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<td><strong>Relationships Between Quantities and Expressions</strong></td>
<td><strong>Reasoning with Linear Equations and Inequalities</strong></td>
<td><strong>Modeling and Analyzing Quadratic Functions</strong></td>
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<td><strong>Similarity, Congruence, and Proofs</strong></td>
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These units were written to build upon concepts from prior units, so later units contain tasks that depend upon the concepts addressed in earlier units. All units will include the Mathematical Practices and indicate skills to maintain.

**NOTE:** Mathematical standards are interwoven and should be addressed throughout the year in as many different units and tasks as possible in order to stress the natural connections that exist among mathematical topics.

**Grade 9-12 Key:**
- **Number and Quantity Strand:** RN = The Real Number System, Q = Quantities, CN = Complex Number System, VM = Vector and Matrix Quantities
- **Algebra Strand:** SSE = Seeing Structure in Expressions, APR = Arithmetic with Polynomial and Rational Expressions, CED = Creating Equations, REI = Reasoning with Equations and Inequalities
- **Functions Strand:** BF = Interpreting Functions, LE = Linear and Exponential Models, BF = Building Functions, TF = Trigonometric Functions
- **Geometry Strand:** CO = Congruence, SRT = Similarity, Right Triangles, and Trigonometry, C = Circles, GPE = Expressing Geometric Properties with Equations, GMD = Geometric Measurement and Dimension, MG = Modeling with Geometry
- **Statistics and Probability Strand:** ID = Interpreting Categorical and Quantitative Data, IC = Making Inferences and Justifying Conclusions, CP = Conditional Probability and the Rules of Probability, MD = Using Probability to Make Decisions
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

### 1st Semester

#### Unit 1
**Relationships Between Quantities and Expressions**

- Extend the properties of exponents to rational exponents.
  - MGSE9.N.RN.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents, i.e., simplify and/or use the operations of addition, subtraction, and multiplication, with radicals within expressions limited to square roots.

- Use properties of rational and irrational numbers.
  - MGSE9.N.RN.3 Explain why the sum of rational numbers is rational, why the sum of a rational number and an irrational number is irrational, and why the product of a nonzero rational number and an irrational number is irrational.

- Reason quantitatively and use units to solve problems.
  - MGSE9.N.Q.1 Use units of measure (linear, area, capacity, rates, and time) as a way to understand problems:
    - a. Identify, use, and record appropriate units of measure within context, within data displays, and on graphs;
    - b. Convert units and rates using dimensional analysis (English-to-English and Metric-to-Metric without conversion factor provided and between English and Metric with conversion factor);
    - c. Use units within multi-step problems and formulas; interpret units of input and resulting units of output.

- MGSE9.N.Q.2 Define appropriate quantities for the purpose of descriptive modeling. Given a situation, context, or problem, students will determine, identify, and use appropriate quantities for representing the situation.

#### Unit 2
**Reasoning with Linear Equations and Inequalities**

- Create equations that describe numbers or relationships.
  - MGSE9.A.CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear, quadratic, simple rational, and exponential functions (integer inputs only).

- MGSE9.A.CED.2 Create linear, quadratic, and exponential equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (The phrase “in two or more variables” refers to formulas like the compound interest formula, in which A = P(1 + r/n)^n has multiple variables.)

- MGSE9.A.CED.3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret data points as possible (i.e. a solution) or not possible (i.e. a non-solution) under the established constraints.

- MGSE9.A.CED.4 Rearrange formulas to highlight a quantity of interest using the same reasoning as in solving equations. Examples: Rearrange Ohm’s law V = IR to highlight resistance R; Rearrange area of a circle formula A = πr^2 to highlight the radius r.

- Understand solving equations as a process of reasoning and explain the reasoning.
  - MGSE9.A.REI.1 Using algebraic properties and the properties of real numbers, justify the steps of a simple, one-equation solution. Students should justify their own steps, or if given two or more steps of an equation, explain the progression from one step to the next using properties.

#### Unit 3
**Modeling and Analyzing Quadratic Functions**

- Interpret the structure of expressions.
  - MGSE9.A.SSE.2 Use the structure of an expression to rewrite it in different equivalent forms. For example, see x^4 – y^4 as (x^2)^2 – (y^2)^2, thus recognizing it as a difference of squares that can be factored as (x^2 + y^2)(x^2 – y^2).

- Write expressions in equivalent forms to solve problems.
  - MGSE9.A.SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

- MGSE9.A.SSE.3a Factor any quadratic expression to reveal the zeros of the function defined by the expression.

- MGSE9.A.SSE.3b Complete the square in a quadratic expression to reveal the maximum or minimum value of the function defined by the expression.

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- MGSE9.A.CED.2 Create linear, quadratic, and exponential equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (The phrase “in two or more variables” refers to formulas like the compound interest formula, in which A = P(1 + r/n)^n has multiple variables.)

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  - MGSE9.A.REI.1 Using algebraic properties and the properties of real numbers, justify the steps of a simple, one-equation solution. Students should justify their own steps, or if given two or more steps of an equation, explain the progression from one step to the next using properties.

- MGSE9.A.REI.2a Write quadratic equations in one variable.

- MGSE9.A.REI.2a Solve quadratic equations in one variable.

- MGSE9.A.REI.4a Use the method of completing the square to transform any...
Solve equations and inequalities in one variable.
MGSE9-12.A.REI.1 Solve linear equations and inequalities in one variable including equations with coefficients represented by letters. For example, given $ax + b = c$, solve for $x$.

Solve systems of equations.
MGSE9-12.A.REI.5 Show and explain why the elimination method works to solve a system of two-variable equations.

MGSE9-12.A.REI.6 Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

Represent and solve equations and inequalities graphically.
MGSE9-12.A.REI.10 Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane.

MGSE9-12.A.REI.11 Using graphs, tables, or successive approximations, show that the solution to the equation $f(x) = g(x)$ is the $x$-value where the $y$-values of $f(x)$ and $g(x)$ are the same.

MGSE9-12.A.REI.12 Graph the solution set to a linear inequality in two variables.

Build a function that models a relationship between two quantities.
MGSE9-12.F.BF.1 Write a function that describes a relationship between two quantities.

MGSE9-12.F.BF.1a Determine an explicit expression and the recursive process (steps for calculation) from context. For example, if Jimmy starts out with $15$ and earns $2$ a day, the explicit expression “$2x+15$” can be described recursively (either in writing or verbally) as “to find out how much money Jimmy will have tomorrow, you add $2$ to his total today.” $J_1 = 15$, $J_{n+1} = J_n + 2$.

MGSE9-12.F.BF.2 Write arithmetic and geometric sequences recursively and explicitly, use them to model situations, and translate between the two forms. Connect arithmetic sequences to linear functions and geometric sequences to exponential functions.

MGSE9-12.F.BF.1 Understand that a function from one set (the input, called the domain) to another set (the output, called the range) assigns to each element of the domain exactly one element of the range, i.e. each input value maps to exactly one output value. If $f$ is a function, $x$ is the input (an element of the domain), and $f(x)$ is the output (an element of the range). Graphically, the graph is $y = f(x)$.

MGSE9-12.F.BF.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

MGSE9-12.F.BF.3 Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. (Generally, the scope of high school math defines this subset as the set of natural numbers $1, 2, 3, 4, ...$) By graphing or calculating terms, students should be able to show how the recursive sequence $a_n = \frac{1}{2}a_{n-1} + 2$; the sequence $s_n = 2(n-1) + 7$; and the function $f(x) = 2x + 5$ (when $x$ is a whole number). For example, given the graph, show how $f(x)$ models the recursive sequence $a_n$ for its first five terms.

MGSE9-12.F.BF.4 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

Interpret functions that arise in applications in terms of the context.
MGSE9-12.F.BF.4 Using tables, graphs, and verbal descriptions, interpret the key characteristics of a function which models the relationship between two quantities. Sketch a graph showing key features including: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.

MGSE9-12.F.BF.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function h(n) gives the number of
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<th>Table 1:</th>
<th>Function Notation</th>
<th>Domain and Range</th>
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<tr>
<td><strong>MGSE9-12.F.IF.2</strong></td>
<td>Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.</td>
<td><strong>MGSE9-12.F.IF.3</strong> Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. (Generally, the scope of high school math defines this subset as the set of natural numbers 1,2,3,...) By graphing or calculating terms, students should be able to show how the recursive sequence $a_1=7$, $a_2=a_1+2$; the sequence $s_n = 2n+1 + 7$; and the function $f(x) = 2x + 5$ (when $x$ is a natural number) all define the same sequence.</td>
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<td><strong>MGSE9-12.F.IF.4</strong></td>
<td>Using tables, graphs, and verbal descriptions, interpret the key characteristics of a function which models the relationship between two quantities. Sketch a graph showing key features including: intercepts; interval where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.</td>
<td><strong>MGSE9-12.F.IF.5</strong> Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function $h(n)$ gives the number of person-hours it takes to assemble $n$ engines in a factory, then the positive integers would be an appropriate domain for the function.</td>
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<td><strong>MGSE9-12.F.IF.6</strong></td>
<td>Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.</td>
<td><strong>MGSE9-12.F.IF.7a</strong> Graph linear and quadratic functions and show intercepts, maxima, and minima (as determined by the function or by context).</td>
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<td><strong>MGSE9-12.F.IF.7</strong></td>
<td>Graph functions expressed algebraically and show key features of the graph both by hand and by using technology.</td>
<td><strong>MGSE9-12.F.IF.7a</strong> Graph linear and quadratic functions and show intercepts, maxima, and minima (as determined by the function or by context).</td>
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<td><strong>MGSE9-12.F.IF.8</strong></td>
<td>Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.</td>
<td><strong>MGSE9-12.F.IF.8a</strong> Use the process of factoring and completing the square in a quadratic function to show zeros, extreme maximums and minimums; symmetries; end behavior; and periodicity.</td>
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<td><strong>MGSE9-12.F.IF.9</strong></td>
<td>Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one function and an algebraic expression for another, say which has the larger maximum.</td>
<td><strong>MGSE9-12.F.IF.9</strong> Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one function and an algebraic expression for another, say which has the larger maximum.</td>
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**Note:**
- **MGSE9-12.F.IF.2** and **MGSE9-12.F.IF.3** discuss the recognition and representation of sequences as functions.
- **MGSE9-12.F.IF.4** focuses on interpreting functions using tables, graphs, and verbal descriptions.
- **MGSE9-12.F.IF.5** and **MGSE9-12.F.IF.6** address the domain of a function and its average rate of change.
- **MGSE9-12.F.IF.7** and **MGSE9-12.F.IF.8** cover graphing and analyzing functions.
- **MGSE9-12.F.IF.9** emphasizes comparing properties of functions in different representations.

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<td><strong>MGSE9-12.F.IF.9</strong> Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). <em>For example, given a graph of one function and an algebraic expression for another, say which has the larger maximum.</em></td>
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Interpret the correlation coefficient “r” of a linear fit.

Model in the context of the data.

Change) and the intercept (constant term) of a linear model in the context of the data.

Compute (using technology) and interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

Interpret linear models.

That suggests a linear association.

Interpret relative frequencies in the context of the data.

Two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

Interpret data on two quantitative variables on a scatter plot, and describe how the variables are related.

Compress or expanded version of a function in the plane using, e.g., graph paper, tracing paper, or geometric software. Specify a sequence of transformations that will carry a given figure onto another.

Summarize, represent, and interpret data on a single count or measurement variable.

Summarize, represent, and interpret categorical data from two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

Summarize categorical data for two categories in two-way frequency tables.

Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

Experiment with transformations in the plane using, e.g., graph paper, tracing paper, or geometric software. Specify a sequence of transformations that will carry a given figure onto another.

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Interpret slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
should be able to tell if the correlation coefficient is positive or negative and give a reasonable estimate of the “r” value.) After calculating the line of best fit using technology, students should be able to describe how strong the goodness of fit of the regression is, using “r”.

MGSE9-12.S.ID.9 Distinguish between correlation and causation.

MGSE9-12.G.CO.8 Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions. (Extend to include HL and AAS.)

**Prove geometric theorems**

MGSE9-12.G.CO.9 Prove theorems about lines and angles. Theorems include: vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment’s endpoints.

MGSE9-12.G.CO.10 Prove theorems about triangles. Theorems include: measures of interior angles of a triangle sum to 180 degrees; base angles of isosceles triangles are congruent; the segment joining midpoints of two sides of a triangle is parallel to the third side and half the length; the medians of a triangle meet at a point.

MGSE9-12.G.CO.11 Prove theorems about parallelograms. Theorems include: opposite sides are congruent, opposite angles are congruent, the diagonals of a parallelogram bisect each other, and conversely, rectangles are parallelograms with congruent diagonals.

**Make geometric constructions**

MGSE9-12.G.CO.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.

MGSE9-12.G.CO.13 Construct an equilateral triangle, a square, and a regular hexagon, each inscribed in a circle.