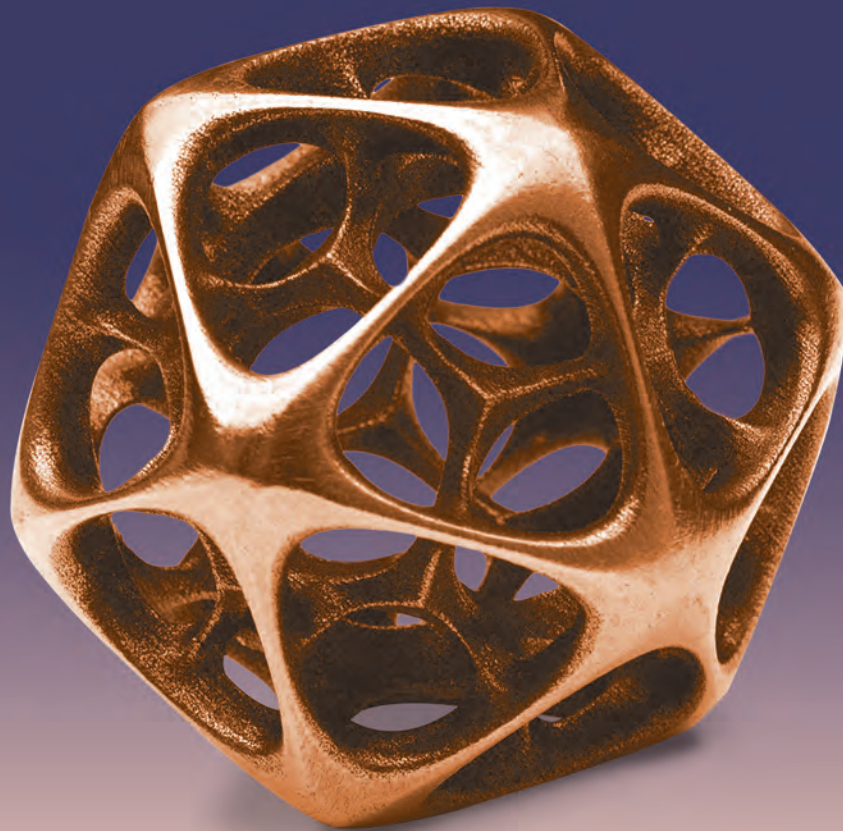


BIG IDEAS
MATH.
Geometry
A Common Core Curriculum

Ron Larson and Laurie Boswell



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BigIdeasLearning.com



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Image of metal sculpture by Vladimir Bulatov

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Authors



Ron Larson, Ph.D., is well known as the lead author of a comprehensive program for mathematics that spans middle school, high school, and college courses. He holds the distinction of Professor Emeritus from Penn State Erie, The Behrend College, where he taught for nearly 40 years. He received his Ph.D. in mathematics from the University of Colorado. Dr. Larson's numerous professional activities keep him actively involved in the mathematics education community and allow him to fully understand the needs of students, teachers, supervisors, and administrators.

Ron Larson

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Laurie Boswell



Dr. Ron Larson and **Dr. Laurie Boswell** began writing together in 1992. Since that time, they have authored over three dozen textbooks. In their collaboration, Ron is primarily responsible for the Student Edition while Laurie is primarily responsible for the Teaching Edition.

For the Student

Welcome to *Big Ideas Math Geometry*. From start to finish, this program was designed with you, the learner, in mind.

As you work through the chapters in your Geometry course, you will be encouraged to think and to make conjectures while you persevere through challenging problems and exercises. You will make errors—and that is ok! Learning and understanding occur when you make errors and push through mental roadblocks to comprehend and solve new and challenging problems.

In this program, you will also be required to explain your thinking and your analysis of diverse problems and exercises. You will master content through engaging explorations that will provide deeper understanding, concise stepped-out examples, and rich thought-provoking exercises. Being actively involved in learning will help you develop mathematical reasoning and use it to solve math problems and work through other everyday challenges.

We wish you the best of luck as you explore Geometry. We are excited to be a part of your preparation for the challenges you will face in the remainder of your high school career and beyond.

4 Transformations

- 4.1 Translations
- 4.2 Reflections
- 4.3 Rotations
- 4.4 Congruence and Transformations
- 4.5 Dilations
- 4.6 Similarity and Transformations



Magnification (p. 213)

Photo Stickers (p. 213)

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Maintaining Mathematical Proficiency

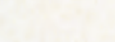
Identifying Transformations

Example 1 Tell whether the red figure is a translation, reflection, rotation, or dilation of the blue figure.

a.  The blue figure maps to form the red figure, so it is a translation.

b.  The red figure is a mirror image of the blue figure, so it is a reflection.

Tell whether the red figure is a translation, reflection, rotation, or dilation of the blue figure.

1.  2.  3.  4. 

Identifying Similar Figures

Example 2 Which rectangle is similar to Rectangle A?

Rectangle A:  Rectangle B:  Rectangle C: 

Each figure is a rectangle, so corresponding angles are congruent. Check to see whether corresponding side lengths are proportional.

Mathematical Practices

Using Dynamic Geometry Software

Core Concept

Dynamic geometry software allows you to create geometric drawings, including:

- drawing a point
- drawing a line
- drawing a line segment
- drawing an angle
- measuring an angle
- measuring a line segment
- drawing a perpendicular line
- drawing a polygon
- copying and sliding an object
- reflecting an object in a line

Example 1 Finding Side Lengths and Angle Measures

Use dynamic geometry software to draw a triangle with vertices at $A(-2, 1)$, $B(2, 1)$, and $C(2, -2)$. Find the side lengths and angle measures of the triangle.

SOLUTION

Using dynamic geometry software, you can create $\triangle ABC$, as shown.

Sample

Points: $A(-2, 1)$, $B(2, 1)$, $C(2, -2)$

4.1 Translations

Essential Question

How can you translate a figure in a coordinate plane?

EXPLORATION 1 Translating a Triangle in a Coordinate Plane

Work with a partner.

a. Use dynamic geometry software to draw any triangle and label it $\triangle ABC$.
b. Copy the triangle and *translate* (or *slide*) it to form a new figure, called an image, $\triangle A'B'C'$. (Read as "triangle A prime, B prime, C prime".)
c. What is the relationship between the coordinates of the vertices of $\triangle ABC$ and those of $\triangle A'B'C'$?
d. What do you observe about the side lengths and angle measures of the two triangles?

Sample

Points: $A(-1, 2)$, $B(1, 2)$, $C(1, -1)$
Segments: $AB = 2$, $BC = 2.24$, $AC = 2.24$
Angles: $m\angle A = 45^\circ$, $m\angle B = 135^\circ$, $m\angle C = 63.43^\circ$

EXPLORATION 2 Translating a Triangle in a Coordinate Plane

Work with a partner.

a. The point (x, y) is translated a units horizontally and b units vertically. Write a rule to determine the coordinates of the image of (x, y) .
 $(x, y) \rightarrow (x + a, y + b)$
b. Use the rule you wrote in part (a) to translate $\triangle ABC$ 4 units left and 3 units down. What are the coordinates of the vertices of the image, $\triangle A'B'C'$?
c. Draw $\triangle A'B'C'$. Are its side lengths the same as those of $\triangle ABC$? Justify your answer.

EXPLORATION 3 Comparing Angles of Translations

Work with a partner.

a. In Exploration 2, is $\triangle ABC$ a right triangle? Justify your answer.
b. In Exploration 2, is $\triangle A'B'C'$ a right triangle? Justify your answer.
c. Do you think translations always preserve angle measures? Explain your reasoning.

Communicate Your Answer

4. How can you translate a figure in a coordinate plane?

5. In Exploration 2, translate $\triangle A'B'C'$ 3 units right and 4 units up. What are the coordinates of the vertices of the image, $\triangle A''B''C''$? How are these coordinates related to the coordinates of the vertices of the original triangle, $\triangle ABC$?

Section 4.1 Translations 173

4.1 Exercises

Dynamic Solutions available at BigIdeasMath.com

Vocabulary and Core Concept Check

1. **VOCABULARY** Name the preimage and image of the transformation $\triangle ABC \rightarrow \triangle A'B'C'$.
2. **COMPLETE THE SENTENCE** A _____ moves every point of a figure the same distance in the same direction.

Monitoring Progress and Modeling with Mathematics

In Exercises 3 and 4, name the vector and write its component form. (See Example 1.)

3. 
4. 

In Exercises 5–8, the vertices of $\triangle DEF$ are $D(2, 5)$, $E(6, 3)$, and $F(4, 6)$. Translate $\triangle DEF$ using the given vector. Graph $\triangle DEF$ and its image. (See Example 2.)

5. $(-3, 0)$ 6. $(5, -1)$
7. $(-3, -7)$ 8. $(-2, -4)$

In Exercises 9 and 10, find the component form of the vector that translates P to Q , to P' .

9. $P(0, 1)$ 10. $P'(-4, 8)$

In Exercises 11 and 12, write a rule for the translation of $\triangle LMN$ to $\triangle L'M'N'$. (See Example 3.)

11. 
12. 

In Exercises 13–16, use the translation, $(x, y) \rightarrow (x + 8, y + 4)$.

13. What is the image of $A(2, 6)$?
14. What is the image of $B(-1, 5)$?
15. What is the preimage of $C'(-3, -10)$?
16. What is the preimage of $D'(-4, -3)$?

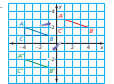
In Exercises 17–20, graph $\triangle PQR$ with vertices $P(-2, 3)$, $Q(1, 2)$, and $R(4, -1)$ and its image after the translation. (See Example 4.)

17. $(x, y) \rightarrow (x + 4, y + 6)$
18. $(x, y) \rightarrow (x - 2, y - 5)$
19. $(x, y) \rightarrow (x - 1, y + 3)$
20. $(x, y) \rightarrow (x + 2, y + 7)$

In Exercises 21 and 22, graph $\triangle XYZ$ with vertices $X(2, 4)$, $Y(6, 0)$, and $Z(2, -2)$ and its image after the composition. (See Example 5.)

21. Translation: $(x, y) \rightarrow (x + 12, y + 4)$
Translation: $(x, y) \rightarrow (x - 5, y - 9)$
22. Translation: $(x, y) \rightarrow (x - 6, y)$
Translation: $(x, y) \rightarrow (x + 2, y + 7)$

In Exercises 23 and 24, describe the composition of translations.

23. 
24. 

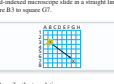
ERROR ANALYSIS Describe and correct the error in graphing the image of quadrilateral $FGHJ$ after the translation $(x, y) \rightarrow (x - 1, y - 2)$.

25. 

MODELING WITH MATHEMATICS In chess, the knight (the piece shaped like a horse) moves in an L pattern. The board shows two consecutive moves of a black knight during a game. Write a composition of translations for the moves. Then describe the composition as a single translation that moves the knight from its original position to its ending position. (See Example 6.)

26. 

PROBLEM SOLVING You are studying an amoeba through a microscope. Suppose the amoeba moves on a grid-induced microscope slide in a straight line from square B3 to square G7.



a. Describe the translation.
b. The side length of each grid square is 2 millimeters. How far does the amoeba travel?
c. The amoeba moves from square B3 to square G7 in 24.5 seconds. What is its speed in millimeters per second?

MATHEMATICAL CONNECTIONS Translation A maps (x, y) to $(x + a, y + b)$. Translation B maps (x, y) to $(x + c, y + d)$.

a. Translate a point using Translation A, followed by Translation B. Write an algebraic rule for the final image of the point after this composition.
b. Translate a point using Translation B, followed by Translation A. Write an algebraic rule for the final image of the point after this composition.
c. Compare the rules you wrote for parts (a) and (b). Does it matter which translation you do first? Explain your reasoning.

MATHEMATICAL CONNECTIONS In Exercises 27 and 28, a translation maps the blue figure to the red figure. Find the value of each variable.

27. 
28. 

Big Ideas Math High School Research

Big Ideas Math Algebra 1, Geometry, and Algebra 2 is a research-based program providing a rigorous, focused, and coherent curriculum for high school students. Ron Larson and Laurie Boswell utilized their expertise as well as the body of knowledge collected by additional expert mathematicians and researchers to develop each course.

The pedagogical approach to this program follows the best practices outlined in the most prominent and widely-accepted educational research and standards, including:

Achieve, ACT, and The College Board

Adding It Up: Helping Children Learn Mathematics
National Research Council ©2001

Common Core State Standards for Mathematics
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Curriculum Focal Points and the *Principles and Standards for School Mathematics* ©2000
National Council of Teachers of Mathematics (NCTM)

Project Based Learning
The Buck Institute

Rigor/Relevance Framework™
International Center for Leadership in Education

Universal Design for Learning Guidelines
CAST ©2011

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We would also like to thank all of our reviewers who took the time to provide feedback during the final development phases.

Common Core State Standards for Mathematical Practice

Make sense of problems and persevere in solving them.

- *Essential Questions* help students focus on core concepts as they analyze and work through each *Exploration*.
- Section opening *Explorations* allow students to struggle with new mathematical concepts and explain their reasoning in the *Communicate Your Answer* questions.

Reason abstractly and quantitatively.

- *Reasoning, Critical Thinking, Abstract Reasoning, and Problem Solving* exercises challenge students to apply their acquired knowledge and reasoning skills to solve each problem.
- *Thought Provoking* exercises test the reasoning skills of students as they analyze and interpret perplexing scenarios.

Construct viable arguments and critique the reasoning of others.

- Students must justify their responses to each *Essential Question* in the *Communicate Your Answer* questions at the end of each *Exploration* set.
- Students are asked to construct arguments and critique the reasoning of others in specialized exercises, including *Making an Argument, How Do You See It?, Drawing Conclusions, Reasoning, Error Analysis, Problem Solving, and Writing*.

Model with mathematics.

- Real-life scenarios are utilized in *Explorations, Examples, Exercises, and Assessments* so students have opportunities to apply the mathematical concepts they have learned to realistic situations.
- *Modeling with Mathematics* exercises allow students to interpret a problem in the context of a real-life situation, often utilizing tables, graphs, visual representations, and formulas.

Use appropriate tools strategically.

- Students are provided opportunities for selecting and utilizing the appropriate mathematical tool in *Using Tools* exercises. Students work with graphing calculators, dynamic geometry software, models, and more.
- A variety of tool papers and manipulatives are available for students to use in problems as strategically appropriate.

Attend to precision.

- *Vocabulary and Core Concept Check* exercises require students to use clear, precise mathematical language in their solutions and explanations.
- The many opportunities for cooperative learning in this program, including working with partners for each *Exploration*, support precise, explicit mathematical communication.

Look for and make use of structure.

- *Using Structure* exercises provide students with the opportunity to explore patterns and structure in mathematics.
- *Proof* exercises require students to understand and apply the structure of geometric theorems to solve each problem.

Look for and express regularity in repeated reasoning.

- Students are continually encouraged to evaluate the reasonableness of their solutions and their steps in the problem-solving process.
- Stepped-out *Examples* encourage students to maintain oversight of their problem-solving process and pay attention to the relevant details in each step.

Go to BigIdeasLearning.com for more information on the Common Core State Standards for Mathematical Practice.

Common Core State Standards for Mathematical Content for Geometry

Chapter Coverage for Standards

1 2 3 4 5 6 7 8 9 10 11 12

Conceptual Category Geometry

● Congruence

1 2 3 4 5 6 7 8 9 10 11 12

Conceptual Category Geometry

● Similarity, Right Triangles, and Trigonometry

1 2 3 4 5 6 7 8 9 10 11 12

Conceptual Category Geometry

● Circles

1 2 3 4 5 6 7 8 9 10 11 12

Conceptual Category Geometry

● Expressing Geometric Properties with Equations

1 2 3 4 5 6 7 8 9 10 11 12

Conceptual Category Geometry

● Geometric Measurement and Dimension

1 2 3 4 5 6 7 8 9 10 11 12

Conceptual Category Statistics and Probability

● Probability

Go to BigIdeasLearning.com for more information on the
Common Core State Standards for Mathematical Content.

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See the Big Idea

Learn how bridges are designed using compression and tension.



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See the Big Idea

Tigers and humans display obvious differences between males and females. Use logic to determine whether other mammals do.

3

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See the Big Idea

Discover why parallel lines and reference points are so important to builders.



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See the Big Idea

Investigate the rotational symmetry of revolving doors and discover why this technology allows skyscrapers to be built.



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See the Big Idea

Learn how to use triangle congruence
in a model hang glider challenge.



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See the Big Idea

Discover why triangles are used in building for strength.



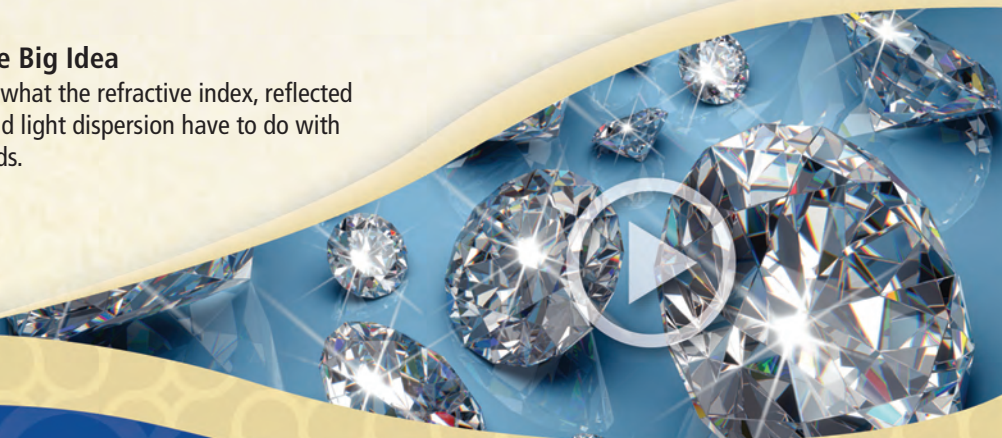
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See the Big Idea

Explore what the refractive index, reflected light, and light dispersion have to do with diamonds.



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See the Big Idea

Discover how many different ways you can scale a model.



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See the Big Idea

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See the Big Idea

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See the Big Idea

Analyze the population density in various parts of Los Angeles—as viewed from an observation point high in the hills of Santa Monica.



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See the Big Idea

Learn about caring for trees at an arboretum.



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How to Use Your Math Book

Get ready for each chapter by **Maintaining Mathematical Proficiency** and reviewing the **Mathematical Practices**. Begin each section by working through the **EXPLORATIONS** to **Communicate Your Answer** to the **Essential Question**. Each **Lesson** will explain **What You Will Learn** through **EXAMPLES**, **Core Concepts**, and **Core Vocabulary**. Answer the **Monitoring Progress** questions as you work through each lesson. Look for **STUDY TIPS**, **COMMON ERRORS**, and suggestions for looking at a problem **ANOTHER WAY** throughout the lessons. We will also provide you with guidance for accurate mathematical **READING** and concept details you should **REMEMBER**.

Sharpen your newly acquired skills with **Exercises** at the end of every section. Halfway through each chapter you will be asked **What Did You Learn?** and you can use the Mid-Chapter **Quiz** to check your progress. You can also use the **Chapter Review** and **Chapter Test** to review and assess yourself after you have completed a chapter.

Apply what you learned in each chapter to a **Performance Task** and build your confidence for taking standardized tests with each chapter's **Cumulative Assessment**.

For extra practice in any chapter, use your *Online Resources*, *Skills Review Handbook*, or your *Student Journal*.

