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 answers to problems using a different method, and they		As part of the *FIRST*® LEGO® League experience students will be expected to analyze the various challenges, 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 symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.		Students in the *FIRST*® LEGO® League program will solve a variety of problems allowing them to develop their ability to reason both quantitatively and abstractly as they work to solve problems associated with 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 determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.		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 conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.		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 solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.		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 various challenges.
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.		Students in the *FIRST*® LEGO® League program in order to complete the challenges in the most efficient manner possible will have to develop their mathematical precision as they program their robot to interact with the different challenge structures as well as navigate the challenge 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 challenges. 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 challenges.

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 challenges in the game.

Domain	**Cluster**	**Standard**	**Indicator/Skill**	***FIRST*® Alignment**	**Instructional Exemplar**
Operations and Algebraic Thinking	Use the four operations with whole numbers to solve problems.	4.OA.A.1	Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 x 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations.		As part of constructing the robot, building the game structures, or developing their program students will work with multiplication and analyze how different arrangements of the numbers in an equation produce similar results.
Operations and Algebraic Thinking	Use the four operations with whole numbers to solve problems.	4.OA.A.2	Multiply or divide to solve word problems involving multiplicative comparison, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem, distinguishing multiplicative comparison from additive comparison.		Students will have to use multiplication or division to determine unknown values in order to program the robot to successfully navigate the game board and interact with challenges.
Operations and Algebraic Thinking	Use the four operations with whole numbers to solve problems.	4.OA.A.3	Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.		Students will have to use a variety of mathematical operations to determine unknown values in order to program the robot to successfully navigate the game board and interact with challenges. Throughout they will have the opportunity to evaluate the reasonableness of their calculations against real-world situations.
Operations and Algebraic Thinking	Gain familiarity with factors and multiples.	4.OA.B.4	Find all factor pairs for a whole 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.		As part of programming the motion of the robot, students may have the opportunity to determine the different factors of a whole number between 1 and 100.

Operations and Algebraic Thinking	Generate and analyze patterns.	4.OA.C.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. *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.*		During construction and programming of the robot, students will generate both number and shape patterns that will inform their decisions and strategies.
Number & Operations in Base Ten	Generalize place value understanding for multi-digit whole numbers.	4.NBT.A.1	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. *For example, recognize that* $700 \div 70 = 10$ *by applying concepts of place value and division.*		As students build their robots or the game challenges they will have to use collections of different LEGO® bricks. This will present an opportunity to explore place value (e.g., 19 bricks is also a group of 10 bricks and a group of 9 bricks).
Number & Operations in Base Ten	Generalize place value understanding for multi-digit whole numbers.	4.NBT.A.2	Read and write multi-digit whole numbers using base-ten numerals, number names, and expanded form. Compare two multi-digit numbers based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.		As students build their robots or the game challenges they will have to use groups of different LEGO® bricks allowing them to make generalizations about the quantities in the groups based on place value if they so choose.
Number & Operations in Base Ten	Generalize place value understanding for multi-digit whole numbers.	4.NBT.A.3	Use place value understanding to round multi-digit whole numbers to any place.		As students build their robots or their game model they will work with LEGO® bricks that are of fixed size allowing extensions to be made to the mathematical procedure of rounding if the coach/mentor so chooses.
Number & Operations in Base Ten	Use place value understanding and properties of operations to perform multi-digit arithmetic.	4.NBT.B.4	Fluently add and subtract multi-digit whole numbers using the standard algorithm.		In order to correctly program the robot to complete tasks, students will be required to add and subtract numbers.
Number & Operations in Base Ten	Use place value understanding and properties of operations to perform multi-digit arithmetic.	4.NBT.B.5	Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.		Students will be required to use multiplication to determine values to program into the robot to govern movement and activity.
Number & Operations in Base Ten	Use place value understanding and properties of operations to perform multi-digit arithmetic.	4.NBT.B.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.		Students will be required to use division to determine values to program into the robot to govern movement and activity.
Number & Operations - Fractions	Extend understanding of fraction equivalence and ordering.	4.NF.A.1	Explain why a fraction a/b is equivalent to a fraction $(n \times a)/(n \times b)$ 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.		As part of construction and programming, students will have opportunities to compare fractions and determine equivalence.
Number & Operations - Fractions	Extend understanding of fraction equivalence and ordering.	4.NF.A.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.		As part of construction and programming, students will have opportunities to compare fractions with different numerators and denominators.
Number & Operations - Fractions	Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	4.NF.B.3.A	Understand a fraction a/b with $a > 1$ as a sum of fractions $1/b$. a. Understand addition and subtraction of fractions as joining and separating parts referring to the same whole.		As part of construction, students will have the opportunity to work with different bricks to create their robot, a whole object, illustrating how separate parts can form a whole.

Number & Operations - Fractions	Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	4.NF.B.3.B	Understand a fraction a/b with a > 1 as a sum of fractions 1/b. 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. Examples: 3/8 = 1/8 + 1/8 + 1/8 ; 3/8 = 1/8 + 2/8 ; 2 1/8 = 1 + 1 + 1/8 = 8/8 + 8/8 + 1/8.		As part of construction of the robot and different challenges, students will work with different bricks and will be able to visualize how different fractions (i.e., components assembled from different bricks) can be combined to make the whole (i.e., the robot, the challenge).
Number & Operations - Fractions	Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	4.NF.B.3.C	Understand a fraction a/b with a > 1 as a sum of fractions 1/b. c. Add and subtract mixed numbers with like denominators, e.g., by replacing each mixed number with an equivalent fraction, and/or by using properties of operations and the relationship between addition and subtraction.		As part of construction and robot programming, students will have to add and subtract mixed numbers by using equivalent fractions.
Number & Operations - Fractions	Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	4.NF.B.3.D	Understand a fraction a/b with a > 1 as a sum of fractions 1/b. d. Solve word problems involving addition and subtraction of fractions referring to the same whole and having like denominators, e.g., by using visual fraction models and equations to represent the problem.		As part of construction, students will create and take apart structures using similar sized elements illustrating the process of adding and subtracting fractions from the whole.
Number & Operations - Fractions	Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	4.NF.B.4.A	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. For example, use a visual fraction model to represent 5/4 as the product 5 × (1/4), recording the conclusion by the equation 5/4 = 5 × (1/4).		As part of construction, students will be able to observe how multiples of similar components are assembled to create the whole.
Number & Operations - Fractions	Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	4.NF.B.4.B	Apply and extend previous understandings of multiplication to multiply a fraction by a whole number. b. Understand a multiple of a/b as a multiple of 1/b, and use this understanding to multiply a fraction by a whole number. For example, 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.)		As part of construction, students will be able to observe how multiples of similar components are assembled to create the whole.
Number & Operations - Fractions	Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	4.NF.B.4.C	Apply and extend previous understandings of multiplication to multiply a fraction by a whole number. c. 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 people at the party, how many pounds of roast beef will be needed? Between what two whole numbers does your answer lie?		While students will work with multiplication, fractions, and whole numbers throughout the construction and programming process, they will not technically be working with word problems. If the coach/mentor chooses the students can convert the real-life problems they are trying to solve into word problems.
Number & Operations - Fractions	Understand decimal notation for fractions, and compare decimal fractions.	4.NF.C.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 100.4 For example, express 3/10 as 30/100, and add 3/10 + 4/100 = 34/100.		As part of programming, students will have to convert real-world data (e.g. distance measurements) into equivalent fractions with denominators of 10 and 100 (e.g., millimeters, centimeters, & meters).
Number & Operations - Fractions	Understand decimal notation for fractions, and compare decimal fractions.	4.NF.C.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.		As part of programming, students will have to convert real-world data (e.g. distance measurements) collected as mixed numbers into numbers with decimals.

Number & Operations - Fractions	Understand decimal notation for fractions, and compare decimal fractions.	4.NF.C.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 >, =, or <, and justify the conclusions, e.g., by using a visual model.		Students will work with decimal values to the hundredths place and make comparisons about their size as they evaluate movement and time data obtain during trial movement of the robot.
Measurement & Data	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	4.MD.A.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), ...		To develop their program to navigate the robot around the game board students will be required to make measurements and convert from larger units (cm) to smaller units (mm).
Measurement & Data	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	4.MD.A.2	Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.		To develop their program to navigate the robot around the game board students will be required to use data collected to solve problems via addition, subtraction, multiplication, and division. Some types of problems listed in the standard may be challenge or solution dependent.
Measurement & Data	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	4.MD.A.3	Apply the area and perimeter formulas for rectangles in real world and mathematical problems. For example, find the width of a rectangular room given the area of the flooring and the length, by viewing the area formula as a multiplication equation with an unknown factor.		To develop their navigation program, students will use area and perimeter formulas of rectangle to determine the shortest/fastest routes to traverse the game board.
Measurement & Data	Represent and interpret data.	4.MD.B.4	Make a line plot to display a data set of measurements in fractions of a unit (1/2, 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.		To develop their robot's navigation program, students will develop representations of different types of data such as distances traveled, rotation of wheels, length of movement (e.g. tables and graphs) to make interpretations of the information.
Measurement & Data	Geometric measurement: understand concepts of angle and measure angles.	4.MD.C.5.A	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 “one-degree angle,” and can be used to measure angles.		To successfully program the robot to complete a series of tasks throughout the competition, students will need to use the concept of angles and the measurement of angles to determine how the robot should move or position itself.
Measurement & Data	Geometric measurement: understand concepts of angle and measure angles.	4.MD.C.5.B	Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement: b. An angle that turns through n one-degree angles is said to have an angle measure of n degrees.		To successfully program the robot to complete a series of tasks throughout the competition, students will need to use the concept of angles and the measurement of angles to determine how the robot should move or position itself.
Measurement & Data	Geometric measurement: understand concepts of angle and measure angles.	4.MD.C.6	Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure.		To successfully program the robot to complete a series of tasks throughout the competition, students will need to use the concept of angles and the measurement of angles to determine how the robot should move or position itself.

Measurement & Data	Geometric measurement: understand concepts of angle and measure angles.	4.MD.C.7	Recognize angle measure as additive. When an angle is decomposed into non-overlapping parts, the angle measure of the whole 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.		Students may choose to use the additive properties of angles to efficiently determine necessary angles to determine how the robot should move or position itself as opposed to using a trial and error method.
Geometry	Draw and identify lines and angles, and classify shapes by properties of their lines and angles.	4.G.A.1	Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.		In order to have the robot successfully navigate the game board, students will need to program their robot to travel along lines they identify, essentially creating a series of two-dimensional figures.
Geometry	Draw and identify lines and angles, and classify shapes by properties of their lines and angles.	4.G.A.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.		Having created two-dimensional figures to aid in robot navigation, students will use right angles, parallel, and perpendicular lines as benchmarks to aid in navigation and programming.
Geometry	Draw and identify lines and angles, and classify shapes by properties of their lines and angles.	4.G.A.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.		During robot construction and programming robot navigation, students may have the opportunity to observe and take advantage of a line of symmetry in a two-dimensional object.