FIRST® Tech Challenge 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*® Tech Challenge 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		Students in the *FIRST*® *Tech Challenge* 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		Building off the first practice, students in the *FIRST® Tech Challenge* program will interact with their peers and be expected to provide reasoned critique of solutions 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		Students in the *FIRST® Tech Challenge* 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, and to track and predict competitor's performance as well as identify potential alliance partnerships.
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		Students in the *FIRST® Tech Challenge* 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.

Domain	Cluster	Standard	Indicator/Skill	*FIRST®* Alignment	Instructional Exemplar
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® Tech Challenge* 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 obstacles as well as navigate the challenge field.
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® Tech Challenge* 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® Tech Challenge* program will be able to experience regularity in repeated reasoning as they program their robot to complete the different challenges in the game.

The Number System	Know that there are numbers that are not rational, and approximate them by rational numbers.	8.NS.A.1	Know that numbers that are not rational are called irrational. Understand informally that every number has a decimal expansion; for rational numbers show that the decimal expansion repeats eventually, and convert a decimal expansion which repeats eventually into a rational number.		Not Applicable
The Number System	Know that there are numbers that are not rational, and approximate them by rational numbers.	8.NS.A.2	Use rational approximations of irrational numbers to compare the size of irrational numbers, locate them approximately on a number line diagram, and estimate the value of expressions (e.g., π2). For example, by truncating the decimal expansion of √2, show that √2 is between 1 and 2, then between 1.4 and 1.5, and explain how to continue on to get better approximations.		Not Applicable
Expressions and Equations	Work with radicals and integer exponents.	8.EE.A.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.		Not Applicable
Expressions and Equations	Work with radicals and integer exponents.	8.EE.A.2	Use square root and cube root symbols to represent solutions to equations of the form x2 = p and x3 = p, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational.		Not Applicable
Expressions and Equations	Work with radicals and integer exponents.	8.EE.A.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 × 108 and the population of the world as 7 × 109, and determine that the world population is more than 20 times larger.		Not Applicable
Expressions and Equations	Work with radicals and integer exponents.	8.EE.A.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.		Not Applicable
Expressions and Equations	Understand the connections between proportional relationships, lines, and linear equations.	8.EE.B.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.		As part of programming, students will analyze the relationships between values (i.e. distance vs. time) using both graphs and equations to represent the data.
Expressions and Equations	Understand the connections between proportional relationships, lines, and linear equations.	8.EE.B.6	Use similar triangles to explain why the slope m is the same between any two distinct 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.		In order to program robot motion, students will work with similar triangles and the slope of the non-vertical line to correctly position the robot.

Expressions and Equations	Analyze and solve linear equations and pairs of simultaneous linear equations.	8.EE.C.7.A	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 numbers).		To determine values to enter into the robot's programming, students will need to solve for a single variables in a linear equations (e.g. speed = distance required to travel divided by allowable time).
Expressions and Equations	Analyze and solve linear equations and pairs of simultaneous linear equations.	8.EE.C.7.B	Solve linear equations in one variable. b. Solve linear equations with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms.		To determine values to enter into the robot's programming, students will need to solve for a single variables in a linear equations (e.g. speed = distance required to travel divided by allowable time).
Expressions and Equations	Analyze and solve linear equations and pairs of simultaneous linear equations.	8.EE.C.8.A	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.		To determine values to enter into the robot's programming, students will need to solve for a single variables in a linear equations (e.g. speed = distance required to travel divided by allowable time).
Expressions and Equations	Analyze and solve linear equations and pairs of simultaneous linear equations.	8.EE.C.8.B	Analyze and solve pairs of simultaneous linear equations. . 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.		Not Applicable
Expressions and Equations	Analyze and solve linear equations and pairs of simultaneous linear equations.	8.EE.C.8.C	Analyze and solve pairs of simultaneous linear equations. 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.		To determine robot motion, students will solve real-world problems with two linear equations and two variables
Functions	Define , evaluate, and compare functions.	8.F.A.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.1		By programming the robot to operate autonomously, students will see that for each given input there is only one set output.
Functions	Define , evaluate, and compare functions.	8.F.A.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.		Students may choose to represent and compare data in different ways when evaluating robot performance or in scouting other teams for alliances.
Functions	Define , evaluate, and compare functions.	8.F.A.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.		In programming the robot, students will work with the linear function y = mx + b to have the robot complete challenges.

Functions	Use functions to model relationships between quantities.	8.F.B.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.		To determine the values to enter into the robots programming to produce the desired result, students will need to first model the linear relationship between the input and required output (e.g. distance traveled vs. wheel rotation).
Functions	Use functions to model relationships between quantities.	8.F.B.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.		Students will work with real-world data to determine the relationship between two quantities.
Geometry	Understand congruence and similarity using physical models, transparencies, or geometry software.	8.G.A.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.		As students program their robots to navigate, they will be working with lines and line segments.
Geometry	Understand congruence and similarity using physical models, transparencies, or geometry software.	8.G.A.1	Verify experimentally the properties of rotations, reflections, and translations: b. Angles are taken to angles of the same measure.		As students program their robots to interact with challenges, they will be working with a variety of angles.
Geometry	Understand congruence and similarity using physical models, transparencies, or geometry software.	8.G.A.1	Verify experimentally the properties of rotations, reflections, and translations: c. Parallel lines are taken to parallel lines.		As students program their robots to navigate, they will be working with parallel lines..
Geometry	Understand congruence and similarity using physical models, transparencies, or geometry software.	8.G.A.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.		As students build their robots, they will be able to explore the concepts of congruence and similarity using physical models.
Geometry	Understand congruence and similarity using physical models, transparencies, or geometry software.	8.G.A.3	Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.		As students program the robot to move and act autonomously, they will explore the effect of dilations, translations, rotations, and reflections on two-dimensional figures.
Geometry	Understand congruence and similarity using physical models, transparencies, or geometry software.	8.G.A.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.		As students construct the robot, they will work with objects that are similar as shown by a sequence of rotations, reflections, translations, and dilations.

Geometry	Understand congruence and similarity using physical models, transparencies, or geometry software.	8.G.A.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.		As students program the robot to act autonomously, they will 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.
Geometry	Understand and apply the Pythagorean Theorem.	8.G.B.6	Explain a proof of the Pythagorean Theorem and its converse.		Not Applicable
Geometry	Understand and apply the Pythagorean Theorem.	8.G.B.7	Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.		Depending on the game challenge, students may use the Pythagorean Theorem to help determine the optimal placement of the robot to complete a particular task.
Geometry	Understand and apply the Pythagorean Theorem.	8.G.B.8	Apply the Pythagorean Theorem to find the distance between two points in a coordinate system.		Depending on the game challenge, students may use the Pythagorean Theorem to help determine the optimal placement of the robot to complete a particular task.
Geometry	Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.	8.G.C.9	Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.		Depending upon the game challenge, students may need to calculate the volume of cylinders, cones, or spheres. For example, a challenge may require the robot to fill up a cylinder with rubber balls. By determining the volume of the cylinder the students will be able to program their robot to successfully complete the desired task(s).
Statistics and Probability	Investigate patterns of association in bivariate data.	8.SP.A.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.		Not Applicable
Statistics and Probability	Investigate patterns of association in bivariate data.	8.SP.A.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.		Not Applicable
Statistics and Probability	Investigate patterns of association in bivariate data.	8.SP.A.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/hr as meaning that an additional hour of sunlight each day is associated with an additional 1.5 cm in mature plant height.		Not Applicable
Statistics and Probability	Investigate patterns of association in bivariate data.	8.SP.A.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. 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?		Not Applicable