The concept of learning progressions was critical in the development and review of the Common Core State Standards (CCSS). Ohio's learning progressions developed during Ohio's international benchmarking project, provided guidance to the writing committees of the CCSS. Ohio believes that the concept of learning progressions is important for the understanding and coherence of mathematical topics within and across the grade levels. The Ohio Department of Education has reformatted the CCSS by domains to show the progression of concepts and skills across the grade levels.

This document is not designed to replace the CCSS. Instead, it should serve as a companion document to be used by curriculum leaders and teachers to better understand the CCSS and to analyze where their curriculum fits within the standards progression of learning for their students. The following examples are ways to use this document for professional learning communities and curriculum development.

**Multi-grade groups of teachers**

Example 1: Select a domain, beginning at the lowest grade of the domain identify the main concepts at that grade. Follow each concept progressing through the grades by identifying how the concept changes and increases in rigor and understanding for the student. Additionally, identify new concepts that are introduced in subsequent grades and follow them through the years.

Example 2: Building on example one, begin to identify the connections among the standards progressions. For instance, how is Measurement and Data connected (used to develop the essential understandings) to other topics in grades 6-8? How is Measurement and Data used in the service of learning other concepts and skills in K-5?

Example 3: Use the standards progressions to identify where concepts and skills have moved. Some concepts and skills have moved to earlier grades, other to later grades.

**Grade level or individual teachers**

Example 4: In partnership with regular classroom formative assessment, teachers can use these documents to assist in identifying student progress or gaps, and then develop supports to accelerate the students in an effort to bring their understandings and skills to the appropriate level or to go deeper into the content. Note that going deeper does not imply going to the next level in the progression, rather building stronger understandings of the content or making connections to other concepts or skills.

Example 5: It is important to make connections among the standards; between standards within a domain, between standards within a cluster, and between clusters across domains. The Mathematics – K-8 Critical Areas of Focus should also be used for making connections.
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</table>
### Counting and Cardinality

#### Kindergarten

**Know number names and the count sequence.**
1. Count to 100 by ones and by tens.
2. Count forward beginning from a given number within the known sequence (instead of having to begin at 1).
3. Write numbers from 0 to 20. Represent a number of objects with a written numeral 0-20 (with 0 representing a count of no objects).

**Count to tell the number of objects.**
4. Understand the relationship between numbers and quantities; connect counting to cardinality.
   a. When counting objects, say the number names in the standard order, pairing each object with one and only one number name and each number name with one and only one object.
   b. Understand that the last number name said tells the number of objects counted. The number of objects is the same regardless of their arrangement or the order in which they were counted.
   c. Understand that each successive number name refers to a quantity that is one larger.
5. Count to answer “how many?” questions about as many as 20 things arranged in a line, a rectangular array, or a circle; or as many as 10 things in a scattered configuration; given a number from 1-20, count out that many objects.

**Compare numbers.**
6. Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group, e.g., by using matching and counting strategies.1
7. Compare two numbers between 1 and 10 presented as written numerals.
Number and Operations in Base Ten

Kindergarten

- Extend the counting sequence. 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.

Grade One

- Understand place value. Understand that the three digits of a three-digit number represent amounts of hundreds, tens, and ones; e.g., 706 equals 7 hundreds, 0 tens, and 6 ones. Understand the following as special cases:
  a. 100 can be thought of as a bundle of ten tens — called a “hundred.”
  b. The numbers from 11 to 19 are composed of a ten and one, two, three, four, five, six, seven, eight, or nine ones.

Grade Two

- Use place value understanding and properties of operations to perform multi-digit arithmetic. Use place value understanding to round whole numbers to the nearest 10 or 100.

Grade Three

- Use place value understanding and properties of operations to perform multi-digit arithmetic. Use place value understanding to round whole numbers to the nearest 10 or 100.

Grade Four

- Generalize place value understanding for multi-digit whole numbers. Recognize that in a multi-digit whole number, a digit in one place represents ten times what it represents in the place to its right.

Grade Five

- Understand the place value system. Understand that in a multi-digit number, a digit in one place represents ten times as much as it represents in the place to its right and one-tenth of what it represents in the place to its left.

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### Number and Operations in Base Ten

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<td>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. 5. Given a two-digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used. 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. Understand that in adding or subtracting three digit numbers, one adds or subtracts hundreds and hundreds, tens and tens, ones and ones; and sometimes it is necessary to compose or decompose tens or hundreds. 8. Mentally add 10 or 100 to a given number 100–900, and mentally subtract 10 or 100 from a given number 100–900. 9. Explain why addition and subtraction strategies work, using place value and the properties of operations.</td>
<td>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. Understand that in adding or subtracting three digit numbers, one adds or subtracts hundreds and hundreds, tens and tens, ones and ones; and sometimes it is necessary to compose or decompose tens or hundreds. 6. Find whole-number quotients of whole numbers with up to four-digit dividends and one-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.</td>
<td>6. Find whole-number quotients and remainders with up to four-digit dividends and one-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.</td>
<td>algorithm. 6. Find whole-number quotients of whole numbers with up to four-digit dividends and two-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models. 7. Add, subtract, multiply, and divide decimals to hundredths, 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. Foundation for Grade 6 The Number System</td>
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Grade Three

Develop understanding of fractions as numbers.
1. Understand a fraction 1/b as the quantity formed by 1 part when a whole is partitioned into b equal parts; understand a fraction a/b as the quantity formed by a parts of size 1/b.
2. Understand a fraction as a number on the number line; represent fractions on a number line diagram.
   a. Represent a fraction a/b on a number line diagram by defining the interval from 0 to 1 as the whole and partitioning it into b equal parts. Recognize that each part has size 1/b and that the endpoint of the part based at 0 locates the number a/b on the number line.
   b. Represent a fraction a/b on a number line diagram by marking off a lengths 1/b from 0. Recognize that the resulting interval has size a/b and that its endpoint locates the number a/b on the number line.
3. Explain equivalence of fractions in special cases, and compare fractions by reasoning about their size.
   a. Understand two fractions as equivalent (equal) if they are the same whole, including cases of unlike denominators, e.g., by using visual fraction models or equations to represent the problem. Use benchmark fractions and number sense of fractions to estimate mentally and assess the reasonableness of answers.
   b. Recognize and generate simple equivalent fractions, e.g., by expressing a/b as a/b = (n × a)/(n × b).
   c. Express whole numbers as fractions, and recognize fractions that are equivalent to whole numbers.

Extend understanding of fraction equivalence and ordering.
1. Explain why a fraction a/b is equivalent to a fraction (n × a)/(n × b) by using visual fraction models, with attention to how the number and size of the parts differ even though the two fractions themselves are the same size. Use this principle to recognize and generate equivalent fractions.
2. Compare two fractions with different numerators and different denominators, e.g., by creating common denominators or numerators, or by comparing to a benchmark fraction such as 1/2. Recognize that comparisons are valid only when the two fractions refer to the same whole. Record the results of comparisons with symbols >, =, or <, and justify the conclusions, e.g., by using a visual fraction model.

Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.
3. Understand a fraction a/b as a sum of fractions 1/b.
   a. Understand addition and subtraction of fractions as joining and separating parts referring to the same whole.
   b. Decompose a fraction into a sum of fractions with the same denominator in more than one way, recording each decomposition by an equation. Justify decompositions, e.g., by using a visual fraction model.
   c. Add and subtract mixed numbers with like denominators, e.g., by replacing each mixed number with an equivalent fraction, and/or by comparing to a benchmark fraction, or by using properties of operations and the relationship between addition and subtraction.

4. Apply and extend previous understandings of multiplication to multiply a fraction by a whole number.
   a. Understand a fraction a/b as a multiple of 1/b.
   b. Interpret the product (a/b) × q as a partition of q into b equal parts; equivalently, as the result of a sequence of operations a × q/b.
   c. Use a visual fraction model to express 3 × (2/5) as 6 × 1/5, recognizing this product as 6/5. (In general, n × (a/b) = (n × a)/b.)
   d. Solve word problems involving multiplication of a fraction by a whole number, e.g., by using visual fraction models and equations to represent the problem.
   For example, if each person at a party will eat 3/8 of a pound of roast beef, and there will be 5

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### Number and Operations - Fractions

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<td>people at the party, how many pounds of roast beef will be needed? Between what two whole numbers does your answer lie? <strong>Understand decimal notation for fractions, and compare decimal fractions.</strong> 5. Express a fraction with denominator 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with respective denominators 10 and 100. For example, express 3/10 as 30/100, and add 3/10 + 4/100 = 34/100. 6. Use decimal notation for fractions with denominators 10 or 100. For example, rewrite 0.62 as 62/100; describe a length as 0.62 meters; locate 0.62 on a number line diagram. 7. Compare two decimals to hundredths by reasoning about their size. Recognize that comparisons are valid only when the two decimals refer to the same whole. Record the results of comparisons with the symbols &gt;, =, or &lt;, and justify the conclusions, e.g., by using a visual model.</td>
<td>fraction less than 1 results in a product smaller than the given number; and relating the principle of fraction equivalence $a/b = (n \times a)/(n \times b)$ to the effect of multiplying $a/b$ by 1. 6. Solve real world problems involving multiplication of fractions and mixed numbers, e.g., by using visual fraction models or equations to represent the problem. 7. Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions. a. Interpret division of a unit fraction by a non-zero whole number, and compute such quotients. For example, create a story context for $(1/3) \div 4$, and use a visual fraction model to show the quotient. Use the relationship between multiplication and division to explain that $(1/3) \div 4 = 1/12$ because $(1/12) \times 4 = 1/3$. b. Solve real world problems involving division of unit fractions by non-zero whole numbers and division of whole numbers by unit fractions, e.g., by using visual fraction models and equations to represent the problem. For example, how much chocolate will each person get if 3 people share 1/2 lb of chocolate equally? How many 1/3-cup servings are in 2 cups of raisins?</td>
<td>Foundation for Learning in Grade 6 The Number system, Ratios and Proportional Relationships</td>
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</table>
# Kindergarten

**Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from.**

1. Represent addition and subtraction with objects, fingers, mental images, drawings\(^2\), sounds (e.g., claps), acting out situations, verbal explanations, expressions, or equations.

2. Solve addition and subtraction word problems, and add and subtract within 10, e.g., by using objects or drawings to represent the problem.

3. Decompose numbers less than or equal to 10 into pairs in all possible decompositions, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem.

- **Represent and solve problems involving addition and subtraction.**
  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.
  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 drawings, equations, and equations with a symbol for the unknown number to represent the problem.

- **Understand and apply properties of operations and the relationship between addition and subtraction.**
  1. Apply properties of operations as strategies to add and subtract. 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.)
  2. Understand subtraction as an unknown-addend problem. For example, subtract 10 – 8 by finding the number that makes 10 when added to 8.
  3. Relate counting to addition and subtraction (e.g., by counting on from 2 to add 2). Add and subtract within 20, demonstrating fluency for addition and subtraction.

- **Represent and solve problems involving multiplication and division.**
  1. Use addition and subtraction within 100 to solve one- and two-step story problems involving situations of adding, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.

- **Apply properties of operations as strategies to multiply and divide.**
  1. Interpret products of whole numbers, e.g., interpret 5 × 7 as the total number of objects in 5 groups of 7 objects each.
  2. Interpret whole-number quotients of whole numbers, e.g., interpret 56 ÷ 8 as the number of objects in each share when 56 objects are partitioned equally into 8 shares, or as a number of shares when 56 objects are partitioned into equal shares of 8 objects each.

- **Determine the unknown whole number in a multiplication or division equation relating three whole numbers.**

- **Use the four operations with whole numbers to solve problems.**
  1. Interpret a multiplication equation as a comparison, e.g., interpret 5 × 7 as a statement that 5 is 7 times as many as 7 and 7 times as many as 5.
  2. Represent verbal statements of multiplicative comparisons as multiplication equations.

- **Determine the unknown whole number in a multiplication or division equation relating three whole numbers.**

- **Gain familiarity with factors and multiples.**
  1. Use factors to generate multiplication and division equations.
  2. Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them.
## Operations and Algebraic Thinking

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<td><strong>subtraction within 10.</strong> 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);**</td>
<td><strong>write an equation to express the total as a sum of equal addends.</strong></td>
<td><strong>multiply.) 3 \times 5 \times 2 can be found by 3 \times 5 = 15, then 15 \times 2 = 30, or by 5 \times 2 = 10, then 3 \times 10 = 30. (Associative property of multiplication.) Knowing that 8 \times 5 = 40 and 8 \times 2 = 16, one can find 8 \times 7 as 8 \times (5 + 2) = (8 \times 5) + (8 \times 2) = 40 + 16 = 56. (Distributive property.)</strong></td>
<td><strong>6. Understand division as an unknown-factor problem.</strong></td>
<td><strong>number in the range 1–100. Recognize that a whole number is a multiple of each of its factors. Determine whether a given whole number in the range 1–100 is a multiple of a given one-digit number. Determine whether a given whole number in the range 1–100 is prime or composite. Generate and analyze patterns.</strong></td>
<td><strong>5. Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself.</strong></td>
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<td><strong>Work with addition and subtraction equations.</strong></td>
<td><strong>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.</strong></td>
<td><strong>8. Determine the unknown number in a whole-number addition or subtraction equation.</strong></td>
<td><strong>For example, determine the unknown number that makes the equation true in each of the equations 8 + ? = 11, 5 = 3 – 3, 6 \times 6 = ?</strong></td>
<td><strong>7. Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 \times 5 = 40, one knows 40 \div 5 = 8) or properties of operations.</strong></td>
<td><strong>5. Generate a number or shape pattern that follows a given rule. Generate and analyze patterns.</strong></td>
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<td><strong>3. Write and interpret numerical expressions involving whole numbers, including whole-number exponents (e.g., 4 \times 3^2).</strong></td>
<td><strong>4. Generate and analyze patterns.</strong></td>
<td><strong>5. Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself.</strong></td>
<td><strong>For example, given the rule “Add 3” and the starting number 1, generate terms in the resulting sequence and observe that the terms appear to alternate between odd and even numbers. Explain informally why the numbers will continue to alternate in this way.</strong></td>
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## Common Core State Standards – Mathematics

### Geometry (K-5)

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<td>Identify and describe shapes (squares, circles, triangles, rectangles, hexagons, cubes, cones, cylinders, and spheres). 1. Describe objects in the environment using names of shapes, and describe the relative positions of these objects using terms such as above, below, beside, in front of, behind, and next to. 2. Correctly name shapes regardless of their orientations or overall size. 3. Identify shapes as two-dimensional (lying in a plane, &quot;flat&quot;) or three dimensional (&quot;solid&quot;). Analyze, compare, create, and compose shapes. 4. Analyze and compare two- and three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and vertices/&quot;corners&quot;) and other attributes (e.g., having sides of equal length). 5. Model shapes in the world by building shapes from components (e.g., sticks and clay balls) and drawing shapes. 6. Compose simple shapes to form larger shapes. For example, &quot;Can you join these two triangles with full sides touching to make a rectangle?&quot;</td>
<td>Reason with shapes and their attributes. 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. 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. 3. Partition circles and rectangles into two, three, or four equal shares, describe the shares using the words halves, thirds, half of, a third of, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape.</td>
<td>Reason with shapes and their attributes. 1. Recognize and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces. 5 Identify triangles, quadrilaterals, pentagons, hexagons, and cubes. 2. Partition a rectangle into rows and columns of same-size squares and count to find the total number of them. 3. Partition circles and rectangles into two, three, or four equal shares, describe the shares using the words halves, thirds, half of, a third of, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape.</td>
<td>Reason with shapes and their attributes. 1. Understand that shapes in different categories (e.g., rhombuses, rectangles, and others) may share attributes (e.g., having four sides), and that the shared attributes can define a larger category (e.g., quadrilaterals). Recognize rhombuses, rectangles, and squares as examples of quadrilaterals, and draw examples of quadrilaterals that do not belong to any of these subcategories. 2. Partition shapes into parts with equal area. Express the area of each part as a unit fraction of the whole. For example, partition a square into 4 parts with equal area, and describe the area of each part as 1/4 of the area of the shape.</td>
<td>Draw and identify lines and angles, and classify shapes by properties of their lines and angles. 1. Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. 2. Classify two-dimensional figures based on the presence or absence of parallel or perpendicular lines, or the presence or absence of angles of a specified size. Recognize right triangles as a category, and identify right triangles. 3. Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line-symmetric figures and draw lines of symmetry.</td>
<td>Graph points on the coordinate plane to solve real-world and mathematical problems. 1. Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and y-coordinate, y-axis and x-coordinate). 2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. Classify two-dimensional figures into categories based on their properties. 3. Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category. For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles. 4. Classify two-dimensional figures in a hierarchy based on properties. Foundation for Grade 6 Geometry</td>
</tr>
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**Common Core State Standards – Mathematics**

### Standards Progressions

#### Measurement and Data

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<tr>
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</table>
| **Describe and compare measurable attributes.** | 1. Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. 2. Directly compare two objects with a measurable attribute in common, to see which object has “more of”/"less of" the attribute, and describe the difference. For example, directly compare the heights of two children and describe one child as taller/shorter. Classify objects and count the number of objects in each category. 3. Classify objects into given categories; count the numbers of objects in each category and sort the categories by count. | **Measure lengths indirectly and by iterating length units.** | 1. Order three objects by length; compare the lengths of two objects indirectly by using a third object. 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.  | **Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects.** | 1. Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two column table. For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...  | **Convert like measurement units within a given measurement system.** | 1. Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems. **Represent and interpret data.** 2. Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Use operations on fractions for this grade to solve problems involving information presented in line plots. For example, given different measurement data, calculate the mean of the data set. The difference between the data set's median and its mean is the median–mean absolute deviation. **Geometry: understand concepts of angle and measure angles.** 3. Recognize angle as an attribute of shape and analyze shapes to determine if the shape has an angle. 4. Identify angles as right, acute, or obtuse. 5. Recognize angles as decomposable into smaller angles. | **Represent and interpret data.** | 2. Directly compare two objects with a measurable attribute to determine which has “more of”/"less of" the attribute, describing the difference. For example, compare the heights of two children and describe one child as taller/shorter. 3. Organize, represent, and interpret data with up to three categories. Solve “how many more” and “how many less” problems using information presented in scaled bar graphs. For example, draw a bar graph in which each square in the bar graph might represent 2 pets. 4. Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. **Geometric measurement: understand concepts of area and relate area to multiplication and addition.** 5. Recognize area as an attribute of plane figures and understand concepts of area measurement. a. A square with side length 1 unit, called “a unit square,” is said to have “one square unit” of area, and can be used to measure area. b. A rectangle can be decomposed into a set of rectangular triangles, each of which has an area of 1/2 the area of the rectangle. 6. Represent whole numbers as lengths from 0 on a number line diagram with equally spaced points corresponding to the 7. Represent and interpret data. Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Use operations on fractions for this grade to solve problems involving information presented in line plots. For example, given different measurement data, calculate the mean of the data set. The difference between the data set's median and its mean is the median–mean absolute deviation. **Geometry: understand concepts of angle and measure angles.** 3. Recognize angle as an attribute of shape and analyze shapes to determine if the shape has an angle. 4. Identify angles as right, acute, or obtuse. 5. Recognize angles as decomposable into smaller angles. **Represent and interpret data.** 4. Make a line plot to display a data set of measurements in fractions of a unit (1/2, ...
**Measurement and Data**

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<td>numbers 0, 1, 2, ..., and represent whole-number sums and differences within 100 on a number line diagram. <strong>Work with time and money.</strong> 7. Tell and write time from analog and digital clocks to the nearest five minutes, using a.m. and p.m. 8. Solve word problems involving dollar bills, quarters, dimes, nickels, and pennies, using $ and ¢ symbols appropriately. Example: If you have 2 dimes and 3 pennies, how many cents do you have? <strong>Represent and interpret data.</strong> 9. Generate measurement data by measuring lengths of several objects to the nearest whole unit, or by making repeated measurements of the same object. Show the measurements by making a line plot, where the horizontal scale is marked off in whole-number units. 10. Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put together, take-apart, and compare problems using information presented in a bar graph.</td>
<td>A plane figure which can be covered without gaps or overlaps by n unit squares is said to have an area of n square units. 6. Measure areas by counting unit squares (square cm, square m, square in, square ft, and improvised units). 7. Relate area to the operations of multiplication and addition. a. Find the area of a rectangle with whole-number side lengths by tiling it, and show that the area is the same as would be found by multiplying the side lengths. b. Multiply side lengths to find areas of rectangles with whole number side lengths in the context of solving real world and mathematical problems, and represent whole-number products as rectangular areas in mathematical reasoning. c. Use tiling to show in a concrete case that the area of a rectangle with whole-number side lengths a and b + c is the sum of a x b and a x c. Use area models to represent the distributive property in mathematical reasoning. d. Recognize area as additive. Find areas of rectilinear figures by decomposing them into non-overlapping rectangles and adding the areas of the non-overlapping parts, applying this technique to solve real world problems. <strong>Geometric measurement: recognize perimeter as an attribute of plane figures and distinguish between linear and area measures.</strong> 8. Solve real world and mathematical problems involving perimeters of polygons, including finding the perimeter given the side lengths, finding an unknown side length, and exhibiting rectangles with the same perimeter and different areas or with the same area and different perimeters.</td>
<td>1/4, 1/8. Solve problems involving addition and subtraction of fractions by using information presented in line plots. For example, from a line plot find and interpret the difference in length between the longest and shortest specimens in an insect collection. <strong>Geometric measurement: understand concepts of angle and measure angles.</strong> 5. Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement: a. An angle is measured with reference to a circle with its center at the common endpoint of the rays, by considering the fraction of the circular arc between the points where the two rays intersect the circle. An angle that turns through 1/360 of a circle is called a &quot;one-degree angle,&quot; and can be used to measure angles. b. An angle that turns through n one-degree angles is said to have an angle measure of n degrees. 6. Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure. 7. Recognize angle measure as additive. When an angle is decomposed into non-overlapping parts, the angle measure of the parts is the sum of the angle measures of the parts. Solve addition and subtraction problems to find unknown angles on a diagram in real world and mathematical problems, e.g., by using an equation with a symbol for the unknown angle measure.</td>
<td>cubes, using cubic cm, cubic in, cubic ft, and improvised units. 5. Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume. a. Find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base. Represent threefold whole-number products as volumes, e.g., to represent the associative property of multiplication. b. Apply the formulas V = l x w x h and V = b x h for rectangular prisms to find volumes of right rectangular prisms with whole number edge lengths in the context of solving real world and mathematical problems. c. Recognize volume as additive. Find volumes of solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real world problems. Foundation for Grade 6 Geometry, Statistics and Probability</td>
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# Ratios and Proportional Relationships

## Grade Six

Understand ratio concepts and use ratio reasoning to solve problems.

1. Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
   
   For example, “The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak.” “For every vote candidate A received, candidate C received nearly three votes.”

2. Understand the concept of a unit rate \( \frac{a}{b} \) associated with a ratio \( a:b \) with \( b \neq 0 \), and use rate language in the context of a ratio relationship.

   For example, “This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is \( \frac{3}{4} \) cup of flour for each cup of sugar.” “We paid $75 for 15 hamburgers, which is a rate of $5 per hamburger.”

3. Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
   
   a. Make tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
   
   b. Solve unit rate problems including those involving unit pricing and constant speed.

   For example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what rate were lawns being mowed?

   c. Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

   d. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

Previous Learning from Grade 5 Number and Operations in Base Ten, Number and Operations - Fractions

## Grade Seven

Analyze proportional relationships and use them to solve real-world and mathematical problems.

1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units.

   For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour.

2. Recognize and represent proportional relationships between quantities.

   a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.

   b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.

   c. Represent proportional relationships by equations.

   For example, if total cost \( t \) is proportional to the number \( n \) of items purchased at a constant price \( p \), the relationship between the total cost and the number of items can be expressed as \( t = pn \).

   d. Explain what a point \((x, y)\) on the graph of a proportional relationship means in terms of the situation, with special attention to the points \((0, 0)\) and \((1, r)\) where \( r \) is the unit rate.

3. Use proportional relationships to solve multistep ratio and percent problems.

   Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.
### Common Core State Standards – Mathematics

#### Standards Progressions

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<th>The Number System</th>
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<td><strong>Grade Six</strong></td>
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<tr>
<td>Apply and extend previous understandings of multiplication and division to divide fractions by fractions.</td>
</tr>
<tr>
<td>1. Interpret and compute quotients of fractions, and solve word problems involving division of fractions by fractions, e.g., by using visual fraction models and equations to represent the problem. For example, create a story context for (2/3) ÷ (3/4) and use a visual fraction model to show the quotient; relate the relationship between multiplication and division to explain that (2/3) ÷ (3/4) = 8/9 because 3/4 of 8/9 is 2/3 (In general, (a/b) ÷ (c/d) = ad/bc). How much chocolate will each person get if 3 people share 1 2/3 lb of chocolate equally? How many 3/4-cup servings are in 2/3 of a cup of yogurt? How wide is a rectangular strip of land with length 3/4 mi and area 1/2 square mi?</td>
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<tr>
<td>2. Fluently divide multi-digit numbers using the standard algorithm.</td>
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<tr>
<td>3. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation. For example, express 36 + 8 as 4 (9 + 2).</td>
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<td>4. Find the greatest common factor of two whole numbers less than or equal to 100 and the least common multiple of two whole numbers less than or equal to 12. Use the distributive property to express a sum of two whole numbers 1 – 100 with a common factor as a multiple of a sum of two whole numbers with no common factor. For example, express 36 + 8 as 4 (9 + 2).</td>
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<tr>
<td>5. Understand that positive and negative numbers are used together to describe quantities having opposite directions in real-world contexts, explaining the meaning of 0 in each situation.</td>
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<tr>
<td>6. Understand a rational number as a point on the number line. Extend number line diagrams and coordinate axes familiar from previous grades to represent points on the line and in the plane with negative number coordinates. a. Recognize opposite signs of numbers as indicating locations on opposite sides of 0 on the number line; recognize that the opposite of the opposite of a number is the number itself, e.g., (–(–3)) = 3, and that 0 is its own opposite. b. Understand signs of numbers in ordered pairs as indicating locations in quadrants of the coordinate plane; recognize that when two ordered pairs differ only by signs, the locations of the points are related by reflections across one or both axes. c. Find and position integers and other rational numbers on a horizontal or vertical number line diagram; find and position pairs of integers and other rational numbers on a coordinate plane. 7. Understand ordering and absolute value of rational numbers. a. Interpret statements of inequality as statements about the relative position of two numbers on a number line diagram. For example, interpret –3 &gt; –7 as a statement that –3 is located to the right of –7 on a number line oriented from left to right. b. Write, interpret, and explain statements of order for rational numbers in real-world contexts. For example, write –3 °C &gt; –7°C to express the fact that –3 °C is warmer than –7°C. c. Understand the absolute value of a rational number as its distance from 0 on the number line; interpret absolute value as magnitude for a positive or negative quantity in a real-world situation.</td>
</tr>
<tr>
<td>8. Understand that positive and negative numbers are used together to describe quantities having opposite directions in real-world contexts, explaining the meaning of 0 in each situation.</td>
</tr>
<tr>
<td>9. Apply and extend previous understandings of numbers to the system of rational numbers. 5. Understand that positive and negative numbers are used together to describe quantities having opposite directions in real-world contexts, explaining the meaning of 0 in each situation.</td>
</tr>
<tr>
<td>Know that positive and negative numbers are used together to describe quantities having opposite directions in real-world contexts, explaining the meaning of 0 in each situation.</td>
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Ohio Department of Education (2/14/12)
The Number System

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<tr>
<td>For example, for an account balance of $-30$ dollars, write $</td>
<td>-30</td>
<td>= 30$ to describe the size of the debt in dollars.</td>
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<tr>
<td>d. Distinguish comparisons of absolute value from statements about order.</td>
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<tr>
<td>For example, recognize that an account balance less than $-30$ dollars represents a debt greater than $30$ dollars.</td>
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<td>8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.</td>
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Previous Learning from Grade 5 Number and Operations in Base Ten, Number and Operations - Fractions
### Grade Six
Apply and extend previous understandings of arithmetic to algebraic expressions.
1. Write and evaluate numerical expressions involving whole-number exponents.
2. Write, read, and evaluate expressions in which letters stand for numbers.
   a. Write expressions that record operations with numbers and with letters standing for numbers.
      For example, express the calculation "Subtract y from 5" as 5 – y.
   b. Identify parts of an expression using mathematical terms (sum, term, product, factor, quotient, coefficient); view one or more parts of an expression as a single entity.
      For example, describe the expression 2 (8 + 7) as a product of two factors; view (8 + 7) as both a single entity and a sum of two terms.
   c. Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole number exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations).
      For example, use the formulas V = s^3 and A = 6 s^2 to find the volume and surface area of a cube with sides of length s = 1/2.
3. Apply the properties of operations to generate equivalent expressions.
   For example, apply the distributive property to the expression 3 (2 + x) to produce the equivalent expression 6 + 3x; apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.
   For example: If a woman making $25 an hour gets a 10% raise, she will make an additional $2.50, for a new salary of $27.50. If you want to place a towel bar 9 3/4 inches long in the center of a door that is 27 1/2 inches wide, you will need to place the bar about 9 inches from each edge; this estimate can be used as a check on the exact computation.
4. Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
   a. Solve word problems leading to equations of the form px + q = r and p(x + q) = r, where p, q, and r are specific rational numbers. Solve equations of these forms fluently. Compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach.
   b. Solve problems by reasoning about the quantities.
      a. Solve word problems leading to equations of the form px + q = r or px + q = r, where p, q, and r are specific rational numbers. Graph the solution set of the inequality and interpret it in the context of the problem.
      For example: As a salesperson, you are paid $50 per week plus $3 per sale. This week you want your pay to be at least $100. Write an inequality for the

### Grade Seven
Use properties of operations to generate equivalent expressions.
1. Apply properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients.
2. Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related.
   For example, a + 0.05a = 1.05a means that “increase by 5%” is the same as “multiply by 1.05.”
3. Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
   a. Solve word problems leading to equations of the form px + q = r and p(x + q) = r, where p, q, and r are specific rational numbers. Solve equations of these forms fluently. Compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach.
   b. Solve problems by reasoning about the quantities.
      a. Solve word problems leading to equations of the form px + q = r or px + q = r, where p, q, and r are specific rational numbers. Graph the solution set of the inequality and interpret it in the context of the problem.
      For example: As a salesperson, you are paid $50 per week plus $3 per sale. This week you want your pay to be at least $100. Write an inequality for the

### Grade Eight
Work with radicals and integer exponents.
1. Know and apply the properties of integer exponents to generate equivalent numerical expressions.
   For example, 32 × 3−5 = 3−3 = 1/33 = 1/27.
2. Use square root and cube root symbols to represent solutions to equations of the form x^2 = p and x^3 = p, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that v2 is irrational.
3. Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other.
   For example, estimate the population of the United States as 3 × 10^8 and the population of the world as 7 × 10^9, and determine that the world population is more than 20 times larger.
4. Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading).
   Interpret scientific notation that has been generated by technology.
   Understand the connections between proportional relationships, lines, and linear equations.
5. Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways.
   For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed.
6. Use similar triangles to explain why the slope is the same between any two different points on a non-vertical line in the coordinate plane; derive the equation y = mx for a line through the origin and the equation y = mx + b for a line intercepting the vertical axis at b.
   Analyze and solve linear equations and pairs of simultaneous linear equations.
7. Solve linear equations in one variable.
   a. Give examples of linear equations in one variable with one solution, infinitely many solutions, or no solutions. Show which of these possibilities is the case by successively transforming the given equation into simpler forms, until an equivalent equation of the form x = a, a = a, or a = b results (where a and b are different
Expressions and Equations

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| a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.  
7. Solve real-world and mathematical problems by writing and solving equations of the form \( x + p = q \) and \( px = q \) for cases in which \( p \), \( q \) and \( x \) are all nonnegative rational numbers.  
8. Write an inequality of the form \( x > c \) or \( x < c \) to represent a constraint or condition in a real-world or mathematical problem. Recognize that inequalities of the form \( x > c \) or \( x < c \) have infinitely many solutions; represent solutions of such inequalities on number line diagrams.  
Represent and analyze quantitative relationships between dependent and independent variables.  
9. Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation \( d = 65t \) to represent the relationship between distance and time.  

Previous Learning from Grade 5 Operations and Algebraic Thinking

| number of sales you need to make, and describe the solutions. |
| b. Solve linear equations with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms.  
8. Analyze and solve pairs of simultaneous linear equations.  
a. Understand that solutions to a system of two linear equations in two variables correspond to points of intersection of their graphs, because points of intersection satisfy both equations simultaneously.  
b. Solve systems of two linear equations in two variables algebraically, and estimate solutions by graphing the equations. Solve simple cases by inspection. For example, \( 3x + 2y = 5 \) and \( 3x + 2y = 6 \) have no solution because \( 3x + 2y \) cannot simultaneously be 5 and 6.  
c. Solve real-world and mathematical problems leading to two linear equations in two variables. For example, given coordinates for two pairs of points, determine whether the line through the first pair of points intersects the line through the second pair. |

numbers).
Functions

Grade Eight

Define, evaluate, and compare functions.
1. Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
2. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).
   For example, given a linear function represented by a table of values and a linear function represented by an algebraic expression, determine which function has the greater rate of change.
3. Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear.
   For example, the function $A = s^2$ giving the area of a square as a function of its side length is not linear because its graph contains the points $(1,1)$, $(2,4)$ and $(3,9)$, which are not on a straight line.

Use functions to model relationships between quantities.
4. Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two $(x, y)$ values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.
5. Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

Previous learning from Grade 5 Operations and Algebraic Thinking.
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<td><strong>Solve real-world and mathematical problems involving area, surface area, and volume.</strong> 1. Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems. 2. Find the volume of a right rectangular prism with fractional edge lengths by packing it with unit cubes of the appropriate unit fraction edge lengths, and show that the volume is the same as would be found by multiplying the edge lengths of the prism. Apply the formulas $V = l \times w \times h$ and $V = b \times h$ to find volumes of right rectangular prisms and right rectangular pyramids.</td>
<td><strong>Draw, construct, and describe geometrical figures and describe the relationships between them.</strong> 1. Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. 2. Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle. 3. Describe the two-dimensional figures that result from slicing three dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids. <strong>Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.</strong> 4. Know the formulas for the area and circumference of a circle. Use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle. 5. Use facts about supplementary, complementary, vertical, and adjacent angles in a multi-step problem to write and solve simple equations for an unknown angle in a figure. 6. Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.</td>
<td><strong>Understand congruence and similarity using physical models, transparencies, or geometry software.</strong> 1. Verify experimentally the properties of rotations, reflections, and translations: a. Lines are taken to lines, and line segments to line segments of the same length. b. Angles are taken to angles of the same measure. c. Parallel lines are taken to parallel lines. 2. Understand that a two-dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them. 3. Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates. 4. Understand that a two-dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two dimensional figures, describe a sequence that exhibits the similarity between them. 5. Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. <strong>Understand and apply the Pythagorean Theorem.</strong> 6. Explain a proof of the Pythagorean Theorem and its converse. 7. Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. 8. Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. <strong>Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.</strong> 9. Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.</td>
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### Common Core State Standards – Mathematics

#### Standards Progressions

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<th>Grade Six</th>
<th>Grade Seven</th>
<th>Grade Eight</th>
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<tr>
<td><strong>Statistics and Probability</strong></td>
<td><strong>Use random sampling to draw inferences about a population.</strong></td>
<td><strong>Investigate patterns of association in bivariate data.</strong></td>
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<td>1. Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers. For example, “How old am I?” is not a statistical question, but “How old are the students in my school?” is a statistical question because one anticipates variability in students’ ages.</td>
<td>1. Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.</td>
<td>1. Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.</td>
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<td>2. Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.</td>
<td>2. Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions. For example, estimate the mean word length in a book by randomly sampling words from the book; predict the winner of a school election based on randomly sampled survey data. Gauge how far off the estimate or prediction might be.</td>
<td>2. Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.</td>
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<td>3. Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number. Summarize and describe distributions.</td>
<td>3. Informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers by expressing it as a multiple of a measure of variability. For example, the mean height of players on the basketball team is 10 cm greater than the mean height of players on the soccer team, about twice the variability (mean absolute deviation) on either team; on a dot plot, the separation between the two distributions of heights is noticeable.</td>
<td>3. Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept. For example, in a linear model for a biology experiment, interpret a slope of 1.5 cm/yr as meaning that an additional hour of sunlight each day is associated with an additional 1.5 cm in mature plant height.</td>
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<td>4. Display numerical data in plots on a number line, including dot plots, histograms, and box plots.</td>
<td>4. Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations. For example, decide whether the words in a chapter of a seventh-grade science book are generally longer than the words in a chapter of a fourth-grade science book.</td>
<td>4. Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables.</td>
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<td>5. Summarize numerical data sets in relation to their context, such as by:</td>
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<td><em>For example, collect data from students in your class on whether or not they have a curfew on school nights and whether or not they have assigned chores at home. Is there evidence that those who have a curfew also tend to have chores?</em></td>
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<td>a. Reporting the number of observations.</td>
<td>a. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.</td>
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<td>b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.</td>
<td>b. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.</td>
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<td>c. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.</td>
<td>c. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.</td>
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<td>d. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.</td>
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Ohio Department of Education (2/14/12)
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| explain possible sources of the discrepancy. | a. Develop a uniform probability model by assigning equal probability to all outcomes, and use the model to determine probabilities of events.  
For example, if a student is selected at random from a class, find the probability that Jane will be selected and the probability that a girl will be selected.  
b. Develop a probability model (which may not be uniform) by observing frequencies in data generated from a chance process.  
For example, find the approximate probability that a spinning penny will land heads up or that a tossed paper cup will land open-end down. Do the outcomes for the spinning penny appear to be equally likely based on the observed frequencies?  
8. Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation.  
a. Understand that, just as with simple events, the probability of a compound event is the fraction of outcomes in the sample space for which the compound event occurs.  
b. Represent sample spaces for compound events using methods such as organized lists, tables and tree diagrams. For an event described in everyday language (e.g., "rolling double sixes"), identify the outcomes in the sample space which compose the event.  
c. Design and use a simulation to generate frequencies for compound events.  
For example, use random digits as a simulation tool to approximate the answer to the question: If 40% of donors have type A blood, what is the probability that it will take at least 4 donors to find one with type A blood? | | |