Colorado
Academic Standards

Mathematics

COLORADO
Department of Education

ALL STUDENTS • ALL STANDARDS

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Purpose of Mathematics

"Pure mathematics is, in its way, the poetry of logical ideas."

~Albert Einstein, *Obituary for Emmy Noether* (1935)

"Systematization is a great virtue of mathematics, and if possible, the student has to learn this virtue, too. But then I mean the activity of systematizing, not its result. Its result is a system, a beautiful closed system, closed with no entrance and no exit. In its highest perfection it can even be handled by a machine. But for what can be performed by machines, we need no humans. What humans have to learn is not mathematics as a closed system, but rather as an activity, the process of mathematizing reality and if possible even that of mathematizing mathematics."

~Hans Freudenthal, *Why to Teach Mathematics So as to Be Useful* (1968)

Mathematics is the human activity of reasoning with number and shape, in concert with the logical and symbolic artifacts that people develop and apply in their mathematical activity. The National Council of Teachers of Mathematics (2018) outlines three primary purposes for learning mathematics:

1. To Expand Professional Opportunity. Just as the ability to read and write was critical for workers when the early 20th century economy shifted from agriculture to manufacturing, the ability to do mathematics is critical for workers in the 21st-century as the economy has shifted from manufacturing to information technology. Workers with a robust understanding of mathematics are in demand by employers, and job growth in STEM (science, technology, engineering, and mathematics) fields is forecast to accelerate over the next decade.

2. Understand and Critique the World. A consequence of living in a technological society is the need to interpret and understand the mathematics behind our social, scientific, commercial, and political systems. Much of this mathematics appears in the way of statistics, tables, and graphs, but this need to understand and critique the world extends to the application of mathematical models, attention given to precision, bias in data collection, and the soundness of mathematical claims and arguments. Learners of mathematics should feel empowered to make sense of the world around them and to better participate as an informed member of a democratic society.

3. Experience Wonder, Joy, and Beauty. Just as human forms and movement can be beautiful in dance, or sounds can make beautiful music, the patterns, shapes, and reasoning of mathematics can also be beautiful. On a personal level, mathematical problem solving can be an authentic act of individual creativity, while on a societal level, mathematics both informs and is informed by the culture of those who use and develop it, just as art or language is used and developed.

References

National Council of Teachers of Mathematics (2018). *Catalyzing change in high school mathematics: Initiating critical conversations*. Reston, VA: National Council of Teachers of Mathematics.

Prepared Graduates in Mathematics

Prepared graduates in mathematics are described by the eight *Standards for Mathematical Practice* described in the Common Core State Standards:

MP1. Make sense of problems and persevere in solving them.

MP2. Reason abstractly and quantitatively.

MP3. Construct viable arguments and critique the reasoning of others.

MP4. Model with mathematics.

MP5. Use appropriate tools strategically.

MP6. Attend to precision.

MP7. Look for and make use of structure.

MP8. Look for and express regularity in repeated reasoning.

Standards in Mathematics

The Colorado Academic Standards in mathematics are the topical organization of the concepts and skills every Colorado student should know and be able to do throughout their preschool through twelfth grade experience. The standards of mathematics are:

1. Number and Quantity
From preschool through high school, students are continually extending their concept of numbers as they build an understanding of whole numbers, rational numbers, real numbers, and complex numbers. As they engage in real-world mathematical problems, they conceive of quantities, numbers with associated units. Students learn that numbers are governed by properties and understand these properties lead to fluency with operations.

2. Algebra and Functions
Algebraic thinking is about understanding and using numbers, and students' work in this area helps them extend the arithmetic of early grades to expressions, equations, and functions in later grades. This mathematics is applied to real-world problems as students use numbers, expressions, and equations to model the world. The mathematics of this standard is closely related to that of Number and Quantity.

3. Data Analysis, Statistics, and Probability
From the early grades, students gather, display, summarize, examine, and interpret data to discover patterns and deviations from patterns. Measurement is used to generate, represent and analyze data. Working with data and an understanding of the principles of probability lead to a formal study of statistics in middle in high school. Statistics provides tools for describing variability in data and for making informed decisions that take variability into account.

4. Geometry
Students' study of geometry allows them to comprehend space and shape. Students analyze the characteristics and relationships of shapes and structures, and engage in logical reasoning. Students learn that geometry is useful in representing, modeling, and solving problems in the real world as well as in mathematics.

Modeling Across the High School Standards

A star symbol (★) in the high school standards represents grade level expectations and evidence outcomes that make up a mathematical modeling standards category.

Modeling links classroom mathematics and statistics to everyday life, work, and decision making. Modeling is the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions. When making mathematical models, technology is valuable for varying assumptions, exploring consequences, and comparing predictions with data. Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards.

COLORADO
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Prepared Graduates:

MP7. Look for and make use of structure.

Grade Level Expectation:

1.NBT.A. Number & Operations in Base Ten: Extend the counting sequence.

Evidence Outcomes

Students Can:

1. Count to 120, starting at any number less than 120. In this range, read and write numerals and represent a number of objects with a written numeral. (CCSS: 1.NBT.A.1)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Make use of the base-ten counting structure when using special words at the decades, like “sixty” and “seventy.” (MP7)

Inquiry Questions:

1. When might someone want to count by tens instead of ones?
2. Which numbers can be written with two numerals and which numbers are written with three?

Coherence Connections:

1. This expectation represents major work of the grade.
2. In kindergarten, students count to 100 by ones and tens, count forward from a given number, and connect counting to cardinality.
3. In Grade 1, this expectation connects with understanding place value and with adding and subtracting within 20.
4. In Grade 2, students extend their place value understanding to hundreds and three-digit numbers, and use this along with the properties of operations to add and subtract within 1000 and fluently add and subtract within 100.

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Prepared Graduates:

MP1. Make sense of problems and persevere in solving them.
MP2. Reason abstractly and quantitatively.
MP4. Model with mathematics.
MP7. Look for and make use of structure.

Grade Level Expectation:

1.NBT.B. Number & Operations in Base Ten: Understand place value.

Evidence Outcomes

Students Can:

2. Understand that the two digits of a two-digit number represent amounts of tens and ones. Understand the following as special cases: (CCSS: 1.NBT.B.2)
   a. 10 can be thought of as a bundle of ten ones — called a "ten." (CCSS: 1.NBT.B.2.a)
   b. The numbers from 11 to 19 are composed of a ten and one, two, three, four, five, six, seven, eight, or nine ones. (CCSS: 1.NBT.B.2.b)
   c. The numbers 10, 20, 30, 40, 50, 60, 70, 80, 90 refer to one, two, three, four, five, six, seven, eight, or nine tens (and 0 ones). (CCSS: 1.NBT.B.2.c)
3. Compare two two-digit numbers based on meanings of the tens and ones digits, recording the results of comparisons with the symbols >, =, and <. (CCSS: 1.NBT.B.3)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Make sense of quantities and their relationships in problem situations. (MP1)
2. Abstract 10 ones into a single conceptual object called a ten. (MP2)
3. Model ones and tens with objects and mathematical representations. (MP4)
4. See the structure of a number as its base-ten units. (MP7)

Inquiry Questions:

1. What does the position of a digit tell you about its value?
2. What are two ways to describe the number 30?
3. Why was a place value system developed? What might numbers look like without it?

Coherence Connections:

1. This expectation represents major work of the grade.
2. In kindergarten, students decompose numbers from 11 to 19 into ten ones and further ones.
3. In Grade 1, this expectation connects with extending the counting sequence and using place value understanding and properties of operations to add and subtract within 100.
4. In Grade 2, students understand hundreds and place value of three-digit numbers, and use this along with the properties of operations to add and subtract.

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Prepared Graduates:

MP1. Make sense of problems and persevere in solving them.
MP7. Look for and make use of structure.

Grade Level Expectation:

1.NBT.C. Number & Operations in Base Ten: Use place value understanding and properties of operations to add and subtract.

Evidence Outcomes

Students Can:

4. Add within 100, including adding a two-digit number and a one-digit number, and adding a two-digit number and a multiple of 10, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used. Understand that in adding two-digit numbers, one adds tens and tens, ones and ones; and sometimes it is necessary to compose a ten. (CCSS: 1.NBT.C.4)
5. Given a two-digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used. (CCSS: 1.NBT.C.5)
6. Subtract multiples of 10 in the range 10–90 from multiples of 10 in the range 10–90 (positive or zero differences), using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used. (CCSS: 1.NBT.C.6)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Perform computation with addition and subtraction while making connections to the properties of operations and to place value structure. (Entrepreneurial Skills: Critical Thinking/Problem Solving)
2. Model quantities with drawings or equations to make sense of place value. (MP1)
3. Use the base-ten structure to add and subtract, including adding and subtracting multiples of ten. (MP7)

Inquiry Questions:

1. Can you add or subtract ten without having to count by ones?
2. How does modeling addition look different if you add tens and ones separately compared to counting on by tens then by ones?

Coherence Connections:

1. This expectation represents major work of the grade.
2. In kindergarten, students model and describe addition as putting together and adding to, and subtraction as taking part and taking from, using objects or drawings. Students also work with numbers 11–19 to gain foundations for place value.
3. In Grade 1, this expectation connects with understanding place value and adding and subtracting within 20.
4. In Grade 2, students understand place value for three-digit numbers and use that understanding and properties of operations to add and subtract within 1000 and fluently add and subtract within 100.

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Prepared Graduates:

MP1. Make sense of problems and persevere in solving them.
MP4. Model with mathematics.

Grade Level Expectation:

1.OA.A. Operations & Algebraic Thinking: Represent and solve problems involving addition and subtraction.

Evidence Outcomes

Students Can:

1. Use addition and subtraction within 20 to solve word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem. (CCSS: 1.OA.A.1)
2. Solve word problems that call for addition of three whole numbers whose sum is less than or equal to 20, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem. (CCSS: 1.OA.A.2)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Make sense of problems by relating objects, drawings, and equations. (MP1)
2. Use cubes, number racks, ten frames and other models to represent addition and subtraction situations in real-world contexts. (MP4)

Inquiry Questions:

1. How can you use cubes to help you compare two numbers?
2. (Given a representation of a value less than ten) How many more do you need to make ten?

Coherence Connections:

1. This expectation represents major work of the grade.
2. In kindergarten, students add and subtract within 10 by using objects or drawings to represent problems.
3. In Grade 1, this expectation connects with comparing, adding, and subtracting numbers, including measurement and data activities.
4. In Grade 2, students represent and solve real-world problems involving addition and subtraction within 100, with fluency expected within 20.

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Prepared Graduates:

MP1. Make sense of problems and persevere in solving them.
MP7. Look for and make use of structure.

Grade Level Expectation:

1.OA.B. Operations & Algebraic Thinking: Understand and apply properties of operations and the relationship between addition and subtraction.

Evidence Outcomes

Students Can:

3. Apply properties of operations as strategies to add and subtract. (Students need not use formal terms for these properties.) *Examples: If* $8 + 3 = 11$ *is known, then* $3 + 8 = 11$ *is also known. (Commutative property of addition.) To add* $2 + 6 + 4$*, the second two numbers can be added to make a ten, so* $2 + 6 + 4 = 2 + 10 = 12$*. (Associative property of addition.)* (CCSS: 1.OA.B.3)
4. Understand subtraction as an unknown-addend problem. *For example, subtract* $10 - 8$ *by finding the number that makes* 10 *when added to* 8*.* (CCSS: 1.OA.B.4)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Make sense of addition and subtraction by applying properties of operations and working with different problem types (see Appendix, Table 1). (MP1)
2. Use properties of operations to recognize equivalent forms of equations. (MP7)

Inquiry Questions:

1. How could you explain why $3 + 8$ and $8 + 3$ both equal 11?
2. How can you use the number line to show how you might use adding OR subtracting to solve the same problem?

Coherence Connections:

1. This expectation represents major work of the grade.
2. In previous grades, students model and describe addition as putting together and adding to, and subtraction as taking apart and taking from, using objects or drawings.
3. In Grade 1, this expectation connects with representing and solving problems involving addition and subtraction and with adding and subtracting within 20.
4. In future grades, students use place value understanding and properties of operations to add and subtract within larger number ranges, then to perform multi-digit arithmetic. Later, students use these concepts to build fractions from unit fractions, and to apply and extend their understandings of arithmetic to algebraic expressions.

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Prepared Graduates:

MP7. Look for and make use of structure.

Grade Level Expectation:

1.OA.C. Operations & Algebraic Thinking: Add and subtract within 20.

Evidence Outcomes

Students Can:

5. Relate counting to addition and subtraction (e.g., by counting on 2 to add 2). (CCSS: 1.OA.C.5)
6. Add and subtract within 20, demonstrating fluency for addition and subtraction within 10. Use strategies such as counting on; making ten (e.g., $8 + 6 = 8 + 2 + 4 = 10 + 4 = 14$); decomposing a number leading to a ten (e.g., $13 - 4 = 13 - 3 - 1 = 10 - 1 = 9$); using the relationship between addition and subtraction (e.g., knowing that $8 + 4 = 12$, one knows $12 - 8 = 4$); and creating equivalent but easier or known sums (e.g., adding $6 + 7$ by creating the known equivalent $6 + 6 + 1 = 12 + 1 = 13$). (CCSS: 1.OA.C.6)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Use multiple strategies to think about problems and see how the quantities involved support the use of some strategies over others. (Entrepreneurial Skills: Critical Thinking/Problem Solving)
2. Make use of the structure of numbers when making tens or when creating equivalent but easier or known sums. (MP7)

Inquiry Questions:

1. Which would you prefer when adding $4 + 7$: starting with 7 and counting up 4 or starting with 4 and counting up 7? Why?
2. Why does knowing doubles like $4 + 4$ or $5 + 5$ help when adding $4 + 5$?
3. How does counting on to add and subtract within 20 make it easier to use fingers even though we have only 10 fingers?

Coherence Connections:

1. This GLE represents major work of the grade.
2. In kindergarten, students understand the relationship between numbers and quantities and connect counting to cardinality.
3. In Grade 1, this expectation connects with place value understanding, properties of addition and subtraction, the relationship between addition and subtraction, and with representing and solving problems involving addition and subtraction.
4. In Grade 2, students fluently add and subtract within 20 using mental strategies and know from memory all sums of two one-digit numbers.

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Prepared Graduates:

MP2. Reason abstractly and quantitatively.
MP3. Construct viable arguments and critique the reasoning of others.

Grade Level Expectation:

1.OA.D. Operations & Algebraic Thinking: Work with addition and subtraction equations.

Evidence Outcomes

Students Can:

7. Understand the meaning of the equal sign, and determine if equations involving addition and subtraction are true or false. *For example, which of the following equations are true and which are false?* $6 = 6$, $7 = 8 - 1$, $5 + 2 = 2 + 5$, $4 + 1 = 5 + 2$. (CCSS: 1.OA.D.7)
8. Determine the unknown whole number in an addition or subtraction equation relating three whole numbers. *For example, determine the unknown number that makes the equation true in each of the equations* $8 + ? = 11$, $5 = \_ - 3$, $6 + 6 = \_$. (CCSS: 1.OA.D.8)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Make sense of quantities and their relationships in problem situations. (MP2)
2. Question assumptions about the meaning of the equals sign and construct viable arguments. (MP3)

Inquiry Questions:

1. What does it mean for two sides of an equation to be "equal"? How can $2 + 3$ "equal" 5?
2. (Given $4 = 4$ If you add 2 more to the 4 on the right, how many do you need to add on the left to make a true statement? How would you write that as an equation?

Coherence Connections:

1. This GLE represents major work of the grade.
2. In kindergarten, students represent addition and subtraction with equations without needing to understand the meaning of the equal sign.
3. In Grade 1, this expectation connects with representing and solving problems involving addition and subtraction.
4. In Grade 2, students work with equal groups of objects to gain foundations for multiplication. In Grade 4, students build fractions from unit fractions and apply addition and subtraction to concepts of angle and angle measurement.

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Prepared Graduates:

MP2. Reason abstractly and quantitatively.
MP3. Construct viable arguments and critique the reasoning of others.
MP5. Use appropriate tools strategically.
MP6. Attend to precision.

Grade Level Expectation:

1.MD.A. Measurement & Data: Measure lengths indirectly and by iterating length units.

Evidence Outcomes

Students Can:

1. Order three objects by length; compare the lengths of two objects indirectly by using a third object. (CCSS: 1.MD.A.1)
2. Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. *Limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps.* (CCSS: 1.MD.A.2)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Abstract comparisons between lengths using statements like $A > B$. (MP2)
2. Use the transitive property to explain if A is longer than B, and B is longer than C, then A must be longer than C. (MP3)
3. Devise different ways to represent the same data set and discuss the strengths and weaknesses of each representation. (MP5)
4. Consider the endpoints of objects when measuring and making comparisons. (MP6)

Inquiry Questions:

1. How is it possible for 5 sticks placed end-to-end to be equal in length to 6 sticks placed end-to-end?
2. Which is longer, the total length of two sticks placed end-to-end vertically or the same two sticks placed end-to-end horizontally?
3. What objects in this classroom are the same length as (or longer than, or shorter than) your forearm?

Coherence Connections:

1. This expectation represents major work of the grade.
2. In kindergarten, students directly compare two objects with a measurable attribute in common.
3. In Grade 1, this expectation is part of a progression of learning that develops conceptions of comparison, conservation, seriation, and iteration.
4. In Grade 2, students measure and estimate lengths in standard units.

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Prepared Graduates:

MP6. Attend to precision.

Grade Level Expectation:

1.MD.B. Measurement & Data: Tell and write time.

Evidence Outcomes

Students Can:

3. Tell and write time in hours and half-hours using analog and digital clocks. (CCSS: 1.MD.B.3)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Tell and manage time to be both personally responsible and responsible to the needs of others. (Personal Skills: Personal Responsibility)
2. Recognize that time is a quantity that can be measured with different degrees of precision. (MP6)

Inquiry Questions:

1. How long is two half-hours?
2. If the time is 2:30, where would the minute hand be pointing on an analog clock?

Coherence Connections:

1. This expectation is in addition to the major work of the grade.
2. In kindergarten, students are not expected to learn how to tell and write time.
3. In Grade 2, students tell and write time from analog and digital clocks to the nearest five minutes.

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Prepared Graduates:

MP1. Make sense of problems and persevere in solving them.
MP2. Reason abstractly and quantitatively.
MP5. Use appropriate tools strategically.
MP6. Attend to precision.

Grade Level Expectation:

1.MD.C. Measurement & Data: Represent and interpret data.

Evidence Outcomes

Students Can:

4. Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another. (CCSS: 1.MD.C.4)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Ask and answer questions about categorical data based on representations of the data. (MP1)
2. Group similar individual objects together and abstract those objects into a new conceptual group. (MP2)
3. Devise different ways to display the same data set then discuss relative strengths and weaknesses of each scheme. (MP5)
4. Use appropriate labels and units of measure. (MP6)

Inquiry Questions:

1. How do different representations of data indicate there are more objects in one category than in another category?
2. How can objects be categorized in different ways?
3. How can an object's attributes determine if it does not belong with other objects in a group?

Coherence Connections:

1. This expectation supports the major work of the grade.
2. In kindergarten, students classify objects into given categories, count the numbers of objects in each category, and sort the categories by count.
3. In Grade 1, this expectation supports representing and solving problems involving addition and subtraction, which is major work of the grade.
4. In Grade 2, students draw a picture graph and a bar graph to represent a data set with up to four categories, and solve put-together, take-apart, and compare problems using the information in a bar graph.

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Prepared Graduates:

MP1. Make sense of problems and persevere in solving them.
MP2. Reason abstractly and quantitatively.
MP3. Construct viable arguments and critique the reasoning of others.
MP7. Look for and make use of structure.

Grade Level Expectation:

1.G.A. Geometry: Reason with shapes and their attributes.

Evidence Outcomes

Students Can:

1. Distinguish between defining attributes (e.g., triangles are closed and three-sided) versus non-defining attributes (e.g., color, orientation, overall size); build and draw shapes to possess defining attributes. (CCSS: 1.G.A.1)
2. Compose two-dimensional shapes (rectangles, squares, trapezoids, triangles, half-circles, and quarter-circles) or three-dimensional shapes (cubes, right rectangular prisms, right circular cones, and right circular cylinders) to create a composite shape, and compose new shapes from the composite shape. (Students do not need to learn formal names, such as "right rectangular prisms.") (CCSS: 1.G.A.2)
3. Partition circles and rectangles into two and four equal shares, describe the shares using the words *halves*, *fourths*, and *quarters*, and use the phrases *half of*, *fourth of*, and *quarter of*. Describe the whole as two of, or four of the shares. Understand for these examples that decomposing into more equal shares creates smaller shares. (CCSS: 1.G.A.3)

Academic Context and Connections

Colorado Essential Skills and Mathematical Practices:

1. Demonstrate flexibility, imagination, and inventiveness in composing two-dimensional and three-dimensional shapes to create composite shapes. (Entrepreneurial Skills: Risk Taking)
2. Sort, classify, build, or draw shapes in terms of defining attributes versus non-defining attributes. (MP1)
3. Determine how to partition a given circle or rectangle into two and four equal shares and describe the whole in terms of equal shares. (MP2)
4. Justify whether a shape belongs in a given category by differentiating between defining attributes and non-defining attributes. (MP3)
5. Analyze how composite shapes can be formed by, or decomposed into, basic shapes. (MP7)

Inquiry Questions:

1. Which properties of shapes are most important when you decide if a shape belongs in a group with other shapes?
2. What kinds of objects can you find in your school or home that are made up of two or more different shapes being put together?
3. In how many different ways can you create two or four equal shares in a rectangle?

Coherence Connections:

1. This expectation is an addition to the major work of the grade.
2. In kindergarten, students identify, describe, analyze, compare, create, and compose shapes (squares, circles, triangles, rectangles, hexagons, cubes, cones, cylinders, and spheres).
3. In Grade 2, students recognize and draw shapes having specified attributes and partition circles and rectangles into two, three, or four equal shares. In Grade 3, students develop understanding of fractions as numbers.