Washington Mathematics

HS Math Credit 3

Standards for Mathematical Practice

1 **Make sense of problems and persevere in solving them.** 1

2 **Reason abstractly and quantitatively.** 2

3 **Construct viable arguments and critique the reasoning of others.** 3

4 **Model with mathematics.** 4

5 **Use appropriate tools strategically.** 5

6 **Attend to precision.** 6

7 **Look for and make use of structure.** 7

8 **Look for and express regularity in repeated reasoning.** 8

Number & Quantity — **Number & Quantity**

The Real Number System

A **Extend the properties of exponents to rational exponents.**

1 Flexibly, efficiently, and accurately explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values using a variety of strategies, allowing for a notation for radicals in terms of rational exponents. N.RN.A.1

2 Rewrite expressions involving radicals and rational exponents using the properties of exponents. Use properties of rational and irrational numbers. N.RN.A.2

B **Use properties of rational and irrational numbers.**

3 Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational. N.RN.B.3

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Quantities

A Reason quantitatively and use units to solve problems.

1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.A.1

2 Define appropriate quantities for the purpose of descriptive modeling. N.Q.A.2

3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. N.Q.A.3

Complex Numbers

A Perform arithmetic operations with complex numbers.

1 Know there is a complex number i such that i2 = -1, and every complex number has the form a + bi with a and b real. N.CN.A.1

2 Use the relation i2 = -1 and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers. N.CN.A.2

B Use complex numbers in polynomial identities and equations.

7 Solve quadratic equations with real coefficients that have complex solutions. N.CN.A.7

Algebra

Algebra

Seeing Structure in Expressions

A Interpret the structure of expressions.

1a Interpret expressions that represent a quantity in terms of its context. A.SSE.A.1A, B

2 Use the structure of an expression to identify ways to rewrite it. A.SSE.A.2

B Write expressions in equivalent forms to solve problems.

3 Flexibly, efficiently, and accurately create an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression including factoring quadratic expressions, completing the square in a quadratic expression to reveal maximums or minimums, and using properties of exponents to create equivalent forms of exponential expressions to reveal properties of interest in the function. A.SSE.B.3

4 Derive the formula for the sum of a finite geometric series (when the common ratio is not 1), and use the formula to solve problems. A.SSE.B.4

Arithmetic with Polynomials and Rational Expressions

A Perform arithmetic operations on polynomials.

1 Flexibly, efficiently, and accurately demonstrate that polynomials form a system similar to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials. A.APR.A.1

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2 Know and apply the Remainder Theorem: For a polynomial p(x) and a number a, the remainder on division by x - a is p(a), so p(a) = 0 if and only if (x - a) is a factor of p(x). A.APR.B.2

3 Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial. A.APR.B.3

4 Prove polynomial identities and use them to describe numerical relationships. A.APR.C.4

6 Rewrite simple rational expressions in different forms; write a(x)/b(x) in the form q(x) + r(x)/b(x), where a(x), b(x), q(x), and r(x) are polynomials with the degree of r(x) less than the degree of b(x), using inspection, long division, or, for the more complicated examples, a computer algebra system. A.APR.D.6

Creating Equations

A Create equations that describe numbers or relationships.

1 Flexibly, efficiently, and accurately create equations and inequalities in one variable and use them to solve problems. A.CED.A.1

2 Flexibly, efficiently, and accurately create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. A.CED.A.2

3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. A.CED.A.3

4 Flexibly, efficiently, and accurately rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. A.CED.A.4

Reason with Equations and Inequalities

A Understand solving equations as a process of reasoning and explain the reasoning.

1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method. A.REI.A.1

2 Solve rational and radical equations in one variable, and give examples showing how extraneous solutions may arise. A.REI.A.2

B Solve equations and inequalities in one variable.

3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. A.REI.B.3

4a, b Solve quadratic equations in one variable by inspection, factoring, completing the square and derive the quadratic formula from this form. Recognize when the quadratic formula give complex solutions and write them as a ± bi for real numbers a and b. A.REI.B.4A, B

C Solve systems of equations.

5 Demonstrate using a variety of strategies that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions. A.REI.C.5

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6 Flexibly, efficiently, and accurately solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables. A.REI.C.6

7 Flexibly, efficiently, and accurately solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. A.REI.C.7

D Represent and solve equations and inequalities graphically.

10 Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line). A.REI.D.10

11 Using a variety of strategies explain why the x-coordinates of the points where the graphs of the equations $yy = ff(xx)$ and $yy = gg(xx)$ intersect are the solutions of the equation $ff(xx) = gg(xx)$ find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $ff(xx)$ and/or $gg(xx)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. A.REI.D.11

12 Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes. A.REI.D.12

Functions **Functions**

Interpreting Functions

A Understand the concept of a function and use function notation.

1 Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If ff is a function and x is an element of its domain, then $ff(xx)$ denotes the output of f corresponding to the input xx. The graph of f is the graph of the equation $yy = ff(xx)$. F.IF.A.1

2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. F.IF.A.2

3 Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. F.IF.A.3

B Interpret functions that arise in applications in terms of the context.

4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries. Functions can include: polynomial, radical, rational, logarithms, absolute value, piecewise, and trigonometric. Linear, exponential, and quadratic relationships in increased complexity. F.IF.B.4

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5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes in context. Functions can include: polynomial, radical, rational, logarithms, absolute value, piecewise, and trigonometric. Linear, exponential, and quadratic relationships in increased complexity. F.IF.B.5

6 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. F.IF.B.6

C Analyze functions using different representations.

7 a, b, c, e Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases including linear, quadratic, exponential, square root, cube root, and piecewise-defined functions, including step functions and absolute value functions, polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior, and exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude. F.IF.C.7 A, B, C, E

8 Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function, including factoring and completing the square to reveal zeros, symmetry, and extreme values of a quadratic functions and non-integer constants for time with exponential growth and decay in context. F.IF.C.8

9 Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Functions can include: polynomial, radical, rational, logarithms, absolute value, piecewise, and trigonometric. Linear, exponential, and quadratic relationships in increased complexity. F.IF.C.9

Building Functions

A Build a function that models a relationship between two quantities.

1a, b Write a function that describes a relationship between two quantities including determining an explicit expression, recursive process, or steps for calculation from a context, and combining standard function types using arithmetic operations. F.BF.A.1A, B

2 Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms. F.BF.A.2

B Build new functions from existing functions.

3 Identify the effect on the graph of replacing $ff(xx)$ $bbbb\,ff(xx) + kk$, $kk\,ff(xx)$, $ff(kkkk)$, $aaaaaa\,ff(xx + kk)$ for specific values of kk (both positive and negative); find the value of kk given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. F.BF.B.3

4 Find inverse functions through focus on relationships between inputs and outputs. F.BF.B.4

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Linear, Quadratic, and Exponential Models

A Construct and compare linear, quadratic, and exponential models and solve problems.

1 Distinguish between situations that can be modeled with linear functions (equal differences over equal intervals) and with exponential functions (equal factors over equal intervals), recognizing constant rates per unit interval, and growth or decay by a constant percent rate per unit interval. F.LE.A.1A, B, C

2 Flexibly, efficiently, and accurately construct linear and exponential functions given a graph, a description of a relationship, or two input-output pairs (include reading these from a table). F.LE.A.2

3 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or as a polynomial function. F.LE.A.3

4 For exponential models, express as a logarithm the solution to abct = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology. F.LE.A.4

B Interpret expressions for functions in terms of the situation they model.

5 Interpret the parameters in a linear or exponential function in terms of a context. F.LE.B.5

Trigonometric Functions

A Extend the domain of trigonometric functions using the unit circle.

2 Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle. F.TF.A.2

B Interpret expressions for functions in terms of the situation they model.

5 Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. F.TF.B.5

C Prove and apply trigonometric identities.

8 Prove the Pythagorean identity $\sin^2(\theta) + \cos^2(\theta) = 1$ and use it to find $\sin(\theta)$, $\cos(\theta)$, or $\tan(\theta)$ given $\sin(\theta)$, $\cos(\theta)$, or $\tan(\theta)$ and the quadrant of the angle. F.TF.C.8

Geometry **Geometry**

Congruence

A Experiment with transformations in the plane.

1 Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc. G.CO.A.1

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2 Flexibly, efficiently, and accurately represent transformations in the plane, e.g., transparencies and geometry software; describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch). G.CO.A.2

3 Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself. G.CO.A.3

4 Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments. G.CO.A.4

5 Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another. G.CO.A.5

B Understand congruence in terms of rigid motions.

6 Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent. G.CO.B.6

7 Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if and only if corresponding pairs of sides and corresponding pairs of angles are congruent. G.CO.B.7

8 Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions. G.CO.B.8

C Solve real-world and mathematical problems involving area, surface area, and volume.

9 Flexibly, efficiently, and accurately prove theorems about lines and angles: vertical, transversals, alternate interior and exterior, perpendicular bisectors, etc. G.CO.C.9

10 Flexibly, efficiently, and accurately prove theorems about triangles: interior angles, base angles, segments joining midpoint of two sides, and medians of a triangle. G.CO.C.10

11 Flexibly, efficiently, and accurately prove theorems about parallelograms: congruence of opposite sides and opposite angles, properties of diagonals. G.CO.C.11

D Make geometric constructions.

12 Make formal geometric constructions with a variety of tools and methods. G.CO.D.12

13 Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle. G.CO.D.13

Similarity, Right Tri Tri

A Understand similarity in terms of similarity transformations.

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1a, b Verify experimentally the properties of dilations given by a center and a scale factor by seeing what happens to lines affected by a center of dilation and how scale factor affects line segments. G.SRT.A.1A, B

2 Given two figures, use the definition of similarity in terms of similarity transformations to decide if they are similar; explain using similarity transformations the meaning of similarity for triangles as the equality of all corresponding pairs of angles and the proportionality of all corresponding pairs of sides. G.SRT.A.2

3 Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar. G.SRT.A.3

B Prove theorems involving similarity

4 Flexibly, efficiently, and accurately prove theorems about triangles: proportionality, triangle similarity, and the Pythagorean Theorem. G.SRT.B.4

5 Flexibly, efficiently, and accurately use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures. G.SRT.B.5

C Define trigonometric ratios and solve problems involving right triangles.

6 Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles. G.SRT.C.6

7 Explain and use the relationship between the sine and cosine of complementary angles. G.SRT.C.7

8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems. G.SRT.C.8

Circles

A Understand and apply theorems about circles.

1 Flexibly, efficiently, and accurately prove that all circles are similar. G.C.A.1

2 Identify and describe relationships among inscribed angles, radii, and chords, including how angles formed inside the circle, the circle's radius, and line segments within the circle are related. Understand special cases including angles formed by diameters and how the circle's edge interacts with its radius. G.C.A.2

3 Construct the inscribed and circumscribed circles of a triangle and flexibly, efficiently, and accurately prove properties of angles for a quadrilateral inscribed in a circle. G.C.A.3

B Find arc lengths and areas of sectors of circles.

5 Derive using similarity the fact that the length of the arc intercepted by an angle is proportional to the radius, and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector. G.C.B.5

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ranslate between the geometric description and the equation for a conic section.

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Equations

1 Derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation. G.GPE.A.1

B Use coordinates to prove simple geometric theorems algebraically.

4 Use coordinates to prove simple geometric theorems algebraically. G.GPE.B.4

5 Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point). G.GPE.B.5

6 Find the point on a directed line segment between two given points that partitions the segment in a given ratio. G.GPE.B.6

7 Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula. G.GPE.B.7

Geometric Measurement and Dimension

A Explain volume formulas and use them to solve problems.

1 Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. G.GMD.A.1

3 Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems. G.GMD.A.3

B Visualize relationships between two-dimensional and three-dimensional objects.

4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects. G.GMD.B.4

Modeling with Geometry

A Apply geometric concepts in modeling situations.

1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder). G.MG.A.1

2 Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot). G.MG.A.2

3 Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios). G.MG.A.3

Statistics and Probability

Statistics and Probability

Interpreting Categorical and Quantitative Data

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

1 Represent data with plots on the real number line (dot plots, histograms, and box plots). S.ID.A.1

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2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. S.ID.A.2

3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). S.ID.A.3

4 Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. S.ID.A.4

B Summarize, represent, and interpret data on two categorical and quantitative variables.

5 Summarize categorical data for 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. S.ID.B.5

6a, b, c Represent data on two quantitative variables on a scatter plot, and describe how the variables are related to solve problems in context by fitting functions to the data and explaining trends and relationships within the data. S.ID.B.6A, B, C

C Interpret linear models.

7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. S.ID.C.7

8 Compute (using technology) and interpret the correlation coefficient of a linear fit. S.ID.C.8

9 Distinguish between correlation and causation. S.ID.C.9

Making Inferences and Justifying Conclusions.

A Understand and evaluate random processes underlying statistical experiments.

1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population. S.IC.A.1

2 Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. S.IC.A.2

B Make inferences and justify conclusions from sample surveys, experiments, and observational studies.

3 Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each. S.IC.B.3

4 Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling. S.IC.B.4

Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant. S.IC.B.5

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6 Evaluate reports based on data. S.IC.B.6

Conditional Probability and the Rules of Probability

A Understand independence and conditional probability and use them to interpret data.

1 Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events ("or," "and," "not"). S.CP.A.1

2 Understand that two events A and B are independent if the probability of A and B occurring together is the product of their probabilities, and use this characterization to determine if they are independent. S.CP.A.2

3 Understand the conditional probability of AA given BB as $PP(AA\ aaaaaa\ BB)$, $PP(BB)$ and interpret independence of AA and BB as saying that the conditional probability of AA given BB is the same as the probability of AA, and the conditional probability of BB given AA is the same as the probability of BB. S.CP.A.3

4 Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities. S.CP.A.4

5 Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. S.CP.A.5

B Use the rules of probability to compute probabilities of compound events.

6 Find the conditional probability of A given B as the fraction of B's outcomes that also belong to A, and interpret the answer in terms of the model. S.CP.B.6

7 Apply the Addition Rule, $PP(AA\ oooo\ BB) = PP(AA) + PP(BB) - PP(AA\ aaaaaa\ BB)$, and interpret the answer in terms of the model. S.CP.B.7

Data Science

Formulate statistical investigative questions.

1 Formulate multivariable statistical investigative questions and determine how data can be collected and provide an answer, consider causality and prediction when posing the question. HS.DS.1

Collect and consider data.

2 Understand the issues of bias and confounding variables when collecting data and their impact on interpretation. Understand practices for collecting and handling data, including sensitive information and concerns for privacy and how that may affect data collection. HS.DS.2

Analyze the data.

3 Create and analyze data sets and data displays, including but not limited to scatter plots, regressions, histograms and boxplots using technology to sort or filter data, summarize, and describe relationships between quantitative variables. HS.DS.3

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terpret results.

4 Acknowledge the presence of missing data values and understand how missing values may add bias to analysis and interpretation. Examine and discuss competing explanations for data trends observed such as confounding variables. Respond to competing arguments or interpretations of the data of different community groups, paying careful attention to what conclusions the data supports, taking into account correlation versus causation. HS.DS.4