FIRST® LEGO® League Common Core Mathematics Standards Alignment & Instructional Exemplars

Rationale	Color Code
There is no evidence that the standard is addressed as part of a _FIRST_® program.	
This standard potentially could be addressed as part of a _FIRST_® program either by actions that the coach/mentor takes when working with the students or by conditions established by the program for that given year.	
The standard is clearly addressed by program activities.	

			Standards for Mathematical Practice	_FIRST_® Alignment	Instructional Exemplar
Standards for Mathematical Practice	Make sense of problems and persevere in solving them.	MP1	Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their		As part of the _FIRST_® LEGO® League experience students will be expected to analyze the Challenge, develop solutions, test and refine their answers all while using mathematical formulas and data. These actions are at the heart of the mathematical practice of making sense of problems and persevering to determine solutions.
Standards for Mathematical Practice	Reason abstractly and quantitatively.	MP2	Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing		Through participation in the _FIRST_® LEGO® League program students will develop their ability to reason both quantitatively and abstractly as they work to solve problems associated with the Challenge and in designing, building and programming their robot

Standards for Mathematical Practice	Construct viable arguments and critique the reasoning of others.	MP3	Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to		Building off the first practice, students in the *FIRST*® LEGO® League program will interact with their peers and be expected to provide reasoned critique of solutions developed, supported by evidence and viable arguments.
Standards for Mathematical Practice	Model with mathematics.	MP4	Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw		Students in the *FIRST*® LEGO® League program will use mathematics and mathematical tools (e.g., charts, graphs, tables) to create different models that inform choices they make about robot design and programming.
Standards for Mathematical Practice	Use appropriate tools strategically.	MP5	Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or		Students in the *FIRST*® LEGO® League program will use a variety of age-appropriate mathematical tools (e.g., charts, graphs, tables, calculators) to solve mathematical problems encountered as they work to program their robot and optimize their strategy to address the Challenge.

Standards for Mathematical Practice	Attend to precision.	MP6	Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions.		In order to complete the missions of the Robot Game in the most efficient manner possible, students in the *FIRST*® LEGO® League program will have to develop their mathematical precision as they program their robot to interact with the different mission structures as well as navigate the Robot Game board.
Standards for Mathematical Practice	Look for and make use of structure.	MP7	Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. Later, students will see 7 × 8 equals the well remembered 7 × 5 + 7 × 3, in preparation for learning about the distributive property. In the expression x2 + 9x + 14, older students can see the 14 as 2 × 7 and the 9 as 2 + 7. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see 5 - 3(x -y)2 as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y.		Students in the *FIRST*® LEGO® League program will learn to recognize and use patterns to solve problems and address the Challenge. In particular, students will take advantage of the properties of different shapes when they build their robot, program its movements, and determine solutions for the different missions.
Standards for Mathematical Practice	Look for and express regularity in repeated reasoning.	MP8	Mathematically proficient students notice if calculations are repeated, and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. By paying attention to the calculation of slope as they repeatedly check whether points are on the line through (1, 2) with slope 3, middle school students might abstract the equation (y - 2)/(x - 1) = 3. Noticing the regularity in the way terms cancel when expanding (x - 1)(x + 1), (x - 1)(x2 + x + 1), and (x - 1)(x3 + x2 +x + 1) might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.		Students in the *FIRST*® LEGO® League program will be able to experience regularity in repeated reasoning as they program their robot to complete the different missions in the Robot Game.

Domain	**Cluster**	**Standard**	**Indicator/Skill**	***FIRST*® Alignment**	**Instructional Exemplar**
Operations and Algebraic Thinking	Write and interpret numerical expressions.	5.OA.A.1	Use parentheses, brackets, or braces in numerical expressions, and evaluate expressions with these symbols.		If students choose to write out calculations and mathematical expressions, they will have the opportunity to use parentheses, brackets, or braces.

Operations and Algebraic Thinking	Write and interpret numerical expressions.	5.OA.A.2	Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them. For example, express the calculation “add 8 and 7, then multiply by 2” as 2 × (8 + 7). Recognize that 3 × (18932 + 921) is three times as large as 18932 + 921, without having to calculate the indicated sum or product.	If the coach/mentor requires it, students will have the opportunity to write simple expressions.
Operations and Algebraic Thinking	Analyze patterns and relationships.	5.OA.B.3	Generate two numerical patterns using two given rules. Identify apparent relationships between corresponding terms. Form ordered pairs consisting of corresponding terms from the two patterns, and graph the ordered pairs on a coordinate plane. For example, given the rule “Add 3” and the starting number 0, and given the rule “Add 6” and the starting number 0, generate terms in the resulting sequences, and observe that the terms in one sequence are twice the corresponding terms in the other sequence. Explain informally why this is so.	As part of strategy design and robot programming, students will have to work with and develop numerical patterns between two related terms.
Number & Operations in Base Ten	Understand the place value system.	5.NBT.A.1	Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.	In order to correctly program the robot to complete tasks, students will use the place value system to evaluate the relationships between different numbers, especially metric measurements.
Number & Operations in Base Ten	Understand the place value system.	5.NBT.A.2	Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. Read, write, and compare decimals to thousandths.	In order to correctly program the robot to complete tasks, students will use decimals and analyze the placement of the decimal in different numbers.
Number & Operations in Base Ten	Understand the place value system.	5.NBT.A.3.A	a. Read and write decimals to thousandths using base-ten numerals, number names, and expanded form, e.g., 347.392 = 3 × 100 + 4 × 10 + 7 × 1 + 3 × (1/10) + 9 × (1/100) + 2 × (1/1000). Read, write, and compare decimals to thousandths.	During robot programming, or when taking measurements, students will read and write decimals to the thousandths.
Number & Operations in Base Ten	Understand the place value system.	5.NBT.A.3.B	b. Compare two decimals to thousandths based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.	During robot programming, or when taking measurements, students will compare and evaluate decimals to the thousandths.
Number & Operations in Base Ten	Understand the place value system.	5.NBT.A.4	Use place value understanding to round decimals to any place.	Students will need to round decimals during the programming of the robot.
Number & Operations in Base Ten	Perform operations with multi-digit whole numbers and with decimals to hundredths.	5.NBT.B.5	Fluently multiply multi-digit whole numbers using the standard algorithm.	As part of robot programming, students will multiply multi-digit whole numbers.
Number & Operations in Base Ten	Perform operations with multi-digit whole numbers and with decimals to hundredths.	5.NBT.B.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.	As part of robot programming, students will divide multi-digit whole numbers.

Number & Operations in Base Ten	Perform operations with multi-digit whole numbers and with decimals to hundredths.	5.NBT.B.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.		As part of robot programming, students will add, subtract, multiply, and divide multi-digit whole numbers.
Number & Operations - Fractions	Use equivalent fractions as a strategy to add and subtract fractions.	5.NF.A.1	Add and subtract fractions with unlike denominators (including mixed numbers) by replacing given fractions with equivalent fractions in such a way as to produce an equivalent sum or difference of fractions with like denominators. For example, 2/3 + 5/4 = 8/12 + 15/12 = 23/12. (In general, a/b + c/d = (ad + bc)/bd.)		As part of programming, students will have to combine fractions with different denominators to determine different robot motions. Students will also measure fractional distances for the robot to move and combine those measurements by adding fractions.
Number & Operations - Fractions	Use equivalent fractions as a strategy to add and subtract fractions.	5.NF.A.2	Solve word problems involving addition and subtraction of fractions referring to 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. For example, recognize an incorrect result 2/5 + 1/2 = 3/7, by observing that 3/7 < 1/2.		If the coach/mentor chooses, the students can work with word problems related to robot programming and movement involving fractions.
Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.3	Interpret a fraction as division of the numerator by the denominator (a/b = a ÷ b). Solve word problems involving division of whole numbers leading to answers in the form of fractions or mixed numbers, e.g., by using visual fraction models or equations to represent the problem. For example, interpret 3/4 as the result of dividing 3 by 4, noting that 3/4 multiplied by 4 equals 3, and that when 3 wholes are shared equally among 4 people each person has a share of size 3/4. If 9 people want to share a 50-pound sack of rice equally by weight, how many pounds of rice should each person get? Between what two whole numbers does your answer lie?		During programming of the robot, students will work with the division of fractions where the numerator is divided by the denominator; particularly when fractions have to be entered into the computer as decimals.
Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.4.A	Apply and extend previous understandings of multiplication to multiply a fraction or whole number by a fraction. a. Interpret the product (a/b) × q as a parts of a partition of q into b equal parts; equivalently, as the result of a sequence of operations a × q ÷ b. For example, use a visual fraction model to show (2/3) × 4 = 8/3, and create a story context for this equation. Do the same with (2/3) × (4/5) = 8/15. (In general, (a/b) × (c/d) = ac/bd.)		During programming and solving missions, students will interpret parts of a whole, and use sequences of operations to program the robot to achieve the Robot Game missions.
Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.4.B	Apply and extend previous understandings of multiplication to multiply a fraction or whole number by a fraction. b. Find the area of a rectangle with fractional side lengths by tiling it with unit squares of the appropriate unit fraction side lengths, and show that the area is the same as would be found by multiplying the side lengths. Multiply fractional side lengths to find areas of rectangles, and represent fraction products as rectangular areas.		If the coach/mentor chooses, students can investigate areas of rectangles with fractional side lengths using the LEGO® bricks.

Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.5.A	Interpret multiplication as scaling (resizing), by: a. Comparing the size of a product to the size of one factor on the basis of the size of the other factor, without performing the indicated multiplication.		As students develop their game strategies, or program the robot, they will be able to evaluate the impact of scaling based on the factors involved.
Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.5.B	Interpret multiplication as scaling (resizing), by: b. Explaining why multiplying a given number by a fraction greater than 1 results in a product greater than the given number (recognizing multiplication by whole numbers greater than 1 as a familiar case); explaining why multiplying a given number by a fraction less than 1 results in a product smaller than the given number; and relating the principle of fraction equivalence a/b = (n×a)/(n×b) to the effect of multiplying a/b by 1.		If the coach/mentor chooses, the students can explain how multiplication by various fractions affects the size of the product.
Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.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.		While programming or developing game strategy, students will have to solve real-world problems using multiplication of fractions and mixed numbers.
Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.7.A	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) ÷ 4, and use a visual fraction model to show the quotient. Use the relationship between multiplication and division to explain that (1/3) ÷ 4 = 1/12 because (1/12) × 4 = 1/3.		If the coach/mentor chooses, students can divide fractions using LEGO® bricks to solve robot building problems or create story context for proposed problems using the LEGO® bricks.
Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.7.B	Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions. b. Interpret division of a whole number by a unit fraction, and compute such quotients. For example, create a story context for 4 ÷ (1/5), and use a visual fraction model to show the quotient. Use the relationship between multiplication and division to explain that 4 ÷ (1/5) = 20 because 20 × (1/5) = 4.		If the coach/mentor chooses, students can divide fractions using LEGO® bricks to solve robot building problems or create story context for proposed problems using the LEGO® bricks.
Number & Operations - Fractions	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	5.NF.B.7. C	Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions. c. 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?		If the coach/mentor chooses, students can divide fractions using LEGO® bricks to solve robot building problems or create story context for proposed problems using the LEGO® bricks.

Measurement & Data	Convert like measurement units within a given measurement system.	5.MD.A.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.		In order to correctly program the robot students will be required to convert numbers from different units (e.g. cm to mm) within a given measurement system.
Measurement & Data	Represent and interpret data.	5.MD.B.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 measurements of liquid in identical beakers, find the amount of liquid each beaker would contain if the total amount in all the beakers were redistributed equally.		To develop their robot's navigation program, students will have to collect a variety of different types of data such as distances traveled, rotation of wheels, length of movement. This will require them to develop representations of the information (e.g. tables and graphs) as well as make interpretations of the information to develop the robot's programming.
Measurement & Data	Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.	5.MD.C.3.A	Recognize volume as an attribute of solid figures and understand concepts of volume measurement. a. A cube with side length 1 unit, called a “unit cube,” is said to have “one cubic unit” of volume, and can be used to measure volume.		Depending upon the Challenge, students may have the opportunity to explore the concept of volume as they design elements of their robot to lift, move, or carry the highest number of LEGO® bricks at one time.
Measurement & Data	Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.	5.MD.C.3.B	Recognize volume as an attribute of solid figures and understand concepts of volume measurement. b. A solid figure which can be packed without gaps or overlaps using n unit cubes is said to have a volume of n cubic units.		Depending upon the Challenge, students may have the opportunity to explore the concept of volume as they design elements of their robot to lift, move, or carry the highest number of LEGO® bricks at one time.
Measurement & Data	Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.	5.MD.C.4	Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units.		Depending upon the Challenge, students may have the opportunity to explore the concept of volume as they design elements of their robot to lift, move, or carry the highest number of LEGO® bricks at one time.
Measurement & Data	Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.	5.MD.C.5.A	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.		Depending upon the Challenge, students may have the opportunity to explore the concept of volume as they design elements of their robot to lift, move, or carry the highest number of LEGO® bricks at one time.
Measurement & Data	Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.	5.MD.C.5.B	Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume. b. Apply the formulas V = l × w × h and V = b × 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.		Depending upon the Challenge, students may have the opportunity to explore the concept of volume as they design elements of their robot to lift, move, or carry the highest number of LEGO® bricks at one time.

Measurement & Data	Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.	5.MD.C.5.C	Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume. 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.		Depending upon the Challenge, students may have the opportunity to explore the concept of volume as they design elements of their robot to lift, move, or carry the highest number of LEGO® bricks at one time.
Geometry	Graph points on the coordinate plane to solve real-world and mathematical problems.	5.G.A.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 x-coordinate, y-axis and y-coordinate).		In order to successfully complete the Challenge, the students will be required to program their robot to navigate the game board. While this navigation can rely on the use of sensors to track position and guide movement, students can also treat the game board as one large coordinate plane. By using the properties of a coordinate plane (i.e. axes, ordered number pairs) students can also create navigation program based on wheel rotations and distances traveled.
Geometry	Graph points on the coordinate plane to solve real-world and mathematical problems.	5.G.A.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.		In order to successfully complete the Challenge, the students will be required to program their robot to navigate the game board. While this navigation can rely on the use of sensors to track position and guide movement, students can also treat the game board as one large coordinate plane. By using the properties of a coordinate plane (i.e. axes, ordered number pairs) students can also create navigation program based on wheel rotations and distances traveled.
Geometry	Classify two-dimensional figures into categories based on their properties.	5.G.B.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.		As students track the robot's movement across the game board a series of two-dimensional figures are created. Through questioning by the coach/mentor the concept that like figures share similar properties and therefore allow for similar solutions to challenges of navigation and movement can be illustrated for the students.
Geometry	Classify two-dimensional figures into categories based on their properties.	5.G.B.4	Classify two-dimensional figures in a hierarchy based on properties.		As students track the robot's movement across the game board a series of two-dimensional figures are created. Through questioning by the coach/mentor the concept that like figures share similar properties and therefore allow for similar solutions to challenges of navigation and movement can be illustrated for the students.