

BEFORE THE BOARD OF PUBLIC EDUCATION
OF THE STATE OF MONTANA

In the matter of the adoption of New) NOTICE OF PUBLIC HEARING ON
Rules I through XVII pertaining to) PROPOSED ADOPTION AND
content standards for mathematics) REPEAL
and repeal of ARM 10.54.4010)
through 10.54.4013, 10.54.4020)
through 10.54.4023, 10.54.4030)
through 10.54.4033, 10.54.4040)
through 10.54.4043, and 10.54.4101)
through 10.54.4112 relating to)
mathematics content standards and)
performance descriptors)

TO: All Concerned Persons

1. On October 24, 2011 at 10:00 a.m. the Board of Public Education will hold a public hearing in the conference room of the Office of Public Instruction building at 1227 11th Avenue, Helena Montana, to consider the proposed adoption and repeal of the above-stated rules.

2. The board will make reasonable accommodations for persons with disabilities who wish to participate in this rulemaking process or need an alternative accessible format of this notice. If you require an accommodation, contact the board no later than 5:00 p.m. on October 17, 2011, to advise us of the nature of the accommodation that you need. Please contact Peter Donovan, Executive Secretary, 46 North Last Chance Gulch, P.O. Box 200601, Helena, Montana, 59620-0601; telephone (406) 444-0302; fax (406) 444-0847; or e-mail pdonovan@mt.gov.

3. The rules as proposed to be adopted provide as follows:

NEW RULE I STANDARDS FOR MATHEMATICAL PRACTICE FOR GRADES K-12 (1) Mathematical practice standard 1 is to make sense of problems and persevere in solving them. Mathematically proficient students:

- (a) explain the meaning of a problem and restate it in their words;
 - (b) analyze given information to develop possible strategies for solving the problem;
 - (c) identify and execute appropriate strategies to solve the problem;
 - (d) evaluate progress toward the solution and make revisions if necessary;
- and
- (e) check their answers using a different method and continually ask "Does this make sense?".

(2) Mathematical practice standard 2 is to reason abstractly and quantitatively. Mathematically proficient students:

- (a) make sense of quantities and their relationships in problem situations;
- (b) use varied representations and approaches when solving problems;

(c) know and flexibly use different properties of operations and objects; and
(d) change perspectives, generate alternatives, and consider different options.

(3) Mathematical practice standard 3 is to construct viable arguments and critique the reasoning of others. Mathematically proficient students:

- (a) understand and use prior learning in constructing arguments;
- (b) habitually ask "why" and seek an answer to that question;
- (c) question and problem-pose;
- (d) develop questioning strategies to generate information;
- (e) seek to understand alternative approaches suggested by others and as a result, adopt better approaches;
- (f) justify their conclusions, communicate them to others, and respond to the arguments of others; and
- (g) 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.

(4) Mathematical practice standard 4 is to model with mathematics. Mathematically proficient students:

- (a) apply the mathematics they know to solve problems arising in everyday life, society, and the workplace;
- (b) make assumptions and approximations to simplify a complicated situation, realizing that these may need revision later;
- (c) identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts, and formulas; and
- (d) analyze mathematical relationships to draw conclusions.

(5) Mathematical practice standard 5 is to use appropriate tools strategically. Mathematically proficient students:

- (a) use tools when solving a mathematical problem and to deepen their understanding of concepts (e.g., pencil and paper, physical models, geometric construction and measurement devices, graph paper, calculators, computer-based algebra, or geometry systems); and
- (b) make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations and detect possible errors by strategically using estimation and other mathematical knowledge.

(6) Mathematical practice standard 6 is to attend to precision. Mathematically proficient students:

- (a) communicate their understanding of mathematics to others;
- (b) use clear definitions and state the meaning of the symbols they choose, including using the equal sign consistently and appropriately;
- (c) specify units of measure and use label parts of graphs and charts; and
- (d) strive for accuracy.

(7) Mathematical practice standard 7 is to look for and make use of structure. Mathematically proficient students:

- (a) look for, develop, generalize, and describe a pattern orally, symbolically, graphically, and in written form; and
- (b) apply and discuss properties.

(8) Mathematical practice standard 8 is to look for and express regularity in repeated reasoning. Mathematically proficient students:

- (a) look for mathematically sound shortcuts; and
- (b) use repeated applications to generalize properties.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE II MONTANA KINDERGARTEN MATHEMATICS CONTENT STANDARDS (1) Mathematics counting and cardinality standards for kindergarten are:

- (a) count to 100 by ones and by tens;
- (b) count forward beginning from a given number within the known sequence (instead of having to begin at 1);
- (c) write numbers from 0-20 and represent a number of objects with a written numeral 0-20 (with 0 representing a count of no objects);
- (d) understand the relationship between numbers and quantities and connect counting to cardinality;
 - (i) when counting objects, say the number names in the standard order, pairing each object with one and only one number name and each number name with one and only one object from a variety of cultural contexts, including those of Montana American Indians;
 - (ii) understand that the last number name said tells the number of objects counted and the number of objects is the same regardless of their arrangement or the order in which they were counted;
 - (iii) understand that each successive number name refers to a quantity that is one larger;
- (e) count to answer "how many?" questions about as many as 20 things arranged in a line, a rectangular array, or a circle, or as many as 10 things in a scattered configuration and given a number from 1-20, count out that many objects from a variety of cultural contexts, including those of Montana American Indians;
- (f) identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group, e.g., by using matching and counting strategies; and
- (g) compare two numbers between 1 and 10 presented as written numerals.

(2) Mathematics operations and algebraic thinking content standards for kindergarten are:

- (a) represent addition and subtraction with objects, fingers, mental images, drawings, sounds (e.g., claps), acting out situations, verbal explanations, expressions, or equations;
- (b) solve addition and subtraction word problems from a variety of cultural contexts, including those of Montana American Indians, and add and subtract within 10, e.g., by using objects or drawings to represent the problem;
- (c) decompose numbers less than or equal to 10 into pairs in more than one way, e.g., by using objects or drawings, and record each decomposition by a drawing or equation (e.g., $5 = 2 + 3$ and $5 = 4 + 1$);
- (d) for any number from 1 to 9, find the number that makes 10 when added to

the given number, e.g., by using objects or drawings, and record the answer with a drawing or equation; and

(e) fluently add and subtract within 5.

(3) Mathematics number and operations in base ten content standard for kindergarten is:

(a) compose and decompose numbers from 11-19 into ten ones and some further ones, e.g., by using objects or drawings; record each composition or decomposition by a drawing or equation (such as $18 = 10 + 8$); and understand that these numbers are composed of ten ones and one, two, three, four, five, six, seven, eight, or nine ones.

(4) Mathematics measurement and data content standards for kindergarten are:

(a) describe measurable attributes of objects, such as length or weight and describe several measurable attributes of a single object;

(b) directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute and describe the difference; for example, directly compare the heights of two children and describe one child as taller/shorter; and

(c) classify objects from a variety of cultural contexts, including those of Montana American Indians, into given categories, count the numbers of objects in each category, and sort the categories by count.

(5) Mathematics geometry content standards for kindergarten are:

(a) describe objects, including those of Montana American Indians, in the environment using names of shapes and describe the relative positions of these objects using terms such as: above, below, beside, in front of, behind, and next to;

(b) correctly name shapes regardless of their orientations or overall size;

(c) identify shapes as two-dimensional (lying in a plane, "flat") or three-dimensional ("solid");

(d) analyze and compare two- and three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and vertices/"corners"), and other attributes (e.g., having sides of equal length);

(e) model shapes in the world from a variety of cultural contexts, including those of Montana American Indians, by building shapes from components (e.g., sticks and clay balls) and drawing shapes; and

(f) compose simple shapes to form larger shapes; for example, "Can you join these two triangles with full sides touching to make a rectangle?".

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE III MONTANA GRADE 1 MATHEMATICS CONTENT STANDARDS (1) Mathematics operations and algebraic thinking content standards for Grade 1 are:

(a) use addition and subtraction within 20 to solve word problems within a cultural context, including those of Montana American Indians, involving situations of adding to, taking from, putting together, taking apart, and comparing with unknowns

in all positions, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem;

(b) solve word problems within a cultural context, including those of Montana American Indians, that call for addition of three whole numbers whose sum is less than or equal to 20, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem;

(c) apply properties of operations as strategies to add and subtract; for example: if $8 + 3 = 11$ is known, then $3 + 8 = 11$ is also known (commutative property of addition); to add $2 + 6 + 4$, the second two numbers can be added to make a ten, so $2 + 6 + 4 = 2 + 10 = 12$ (associative property of addition);

(d) understand subtraction as an unknown-addend problem; for example, subtract $10 - 8$ by finding the number that makes 10 when added to 8;

(e) relate counting to addition and subtraction (e.g., by counting on 2 to add 2);

(f) add and subtract within 20 demonstrating fluency for addition and subtraction within 10; use strategies such as counting on; making ten (e.g., $8 + 6 = 8 + 2 + 4 = 10 + 4 = 14$); decomposing a number leading to a ten (e.g., $13 - 4 = 13 - 3 - 1 = 10 - 1 = 9$); using the relationship between addition and subtraction (e.g., knowing that $8 + 4 = 12$, one knows $12 - 8 = 4$); and creating equivalent but easier or known sums (e.g., adding $6 + 7$ by creating the known equivalent $6 + 6 + 1 = 12 + 1 = 13$);

(g) understand the meaning of the equal sign and determine if equations involving addition and subtraction are true or false; for example, which of the following equations are true and which are false? $6 = 6$, $7 = 8 - 1$, $5 + 2 = 2 + 5$, $4 + 1 = 5 + 2$; and

(h) determine the unknown whole number in an addition or subtraction equation relating to three whole numbers; for example, determine the unknown number that makes the equation true in each of the equations: $8 + ? = 11$, $5 = ? - 3$, $6 + 6 = ?$.

(2) Mathematics number and operations in base ten content standards for Grade 1 are:

(a) count to 120, starting at any number less than 120 and read and write numerals and represent a number of objects with a written numeral in this range;

(b) understand that the two digits of a two-digit number represent amounts of tens and ones and understand the following as special cases:

(i) 10 can be thought of as a bundle of ten ones called a "ten";

(ii) the numbers from 11 to 19 are composed of a ten and one, two, three, four, five, six, seven, eight, or nine ones;

(iii) the numbers 10, 20, 30, 40, 50, 60, 70, 80, 90 refer to one, two, three, four, five, six, seven, eight, or nine tens (and 0 ones);

(c) compare two two-digit numbers based on meanings of the tens and ones digits, recording the results of comparisons with the symbols $>$, $=$, and $<$;

(d) add within 100, including adding a two-digit number and a one-digit number, and adding a two-digit number and a multiple of 10, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used; understand that in adding two-digit

numbers, one adds tens and tens, ones and ones; and sometimes it is necessary to compose a ten;

(e) given a two-digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used; and

(f) subtract multiples of 10 in the range 10-90 from multiples of 10 in the range 10-90 (positive or zero differences) using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction, relate the strategy to a written method, and explain the reasoning used.

(3) Mathematics measurement and data content standards for Grade 1 are:

(a) order three objects from a variety of cultural contexts, including those of Montana American Indians, by length and compare the lengths of two objects indirectly by using a third object;

(b) express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps and limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps;

(c) tell and write time in hours and half-hours using analog and digital clocks; and

(d) organize, represent, and interpret data with up to three categories and ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.

(4) Mathematics geometry content standards for Grade 1 are:

(a) distinguish between defining attributes (e.g., triangles are closed and three-sided) versus nondefining attributes (e.g., color, orientation, overall size) and build and draw shapes to possess defining attributes;

(b) compose two-dimensional shapes (rectangles, squares, trapezoids, triangles, half-circles, and quarter-circles) or three-dimensional shapes (cubes, right rectangular prisms, right circular cones, and right circular cylinders) to create a composite shape, and compose new shapes from the composite shape;

(c) partition circles and rectangles into two and four equal shares; describe the shares using the words: halves, fourths, and quarters, and use the phrases half of, fourth of, and quarter of; describe the whole as two of, or four of the shares; and understand for these examples that decomposing into more equal shares creates smaller shares.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE IV MONTANA GRADE 2 MATHEMATICS CONTENT

STANDARDS (1) Mathematics operations and algebraic thinking content standards for Grade 2 are:

(a) use addition and subtraction within 100 to solve one- and two-step word problems involving situations within a cultural context, including those of Montana American Indians, of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using drawings and equations

with a symbol for the unknown number to represent the problem;

(b) fluently add and subtract within 20 using mental strategies and by the end of Grade 2, know from memory all sums of two one-digit numbers;

(c) determine whether a group of objects (up to 20) has an odd or even number of members, e.g., by pairing objects or counting them by 2s and write an equation to express an even number as a sum of two equal addends; and

(d) use addition to find the total number of objects arranged in rectangular arrays with up to five rows and up to five columns and write an equation to express the total as a sum of equal addends.

(2) Mathematics number and operations in base ten content standards for Grade 2 are:

(a) understand that the three digits of a three-digit number represent amounts of hundreds, tens, and ones, e.g., 706 equals 7 hundreds, 0 tens, and 6 ones and understand the following special cases:

(i) 100 can be thought of as a bundle of ten tens – called a "hundred;" and

(ii) the numbers 100, 200, 300, 400, 500, 600, 700, 800, and 900 refer to one, two, three, four, five, six, seven, eight, or nine hundreds (and 0 tens and 0 ones);

(b) count within 1000; skip-count by 5s, 10s, and 100s;

(c) read and write numbers to 1000 using base-ten numerals, number names, and expanded form;

(d) compare two three-digit numbers based on meanings of the hundreds, tens, and ones digits, using $>$, $=$, and $<$ symbols to record the results of comparisons;

(e) fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction;

(f) add up to four two-digit numbers using strategies based on place value and properties of operations;

(g) add and subtract within 1000 using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method; understand that in adding or subtracting three-digit numbers, one adds or subtracts hundreds and hundreds, tens and tens, ones and ones, and sometimes it is necessary to compose or decompose tens or hundreds;

(h) mentally add 10 or 100 to a given number 100-900 and mentally subtract 10 or 100 from a given number 100-900; and

(i) explain why addition and subtraction strategies work using place value and the properties of operations.

(3) Mathematics measurement and data content standards for Grade 2 are:

(a) measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes;

(b) measure the length of an object twice, using length units of different lengths for the two measurements and describe how the two measurements relate to the size of the unit chosen;

(c) estimate lengths using units of inches, feet, centimeters, and meters;

(d) measure to determine how much longer one object is than another,

expressing the length difference in terms of a standard length unit;

(e) use addition and subtraction within 100 to solve word problems within a cultural context, including those of Montana American Indians, involving lengths that are given in the same units, e.g., by using drawings (such as drawings of rulers) and equations with a symbol for the unknown number to represent the problem;

(f) represent whole numbers as lengths from 0 on a number line diagram with equally spaced points corresponding to the numbers 0, 1, 2, ... and represent whole-number sums and differences within 100 on a number line diagram;

(g) tell and write time from analog and digital clocks to the nearest five minutes using a.m. and p.m.;

(h) solve word problems involving dollar bills, quarters, dimes, nickels, and pennies, using \$ and ¢ symbols appropriately; for example: if you have two dimes and three pennies, how many cents do you have?;

(i) generate measurement data by measuring lengths of several objects to the nearest whole unit or by making repeated measurements of the same object and show the measurements by making a line plot, where the horizontal scale is marked off in whole-number units; and

(j) draw a picture graph and a bar graph (with single unit scale) to represent a data set from a variety of cultural contexts, including those of Montana American Indians, with up to four categories and solve simple put together, take apart and compare problems using information presented in a bar graph.

(4) Mathematics geometry content standards for Grade 2 are:

(a) recognize and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces and identify triangles, quadrilaterals, pentagons, hexagons, and cubes;

(b) partition a rectangle into rows and columns of same size squares and count to find the total number of them; and

(c) partition circles and rectangles into two, three, or four equal shares; describe the shares using the words halves, thirds, half of, a third of, etc.; describe the whole as two halves, three thirds, four fourths; and recognize that equal shares of identical wholes need not have the same shape.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE V MONTANA GRADE 3 MATHEMATICS CONTENT

STANDARDS (1) Mathematics operations and algebraic thinking content standards for Grade 3 are:

(a) interpret products of whole numbers, e.g., interpret 5×7 as the total number of objects in 5 groups of 7 objects each; for example, describe a context in which a total number of objects can be expressed as 5×7 ;

(b) interpret whole-number quotients of whole numbers, e.g., interpret $56 \div 8$ as the number of objects in each share when 56 objects are partitioned equally into 8 shares, or as a number of shares when 56 objects are partitioned into equal shares of 8 objects each; for example, describe a context in which a number of shares or a number of groups can be expressed as $56 \div 8$;

(c) use multiplication and division within 100 to solve word problems in

situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem;

(d) determine the unknown whole number in a multiplication or division equation relating three whole numbers; for example, determine the unknown number that makes the equation true in each of the equations $8 \times ? = 48$, $5 = ? \div 3$, $6 \times 6 = ?$;

(e) apply properties of operations as strategies to multiply and divide; for example: if $6 \times 4 = 24$ is known, then $4 \times 6 = 24$ is also known (commutative property of multiplication); $3 \times 5 \times 2$ can be found by $3 \times 5 = 15$, then $15 \times 2 = 30$, or by $5 \times 2 = 10$, then $3 \times 10 = 30$ (associative property of multiplication); knowing that $8 \times 5 = 40$ and $8 \times 2 = 16$, one can find 8×7 as $8 \times (5 + 2) = (8 \times 5) + (8 \times 2) = 40 + 16 = 56$ (distributive property);

(f) understand division as an unknown factor problem; for example, find $32 \div 8$ by finding the number that makes 32 when multiplied by 8;

(g) fluently multiply and divide within 100 using strategies such as the relationship between multiplication and division (e.g., knowing that $8 \times 5 = 40$, one knows $40 \div 5 = 8$) or properties of operations and by the end of Grade 3, know from memory all products of two one-digit numbers;

(h) solve two step word problems using the four operations within cultural contexts, including those of Montana American Indians; represent these problems using equations with a letter standing for the unknown quantity; and assess the reasonableness of answers using mental computation and estimation strategies including rounding; and

(i) identify arithmetic patterns (including patterns in the addition table or multiplication table) and explain them using properties of operations; for example, observe that four times a number is always even, and explain why four times a number can be decomposed into two equal addends.

(2) Mathematics number and operations in base ten content standards for Grade 3 are:

(a) use place value understanding to round whole numbers to the nearest 10 or 100;

(b) fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction; and

(c) multiply one-digit whole numbers by multiples of 10 in the range 10-90 (e.g., 9×80 , 5×60) using strategies based on place value and properties of operations.

(3) Mathematics number and operations fractions content standards for Grade 3 are:

(a) understand a fraction $1/b$ as the quantity formed by 1 part when a whole is partitioned into b equal parts and understand a fraction a/b as the quantity formed by a parts of size $1/b$;

(b) understand a fraction as a number on the number line and represent fractions on a number line diagram;

(i) represent a fraction $1/b$ on a number line diagram by defining the interval from 0 to 1 as the whole and partitioning it into b equal parts, recognize that each

part has size $1/b$, and that the endpoint of the part based at 0 locates the number $1/b$ on the number line; and

(ii) represent a fraction a/b on a number line diagram by marking off a lengths $1/b$ from 0 and recognize that the resulting interval has size a/b and that its endpoint locates the number a/b on the number line;

(c) explain equivalence of fractions in special cases and compare fractions by reasoning about their size;

(i) understand two fractions as equivalent (equal) if they are the same size or the same point on a number line;

(ii) recognize and generate simple equivalent fractions, e.g., $1/2 = 2/4$, $4/6 = 2/3$ and explain why the fractions are equivalent, e.g., by using a visual fraction model;

(iii) express whole numbers as fractions, and recognize fractions that are equivalent to whole numbers; for example: express 3 in the form $3 = 3/1$; recognize that $6/1 = 6$; and locate $4/4$ and 1 at the same point of a number line diagram; and

(iv) compare two fractions with the same numerator or the same denominator by reasoning about their size; recognize that comparisons are valid only when the two fractions refer to the same whole; record the results of comparisons with the symbols $>$, $=$, or $<$; and justify the conclusions, e.g., by using a visual fraction model.

(4) Mathematics measurement and data content standards for Grade 3 are:

(a) tell and write time to the nearest minute and measure time intervals in minutes and solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram;

(b) measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l) and add, subtract, multiply, or divide to solve one step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem;

(c) draw a scaled picture graph and a scaled bar graph to represent a data set with several categories, within cultural contexts including those of Montana American Indians; solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs; for example, draw a bar graph in which each square in the bar graph might represent five pets;

(d) generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch and show the data by making a line plot where the horizontal scale is marked off in appropriate units, i.e. whole numbers, halves, or quarters;

(e) recognize area as an attribute of plane figures and understand concepts of area measurement;

(i) a square with side length 1 unit, called "a unit square," is said to have "one square unit" of area and can be used to measure area; and

(ii) a plane figure which can be covered without gaps or overlaps by n unit squares is said to have an area of n square units;

(f) measure areas by counting unit squares (square cm, square m, square in, square ft, and improvised units);

(g) relate area to the operations of multiplication and addition;

(i) find the area of a rectangle with whole-number side lengths by tiling it, and

show that the area is the same as would be found by multiplying the side lengths;

(ii) multiply side lengths to find areas of rectangles with whole-number side lengths in the context of solving real-world and mathematical problems and represent whole-number products as rectangular areas in mathematical reasoning;

(iii) use tiling to show in a concrete case that the area of a rectangle with whole-number side lengths a and $b + c$ is the sum of $a \times b$ and $a \times c$ and use area models to represent the distributive property in mathematical reasoning;

(iv) recognize area as additive; find areas of rectilinear figures by decomposing them into nonoverlapping rectangles and adding the areas of the nonoverlapping parts; and apply this technique to solve real-world problems, including those of Montana American Indians; and

(h) solve real-world and mathematical problems involving perimeters of polygons, including finding the perimeter given the side lengths, finding an unknown side length, and exhibiting rectangles with the same perimeter and different areas or with the same area and different perimeters.

(5) Mathematics geometry content standards for Grade 3 are:

(a) understand that shapes in different categories (e.g., rhombuses, rectangles, and others) may share attributes (e.g., having four sides) and that the shared attributes can define a larger category (e.g., quadrilaterals); recognize rhombuses, rectangles, and squares as examples of quadrilaterals; and draw examples of quadrilaterals that do not belong to any of these subcategories; and

(b) partition shapes into parts with equal areas; express the area of each part as a unit fraction of the whole; for example, partition a shape into four parts with equal area, and describe the area of each part as $\frac{1}{4}$ of the area of the shape.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE VI MONTANA GRADE 4 MATHEMATICS CONTENT

STANDARDS (1) Mathematics operations and algebraic thinking content standards for Grade 4 are:

(a) interpret a multiplication equation as a comparison, e.g., interpret $35 = 5 \times 7$ as a statement that 35 is 5 times as many as 7 and 7 times as many as 5 and represent verbal statements of multiplicative comparisons as multiplication equations;

(b) 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;

(c) solve multistep word problems within cultural contexts, including those of Montana American Indians, 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; and assess the reasonableness of answers using mental computation and estimation strategies including rounding;

(d) 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 1-1000 is a multiple of a given one-digit number; and determine whether a given whole number in the range 1-100 is prime or composite; and

(e) generate number or shape patterns 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.

(2) Mathematics number and operations in base ten content standards for Grade 4 are:

(a) recognize that in a multidigit 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;

(b) read and write multidigit whole numbers using base ten numerals, number names, and expanded form and compare two multidigit numbers based on meanings of the digits in each place, using $>$, $=$, and $<$ symbols to record the results of comparisons;

(c) use place value understanding to round multidigit whole numbers to any place;

(d) fluently add and subtract multidigit whole numbers using the standard algorithm;

(e) multiply a whole number of up to four digits by a one-digit whole number; multiply two two-digit numbers using strategies based on place value and the properties of operations; and illustrate and explain the calculation by using equations, rectangular arrays, and/or area models; and

(f) 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 and illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.

(3) Mathematics number and operations - fractions content standards for Grade 4 are:

(a) 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 and use this principle to recognize and generate equivalent fractions;

(b) 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;

(c) understand a fraction a/b with $a > 1$ as a sum of fractions $1/b$;

(i) understand addition and subtraction of fractions as joining and separating parts referring to the same whole;

(ii) 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; for example: $3/8 = 1/8 + 1/8 +$

$1/8$; $3/8 = 1/8 + 2/8$; $2 \frac{1}{8} = 1 + 1 + 1/8 = 8/8 + 8/8 + 1/8$;

(iii) 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; and

(iv) solve word problems within cultural contexts, including those of Montana American Indians, 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;

(d) apply and extend previous understandings of multiplication to multiply a fraction by a whole number;

(i) 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 $5 \times (1/4)$, recording the conclusion by the equation $5/4 = 5 \times (1/4)$;

(ii) 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 $3 \times (2/5)$ as $6 \times (1/5)$, recognizing this product as $6/5$ (in general, $n \times (a/b) = (n \times a)/b$);

(iii) solve word problems within cultural contexts, including those of Montana American Indians, 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 five people at the party, how many pounds of roast beef will be needed? Between what two whole numbers does your answer lie? As a contemporary American Indian example, for family/cultural gatherings, the Canadian and Montana Cree bake bannock made from flour, salt, grease, and baking soda, in addition to $3/4$ cup water per pan. When making four pans, how much water will be needed?;

(e) 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; for example, express $3/10$ as $30/100$, and add $3/10 + 4/100 = 34/100$;

(f) 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; and locate 0.62 on a number line diagram;

(g) 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.

(4) Mathematics measurement and data content standards for Grade 4 are:

(a) know relative sizes of measurement units within one system of units including km, m, cm, kg, g, lb., oz., l, ml, hr, min., and 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 four ft snake as 48 in.; generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...;

(b) use the four operations to solve word problems within cultural contexts, including those of Montana American Indians, 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;

(c) 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;

(d) make a line plot to display a data set of measurements in fractions of a unit ($\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$); 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 or arrow/spearhead collection;

(e) recognize angles as geometric shapes that are formed wherever two rays share a common endpoint and understand concepts of angle measurement:

(i) 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 $\frac{1}{360}$ of a circle is called a "one-degree angle" and can be used to measure angles; and

(ii) an angle that turns through n one-degree angles is said to have an angle measure of n degrees;

(f) measure angles in whole-number degrees using a protractor and sketch angles of specified measure;

(g) recognize angle measure as additive; when an angle is decomposed into nonoverlapping 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.

(5) Mathematics geometry content standards for Grade 4 are:

(a) draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines and identify these in two-dimensional figures;

(b) 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; and

(c) recognize a line of symmetry for a two-dimensional figure, including those found in Montana American Indian designs, 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.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE VII MONTANA GRADE 5 MATHEMATICS CONTENT

STANDARDS (1) Mathematics operations and algebraic thinking content standards for Grade 5 are:

(a) use parentheses, brackets, or braces in numerical expressions and evaluate expressions with these symbols;

(b) write simple expressions that record calculations with numbers and interpret numerical expressions without evaluating them; for example, express the calculation "add 8 and 7, then multiply by 2" as $2 \times (8 + 7)$; recognize that $3 \times (18932 + 921)$ is three times as large as $18932 + 921$, without having to calculate the indicated sum or product; and

(c) generate two numerical patterns using two given rules; identify apparent relationships between corresponding terms; form ordered pairs consisting of corresponding terms from the two patterns and graph the ordered pairs on a coordinate plane; for example, given the rule "add 3" and the starting number 0, and given the rule "add 6" and the starting number 0, generate terms in the resulting sequences and observe that the terms in one sequence are twice the corresponding terms in the other sequence; and explain informally why this is so.

(2) Mathematics number and operations in base ten content standards for Grade 5 are:

(a) recognize that in a multidigit number, a digit in one place represents 10 times as much as it represents in the place to its right and $1/10$ of what it represents in the place to its left;

(b) explain patterns in the number of zeros of the product when multiplying a number by powers of 10; explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10; and use whole-number exponents to denote powers of 10;

(c) read, write, and compare decimals to thousandths;

(i) read and write decimals to thousandths using base ten numerals, number names, and expanded form, e.g. $347.392 = 3 \times 100 + 4 \times 10 + 7 \times 1 + 3 \times (1/10) + 9 \times (1/100) + 2 \times (1/1000)$; and

(ii) compare two decimals to thousandths based on meanings of the digits in each place using $>$, $=$, and $<$ symbols to record the results of comparisons;

(d) use place value understandings to round decimals to any place;

(e) fluently multiply multidigit whole numbers using the standard algorithm;

(f) find whole-number quotients of whole numbers with up to four-digit dividends and two-digit divisors using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division and illustrate and explain the calculation by using equations, rectangular arrays, and/or area models; and

(g) add, subtract, multiply, and divide decimals to hundredths using concrete models or drawings within cultural contexts, including those of Montana American Indians, and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method; and explain the reasoning used.

(3) Mathematics number and operations – fractions content standards for Grade 5 are:

(a) add and subtract fractions with unlike denominators (including mixed numbers) by replacing given fractions with equivalent fractions in such a way as to produce an equivalent sum or difference of fractions with like denominators; for example, $2/3 + 5/4 = 8/12 + 15/12 = 23/12$ (in general, $a/b + c/d = (ad + bc)/bd$);

(b) solve word problems involving addition and subtraction of fractions referring to the same whole, including cases of unlike denominators, e.g., by using

visual fraction models or equations to represent the problem; use benchmark fractions and number sense of fractions to estimate mentally and assess the reasonableness of answers; for example, recognize an incorrect result $2/5 + 1/2 = 3/7$, by observing that $3/7 < 1/2$;

(c) interpret a fraction as division of the numerator by the denominator ($a/b = a \div b$); solve word problems involving division of whole numbers leading to answers in the form of fractions or mixed numbers, e.g., by using visual fraction models or equations to represent the problem; for example, interpret $3/4$ as the result of dividing 3 by 4, noting that $3/4$ multiplied by 4 equals 3 and that when 3 wholes are shared equally among 4 people each person has a share of size $3/4$; if 9 people want to share a 50-pound sack of rice equally by weight, how many pounds of rice should each person get? Between what two whole numbers does your answer lie?;

(d) apply and extend previous understandings of multiplication to multiply a fraction or whole number by a fraction;

(i) interpret the product $(a/b) \times q$ as a parts of a partition of q into b equal parts; equivalently, as the result of a sequence of operations $a \times q \div b$; for example, use a visual fraction model to show $(2/3) \times 4 = 8/3$, and create a story context for this equation within cultural contexts, including those of Montana American Indians; and do the same with $(2/3) \times (4/5) = 8/15$ (in general, $(a/b) \times (c/d) = ac/bd$);

(ii) find the area of a rectangle with fractional side lengths by tiling it with unit squares of the appropriate unit fraction side lengths; show that the area is the same as would be found by multiplying the side lengths; multiply fractional side lengths to find areas of rectangles; and represent fraction products as rectangular areas;

(e) interpret multiplication as scaling (resizing), by:

(i) comparing the size of a product to the size of one factor on the basis of the size of the other factor without performing the indicated multiplication; and

(ii) explaining why multiplying a given number by a fraction greater than 1 results in a product greater than the given number (recognizing multiplication by whole numbers greater than 1 as a familiar case); explaining why multiplying a given number by a fraction less than 1 results in a product smaller than the given number; and relating the principle of fraction equivalence $a/b = (n \times a)/(n \times b)$ to the effect of multiplying a/b by 1;

(f) solve real-world problems involving multiplication of fractions and mixed numbers, e.g., by using visual fraction models or equations to represent the problem within cultural contexts, including those of Montana American Indians;

(g) apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions;

(i) interpret division of a unit fraction by a nonzero whole number and compute such quotients; for example, create a story context within cultural contexts, including those of Montana American Indians, for $(1/3) \div 4$, and use a visual fraction model to show the quotient; use the relationship between multiplication and division to explain that $(1/3) \div 4 = 1/12$ because $(1/12) \times 4 = 1/3$;

(ii) interpret division of a whole number by a unit fraction and compute such quotients; for example, create a story context within cultural contexts, including those of Montana American Indians, for $4 \div (1/5)$, and use a visual fraction model to show the quotient; and use the relationship between multiplication and division to explain that $4 \div (1/5) = 20$ because $20 \times (1/5) = 4$; and

(iii) solve real-world problems involving division of unit fractions by nonzero whole numbers and division of whole numbers by unit fractions, e.g., by using visual fraction models and equations to represent the problem; for example, how much chocolate will each person get if 3 people share $\frac{1}{2}$ lb of chocolate equally? How many $\frac{1}{3}$ -cup servings are in 2 cups of raisins?.

(4) Mathematics measurement and data content standards for Grade 5 are:

(a) convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m) and use these conversions in solving multistep, real-world problems within a cultural context, including those of Montana American Indians;

(b) make a line plot to display a data set of measurements in fractions of a unit ($\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$); use operations on fractions for this grade to solve problems involving information presented in line plots; for example, given different measurements of liquid in identical beakers, find the amount of liquid each beaker would contain if the total amount in all the beakers were redistributed equally;

(c) recognize volume as an attribute of solid figures and understand concepts of volume measurement;

(i) a cube with side length 1 unit, called a "unit cube," is said to have "one cubic unit" of volume and can be used to measure volume; and

(ii) a solid figure which can be packed without gaps or overlaps using n unit cubes is said to have a volume of n cubic units;

(d) measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units;

(e) relate volume to the operations of multiplication and addition and solve real-world and mathematical problems involving volume within cultural contexts, including those of Montana American Indians;

(i) find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base; and represent threefold whole-number products as volumes, e.g., to represent the associative property of multiplication;

(ii) apply the formulas $V = l \times w \times h$ and $V = b \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole-number edge lengths in the context of solving real-world and mathematical problems; and

(iii) recognize volume as additive and find volumes of solid figures composed of two nonoverlapping right rectangular prisms by adding the volumes of the nonoverlapping parts, applying this technique to solve real-world problems.

(5) Mathematics geometry content standards for Grade 5 are:

(a) use a pair of perpendicular number lines, called axes, to define a coordinate system with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates; understand that the first number indicates how far to travel from the origin in the direction of one axis and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate);

(b) represent real-world and mathematical problems by graphing points in the

first quadrant of the coordinate plane and interpret coordinate values of points in the context of the situation, including those found in Montana American Indian designs;

(c) understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category; for example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles; and

(d) classify two-dimensional figures in a hierarchy based on properties.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE VIII MONTANA GRADE 6 MATHEMATICS CONTENT STANDARDS (1) Mathematics ratios and proportional relationship content standards for Grade 6 are:

(a) understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities; for example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes."

(b) understand the concept of a unit rate a/b associated with a ratio $a:b$ with $b \neq 0$, and use rate language in the context of a ratio relationship; for example, "This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is $3/4$ cup of flour for each cup of sugar." "We paid \$75 for 15 hamburgers, which is a rate of \$5 per hamburger."

(c) use ratio and rate reasoning to solve real-world and mathematical problems from a variety of cultural contexts, including those of Montana American Indians, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations;

(i) make tables of equivalent ratios relating quantities with whole-number measurements, find missing values in the tables, plot the pairs of values on the coordinate plane, and use tables to compare ratios;

(ii) solve unit rate problems including those involving unit pricing and constant speed; for example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what rate were lawns being mowed? As a contemporary American Indian example, it takes at least 16 hours to bead a Crow floral design on moccasins for two children. How many pairs of moccasins can be completed in 72 hours?;

(iii) find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means $30/100$ times the quantity) and solve problems involving finding the whole, given a part and the percent;

(iv) use ratio reasoning to convert measurement units and manipulate and transform units appropriately when multiplying or dividing quantities.

(2) Mathematics number system content standards for Grade 6 are:

(a) interpret and compute quotients of fractions and solve word problems involving division of fractions by fractions, e.g., by using visual fraction models and equations to represent the problem; for example, create a story context for $(2/3) \div (3/4)$ and use a visual fraction model to show the quotient; use the relationship between multiplication and division to explain that $(2/3) \div (3/4) = 8/9$ because $3/4$ of

$\frac{8}{9}$ is $\frac{2}{3}$. (In general, $(a/b) \div (c/d) = ad/bc$.) How much chocolate will each person get if 3 people share $\frac{1}{2}$ lb of chocolate equally? How many $\frac{3}{4}$ -cup servings are in $\frac{2}{3}$ of a cup of yogurt? How wide is a rectangular strip of land with length $\frac{3}{4}$ mi and area $\frac{1}{2}$ square mi?;

(b) fluently divide multidigit numbers using the standard algorithm;

(c) fluently add, subtract, multiply, and divide multidigit decimals using the standard algorithm for each operation;

(d) find the greatest common factor of two whole numbers less than or equal to 100 and the least common multiple of two whole numbers less than or equal to 12; use the distributive property to express a sum of two whole numbers 1-100 with a common factor as a multiple of a sum of two whole numbers with no common factor; for example, express $36 + 8$ as $4(9 + 2)$;

(e) understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge) and use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation;

(f) understand a rational number as a point on the number line and extend number line diagrams and coordinate axes familiar from previous grades to represent points on the line and in the plane with negative number coordinates;

(i) recognize opposite signs of numbers as indicating locations on opposite sides of 0 on the number line; recognize that the opposite of the opposite of a number is the number itself, e.g., $-(-3) = 3$; and that 0 is its own opposite;

(ii) understand signs of numbers in ordered pairs as indicating locations in quadrants of the coordinate plane and recognize that when two ordered pairs differ only by signs, the locations of the points are related by reflections across one or both axes; and

(iii) find and position integers and other rational numbers on a horizontal or vertical number line diagram and find and position pairs of integers and other rational numbers on a coordinate plane;

(g) understand ordering and absolute value of rational numbers;

(i) interpret statements of inequality as statements about the relative position of two numbers on a number line diagram; for example, interpret $-3 > -7$ as a statement that -3 is located to the right of -7 on a number line oriented from left to right;

(ii) write, interpret, and explain statements of order for rational numbers in real-world contexts; for example, write $-3^{\circ}\text{C} > -7^{\circ}\text{C}$ to express the fact that -3°C is warmer than -7°C ;

(iii) understand the absolute value of a rational number as its distance from 0 on the number line; interpret absolute value as magnitude for a positive or negative quantity in a real-world situation; for example, for an account balance of -30 dollars, write $|-30| = 30$ to describe the size of the debt in dollars; and

(iv) distinguish comparisons of absolute value from statements about order; for example, recognize that an account balance less than -30 dollars represents a debt greater than 30 dollars;

(h) solve real-world and mathematical problems from a variety of cultural contexts, including those of Montana American Indians, by graphing points in all four

quadrants of the coordinate plane and include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.

(3) Mathematics expressions and equations content standards for Grade 6 are:

(a) write and evaluate numerical expressions involving whole-number exponents;

(b) write, read, and evaluate expressions in which letters stand for numbers;

(i) write expressions that record operations with numbers and with letters standing for numbers; for example, express the calculation "subtract y from 5" as $5 - y$;

(ii) identify parts of an expression using mathematical terms (sum, term, product, factor, quotient, coefficient); view one or more parts of an expression as a single entity; for example, describe the expression $2(8 + 7)$ as a product of two factors; and view $(8 + 7)$ as both a single entity and a sum of two terms; and

(iii) evaluate expressions at specific values of their variables; include expressions that arise from formulas used in real-world problems; perform arithmetic operations, including those involving whole-number exponents in the conventional order when there are no parentheses to specify a particular order (order of operations); for example, use the formulas $V = s^3$ and $A = 6s^2$ to find the volume and surface area of a cube with sides of length $s = 1/2$;

(c) apply the properties of operations to generate equivalent expressions; for example, apply the distributive property to the expression $3(2 + x)$ to produce the equivalent expression $6 + 3x$; apply the distributive property to the expression $24x + 18y$ to produce the equivalent expression $6(4x + 3y)$; and apply properties of operations to $y + y + y$ to produce the equivalent expression $3y$;

(d) identify when two expressions are equivalent (i.e., when the two expressions name the same number regardless of which value is substituted into them); for example, the expressions $y + y + y$ and $3y$ are equivalent because they name the same number regardless of which number y stands for;

(e) understand solving an equation or inequality as a process of answering a question: which values from a specified set, if any, make the equation or inequality true? Use substitution to determine whether a given number in a specified set makes an equation or inequality true;

(f) use variables to represent numbers and write expressions when solving a real-world or mathematical problem and understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set;

(g) solve real-world and mathematical problems by writing and solving equations of the form $x + p = q$ and $px = q$ for cases in which p , q , and x are all nonnegative rational numbers;

(h) write an inequality of the form $x > c$ or $x < c$ to represent a constraint or condition in a real-world or mathematical problem; recognize that inequalities of the form $x > c$ or $x < c$ have infinitely many solutions; and represent solutions of such inequalities on number line diagrams; and

(i) use variables to represent two quantities in a real-world problem from a variety of cultural contexts, including those of Montana American Indians, that

change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable; analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation; for example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times and write the equation $d = 65t$ to represent the relationship between distance and time.

(4) Mathematics geometry content standards for Grade 6 are:

(a) find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems within cultural contexts, including those of Montana American Indians; for example, use Montana American Indian designs to decompose shapes and find the area;

(b) find the volume of a right rectangular prism with fractional edge lengths by packing it with unit cubes of the appropriate unit fraction edge lengths and show that the volume is the same as would be found by multiplying the edge lengths of the prism and apply the formulas $V = lwh$ and $V = bh$ to find volumes of right rectangular prisms with fractional edge lengths in the context of solving real-world and mathematical problems;

(c) draw polygons in the coordinate plane given coordinates for the vertices; use coordinates to find the length of a side joining points with the same first coordinate or the same second coordinate; and apply these techniques in the context of solving real-world and mathematical problems; and

(d) represent three-dimensional figures using nets made up of rectangles and triangles and use the nets to find the surface area of these figures and apply these techniques in the context of solving real-world and mathematical problems within cultural contexts, including those of Montana American Indians.

(5) Mathematics statistics and probability content standards for Grade 6 are:

(a) recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers; for example, "How old am I?" is not a statistical question, but "How old are the students in my school?" is a statistical question because one anticipates variability in students' ages;

(b) understand that a set of data collected (including Montana American Indian demographic data) to answer a statistical question has a distribution which can be described by its center, spread, and overall shape;

(c) recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number;

(d) display numerical data in plots on a number line, including dot plots, histograms, and box plots; and

(e) summarize numerical data sets in relation to their context, such as by:

(i) reporting the number of observations;

(ii) describing the nature of the attribute under investigation, including how it was measured and its units of measurement;

(iii) giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing

any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered; and

(iv) relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE IX MONTANA GRADE 7 MATHEMATICS CONENT STANDARDS (1) Mathematics ratios and proportional relationship content standards for Grade 7 are:

(a) compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units; for example, if a person walks $\frac{1}{2}$ mile in each $\frac{1}{4}$ hour, compute the unit rate as the complex fraction $\frac{1/2}{1/4}$ miles per hour, equivalently 2 miles per hour;

(b) recognize and represent proportional relationships between quantities, including those represented in Montana American Indian cultural contexts;

(i) decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin;

(ii) identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships;

(iii) represent proportional relationships by equations; for example, if total cost t is proportional to the number n of items purchased at a constant price p , the relationship between the total cost and the number of items can be expressed as $t = pn$; as a contemporary American Indian example, analyze cost of beading materials; cost of cooking ingredients for family gatherings, community celebrations, etc.; and

(iv) explain what a point (x, y) on the graph of a proportional relationship means in terms of the situation, with special attention to the points $(0, 0)$ and $(1, r)$ where r is the unit rate;

(c) use proportional relationships to solve multistep ratio and percent problems within cultural contexts, including those of Montana American Indians (e.g., percent of increase and decrease of tribal land); for example: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

(2) Mathematics number system content standards for Grade 7 are:

(a) apply and extend previous understandings of addition and subtraction to add and subtract rational numbers and represent addition and subtraction on a horizontal or vertical number line diagram;

(i) describe situations in which opposite quantities combine to make 0; for example, a hydrogen atom has 0 charge because its two constituents are oppositely charged;

(ii) understand $p + q$ as the number located a distance $|q|$ from p , in the positive or negative direction depending on whether q is positive or negative; show that a number and its opposite have a sum of 0 (are additive inverses); and interpret sums of rational numbers by describing real-world contexts;

(iii) understand subtraction of rational numbers as adding the additive

inverse, $p - q = p + (-q)$; show that the distance between two rational numbers on the number line is the absolute value of their difference; and apply this principle in real-world contexts; and

(iv) apply properties of operations as strategies to add and subtract rational numbers;

(b) apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers;

(i) understand that multiplication is extended from fractions to rational numbers by requiring that operations continue to satisfy the properties of operations, particularly the distributive property, leading to products such as $(-1)(-1) = 1$ and the rules for multiplying signed numbers; and interpret products of rational numbers by describing real-world contexts;

(ii) understand that integers can be divided, provided that the divisor is not zero, and every quotient of integers (with nonzero divisor) is a rational number, i.e. if p and q are integers, then $-(p/q) = (-p)/q = p/(-q)$; and interpret quotients of rational numbers by describing real-world contexts;

(iii) apply properties of operations as strategies to multiply and divide rational numbers; and

(iv) convert a rational number to a decimal using long division; and know that the decimal form of a rational number terminates in 0s or eventually repeats;

(c) solve real-world and mathematical problems from a variety of cultural contexts, including those of Montana American Indians, involving the four operations with rational numbers.

(3) Mathematics expressions and equations content standards for Grade 7 are:

(a) apply properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients;

(b) understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related; for example, $a + 0.05a = 1.05a$ means that "increase by 5%" is the same as "multiply by 1.05;"

(c) solve multistep real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically; apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies; for example: if a woman making \$25 an hour gets a 10% raise, she will make an additional $1/10$ of her salary an hour, or \$2.50, for a new salary of \$27.50 and if you want to place a towel bar $9 \frac{3}{4}$ inches long in the center of a door that is $27 \frac{1}{2}$ inches wide, you will need to place the bar about 9 inches from each edge; this estimate can be used as a check on the exact computation; and

(d) use variables to represent quantities in a real-world or mathematical problems, including those represented in Montana American Indian cultural contexts, and construct simple equations and inequalities to solve problems by reasoning about the quantities;

(i) solve word problems leading to equations of the form $px + q = r$ and $p(x + q) = r$, where p , q , and r are specific rational numbers; solve equations of these

forms fluently; compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach; for example, the perimeter of a rectangle is 54 cm. and its length is 6 cm. What is its width?; and

(ii) solve word problems leading to inequalities of the form $px + q > r$ or $px + q < r$, where p , q , and r are specific rational numbers; graph the solution set of the inequality and interpret it in the context of the problem; for example: as a salesperson, you are paid \$50 per week plus \$3 per sale; this week you want your pay to be at least \$100; write an inequality for the number of sales you need to make and describe the solutions.

(4) Mathematics geometry content standards for Grade 7 are:

(a) solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale;

(b) draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions; focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle;

(c) describe the two-dimensional figures that result from slicing three-dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids;

(d) know the formulas for the area and circumference of a circle and use them to solve problems from a variety of cultural contexts, including those of Montana American Indians and give an informal derivation of the relationship between the circumference and area of a circle;

(e) use facts about supplementary, complementary, vertical, and adjacent angles in a multistep problem to write and solve simple equations for an unknown angle in a figure; and

(f) solve real-world and mathematical problems from a variety of cultural contexts, including those of Montana American Indians, involving area, volume, and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

(5) Mathematics statistics and probability content standards for Grade 7 are:

(a) understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population; and understand that random sampling tends to produce representative samples and support valid inferences;

(b) use data, including Montana American Indian demographics data, from a random sample to draw inferences about a population with an unknown characteristic of interest; generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions; for example, estimate the mean word length in a book by randomly sampling words from the book; predict the winner of a school election based on randomly sampled survey data; predict how many text messages your classmates receive in a day and gauge how far off the estimate or prediction might be;

(c) informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers

by expressing it as a multiple of a measure of variability; for example, the mean height of players on the basketball team is 10 cm greater than the mean height of players on the soccer team, about twice the variability (mean absolute deviation) on either team; on a dot plot, the separation between the two distributions of heights is noticeable;

(d) use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations; for example, decide whether the words in a chapter of a seventh-grade science book are generally longer than the words in a chapter of a fourth-grade science book;

(e) understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring; larger numbers indicate greater likelihood; a probability near 0 indicates an unlikely event; a probability around $1/2$ indicates an event that is neither unlikely nor likely; and a probability near 1 indicates a likely event;

(f) approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency and predict the approximate relative frequency given the probability; for example, when rolling a number cube 600 times, predict that a 3 or 6 would be rolled roughly 200 times, but probably not exactly 200 times and when playing Montana American Indian hand/stick games, you can predict the approximate number of accurate guesses;

(g) develop a probability model and use it to find probabilities of events; compare probabilities from a model to observed frequencies; and if the agreement is not good, explain possible sources of the discrepancy;

(i) develop a uniform probability model by assigning equal probability to all outcomes and use the model to determine probabilities of events; for example, if a student is selected at random from a class, find the probability that Jane will be selected and the probability that a girl will be selected; and

(ii) develop a probability model (which may not be uniform) by observing frequencies in data generated from a chance process; for example, find the approximate probability that a spinning penny will land heads up or that a tossed paper cup will land open-end down; do the outcomes for the spinning penny appear to be equally likely based on the observed frequencies?;

(h) find probabilities of compound events using organized lists, tables, tree diagrams, and simulation;

(i) understand that, just as with simple events, the probability of a compound event is the fraction of outcomes in the sample space for which the compound event occurs;

(ii) represent sample spaces for compound events using methods such as organized lists, tables and tree diagrams; for an event described in everyday language (e.g., "rolling double sixes"), identify the outcomes in the sample space which compose the event; and

(iii) design and use a simulation to generate frequencies for compound events; for example, use random digits as a simulation tool to approximate the answer to the question: If 40% of donors have type A blood, what is the probability that it will take at least 4 donors to find one with type A blood?.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE X MONTANA GRADE 8 MATHEMATICS CONTENT

STANDARDS (1) Mathematics number system content standards for Grade 8 are:

(a) 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; and

(b) 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., π^2); for example, by truncating the decimal expansion of $\sqrt{2}$, show that $\sqrt{2}$ is between 1 and 2, then between 1.4 and 1.5, and explain how to continue on to get better approximations.

(2) Mathematics expressions and equations content standards for Grade 8 are:

(a) know and apply the properties of integer exponents to generate equivalent numerical expressions; for example, $3^2 \times 3^{-5} = 3^{-3} = 1/3^3 = 1/27$;

(b) use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number; evaluate square roots of small perfect squares and cube roots of small perfect cubes; and know that $\sqrt{2}$ is irrational;

(c) use numbers expressed in the form of a single digit times a whole-number 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 times 10^8 and the population of the world as 7 times 10^9 and determine that the world population is more than 20 times larger;

(d) 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); and interpret scientific notation that has been generated by technology;

(e) 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;

(f) use similar triangles to explain why the slope m is the same between any two distinct points on a nonvertical 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 ;

(g) solve linear equations in one variable;

(i) give examples of linear equations in one variable with one solution, infinitely many solutions, or no solutions and 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);

(ii) solve linear equations with rational number coefficients, including

equations whose solutions require expanding expressions using the distributive property and collecting like terms; and

(h) analyze and solve pairs of simultaneous linear equations;

(i) 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;

(ii) 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; and

(iii) solve real-world and mathematical problems from a variety of cultural contexts, including those of Montana American Indians, 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.

(3) Mathematics functions content standards for Grade 8 are:

(a) understand that a function is a rule that assigns to each input exactly one output and the graph of a function is the set of ordered pairs consisting of an input and the corresponding output;

(b) 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;

(c) 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;

(d) 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; and 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;

(e) describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear) and sketch a graph that exhibits the qualitative features of a function that has been described verbally.

(4) Mathematics geometry content standards for Grade 8 are:

(a) verify experimentally the properties of rotations, reflections, and translations from a variety of cultural contexts, including those of Montana American Indians:

(i) lines are taken to lines and line segments to line segments of the same length;

(ii) angles are taken to angles of the same measure; and

(iii) parallel lines are taken to parallel lines;

(b) 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 and given two congruent figures, describe a sequence that exhibits the congruence between them;

(c) describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures from a variety of cultural contexts, including those of Montana American Indians, using coordinates;

(d) 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 and given two similar two-dimensional figures, describe a sequence that exhibits the similarity between them;

(e) 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;

(f) explain a proof of the Pythagorean Theorem and its converse;

(g) apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions; for example, determine the unknown height of a Plains Indian tipi when given the side length and radius;

(h) apply the Pythagorean Theorem to find the distance between two points in a coordinate system; and

(i) know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.

(5) Mathematics statistics and probability content standards for Grade 8 are:

(a) construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities and describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association;

(b) know that straight lines are widely used to model relationships between two quantitative variables and 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;

(c) 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;

(d) 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 including data from Montana American Indian sources 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?.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE XI SYMBOLS (1) The symbol "+" denotes science, technology, engineering, mathematics (STEM) standards that students should learn in order to take advanced courses such as calculus, advanced statistics, or discrete mathematics.

(2) The symbol "*" denotes specific modeling standards appearing throughout the high school mathematics standards.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE XII MONTANA HIGH SCHOOL MATHEMATICS NUMBER AND QUANTITY STANDARDS (1) Mathematics number and quantity: the real number system content standards for high school are:

(a) explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents; for example, we define $5^{1/3}$ to be the cube root of 5 because we want $(5^{1/3})^3 = 5^{(1/3)3}$ to hold, so $(5^{1/3})^3$ must equal 5;

(b) rewrite expressions involving radicals and rational exponents using the properties of exponents; and

(c) 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.

(2) Mathematics number and quantity: quantities content standards for high school are:

(a) use units as a way to understand problems from a variety of contexts (e.g., science, history, and culture), including those of Montana American Indians, and to guide the solution of multistep problems; choose and interpret units consistently in formulas; and choose and interpret the scale and the origin in graphs and data displays;

(b) define appropriate quantities for the purpose of descriptive modeling; and

(c) choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

(3) Mathematics number and quantity: the complex number system content standards for high school are:

(a) know there is a complex number i such that $i^2 = -1$ and every complex number has the form $a + bi$ with a and b real;

(b) use the relation $i^2 = -1$ and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers;

(c) (+) find the conjugate of a complex number and use conjugates to find moduli and quotients of complex numbers;

(d) (+) represent complex numbers on the complex plane in rectangular and polar form (including real and imaginary numbers) and explain why the rectangular and polar forms of a given complex number represent the same number;

(e) (+) represent addition, subtraction, multiplication, and conjugation of

complex numbers geometrically on the complex plane; use properties of this representation for computation; for example, $(-1 + \sqrt{3}i)^3 = 8$ because $(-1 + \sqrt{3}i)$ has modulus 2 and argument 120° ;

(f) (+) calculate the distance between numbers in the complex plane as the modulus of the difference and the midpoint of a segment as the average of the numbers at its endpoints;

(g) solve quadratic equations with real coefficients that have complex solutions;

(h) (+) extend polynomial identities to the complex numbers and for example, rewrite $x^2 + 4$ as $(x + 2i)(x - 2i)$; and

(i) (+) know the Fundamental Theorem of Algebra and show that it is true for quadratic polynomials.

(4) Mathematics number and quantity: vector and matrix quantities content standards for high school are:

(a) (+) recognize vector quantities as having both magnitude and direction; represent vector quantities by directed line segments; and use appropriate symbols for vectors and their magnitudes (e.g., v , $|v|$, $\|v\|$, v);

(b) (+) find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point;

(c) (+) solve problems from a variety of contexts (e.g., science, history, and culture), including those of Montana American Indians, involving velocity and other quantities that can be represented by vectors;

(d) (+) add and subtract vectors;

(i) add vectors end-to-end, component-wise, and by the parallelogram rule and understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes;

(ii) given two vectors in magnitude and direction form, determine the magnitude and direction of their sum; and

(iii) understand vector subtraction $v - w$ as $v + (-w)$ where $-w$ is the additive inverse of w , with the same magnitude as w and pointing in the opposite direction and represent vector subtraction graphically by connecting the tips in the appropriate order and perform vector subtraction component-wise;

(e) (+) multiply a vector by a scalar;

(i) represent scalar multiplication graphically by scaling vectors and possibly reversing their direction and perform scalar multiplication component-wise, e.g., as $c(v_x, v_y) = (cv_x, cv_y)$; and

(ii) compute the magnitude of a scalar multiple cv using $\|cv\| = |c|v$ and compute the direction of cv knowing that when $|c|v \neq 0$, the direction of cv is either along v (for $c > 0$) or against v (for $c < 0$);

(f) (+) use matrices to represent and manipulate data, e.g., to represent payoffs or incidence relationships in a network;

(g) (+) multiply matrices by scalars to produce new matrices, e.g., as when all of the payoffs in a game are doubled;

(h) (+) add, subtract, and multiply matrices of appropriate dimensions;

(i) (+) understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties;

(j) (+) understand that the zero and identity matrices play a role in matrix addition and multiplication similar to the role of 0 and 1 in the real numbers and the determinant of a square matrix is nonzero if and only if the matrix has a multiplicative inverse;

(k) (+) multiply a vector (regarded as a matrix with one column) by a matrix of suitable dimensions to produce another vector and work with matrices as transformations of vectors; and

(l) (+) work with 2×2 matrices as transformations of the plane and interpret the absolute value of the determinant in terms of area.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE XIII MONTANA HIGH SCHOOL MATHEMATICS ALGEBRA CONTENT STANDARDS (1) Mathematics algebra: seeing structure in expressions content standards for high school are:

(a) interpret expressions that represent a quantity in terms of its context;*

(i) interpret parts of an expression, such as terms, factors, and coefficients; and

(ii) interpret complicated expressions by viewing one or more of their parts as a single entity; for example, interpret $P(1+r)^n$ as the product of P and a factor not depending on P ;

(b) use the structure of an expression to identify ways to rewrite it; 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 $(x^2 - y^2)(x^2 + y^2)$;

(c) choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression;*

(i) factor a quadratic expression to reveal the zeros of the function it defines;

(ii) complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines; and

(iii) use the properties of exponents to transform expressions for exponential functions; for example the expression 1.15^t can be rewritten as $(1.15^{1/12})^{12t} \approx 1.012^{12t}$ to reveal the approximate equivalent monthly interest rate if the annual rate is 15%;

(d) 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; for example, calculate mortgage payments.*

(2) Mathematics algebra: arithmetic with polynomials and rational expressions content standards for high school are:

(a) understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication and add, subtract, and multiply polynomials;

(b) 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 $p(x)$;

(c) 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;

(d) prove polynomial identities and use them to describe numerical relationships; for example, the polynomial identity $(x^2 + y^2)^2 = (x^2 - y^2)^2 + (2xy)^2$ can be used to generate Pythagorean triples;

(e) (+) know and apply the Binomial Theorem for the expansion of $(x + y)^n$ in powers of x and y for a positive integer n , where x and y are any numbers, with coefficients determined for example by Pascal's Triangle;

(f) rewrite simple rational expressions in different forms; write $\frac{a(x)}{b(x)}$ in the form $q(x) + \frac{r(x)}{b(x)}$, 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; and

(g) (+) understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression and add, subtract, multiply, and divide rational expressions.

(3) Mathematics algebra: creating equations content standards for high school are:

(a) create equations and inequalities in one variable and use them to solve problems from a variety of contexts (e.g., science, history, and culture, including those of Montana American Indians) and include equations arising from linear and quadratic functions, and simple rational and exponential functions;

(b) create equations in two or more variables to represent relationships between quantities and graph equations on coordinate axes with labels and scales;

(c) 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; for example, represent inequalities describing nutritional and cost constraints on combinations of different foods; and

(d) rearrange formulas to highlight a quantity of interest using the same reasoning as in solving equations; for example, rearrange Ohm's law $V = IR$ to highlight resistance R .

(4) Mathematics algebra: reasoning with equations and inequalities content standards for high school are:

(a) 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 and construct a viable argument to justify a solution method;

(b) solve simple rational and radical equations in one variable and give examples showing how extraneous solutions may arise;

(c) solve linear equations and inequalities in one variable, including equations with coefficients represented by letters;

(d) solve quadratic equations in one variable;

(i) use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions and derive the quadratic formula from this form; and

(ii) solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation and recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b ;

(e) prove 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;

(f) solve systems of linear equations exactly and approximately (e.g., with graphs) focusing on pairs of linear equations in two variables;

(g) solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically; for example, find the points of intersection between the line $y = -3x$ and the circle $x^2 + y^2 = 3$;

(h) (+) represent a system of linear equations as a single matrix equation in a vector variable;

(i) (+) find the inverse of a matrix if it exists and use it to solve systems of linear equations (using technology for matrices of dimension 3×3 or greater);

(j) 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);

(k) explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values or find successive approximations and include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions; and

(l) 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.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE XIV MONTANA HIGH SCHOOL MATHEMATICS FUNCTIONS STANDARDS (1) Mathematics functions: interpreting functions content standards for high school are:

(a) 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 f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x ; and the graph of f is the graph of the equation $y = f(x)$;

(b) use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context;

(c) recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers; for example, the Fibonacci sequence is defined recursively by $f(0) = f(1) = 1$, $f(n+1) = f(n) + f(n-1)$ for $n \geq 1$;

(d) 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; end behavior; and

periodicity;*

(e) 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;*

(f) calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval and estimate the rate of change from a graph;*

(g) graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases;*

(i) graph linear and quadratic functions and show intercepts, maxima, and minima;

(ii) graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions;

(iii) graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior;

(iv) (+) graph rational functions, identifying zeros and asymptotes when suitable factorizations are available and showing end behavior; and

(v) graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude;

(h) write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function;

(i) use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph and interpret these in terms of a context; and

(ii) use the properties of exponents to interpret expressions for exponential functions; for example, identify percent rate of change in functions such as $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)^{12t}$, $y = (1.2)^{t/10}$ and classify them as representing exponential growth or decay; and

(i) 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 quadratic function and an algebraic expression for another, say which has the larger maximum.

(2) Mathematics functions: building functions content standards for high school are:

(a) write a function that describes a relationship between two quantities;*

(i) determine an explicit expression, a recursive process, or steps for calculation from a context;

(ii) combine standard function types using arithmetic operations; for example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential and relate these functions to the model; and

(iii) (+) compose functions; for example, if $T(y)$ is the temperature in the atmosphere as a function of height and $h(t)$ is the height of a weather balloon as a function of time, then $T(h(t))$ is the temperature at the location of the weather balloon as a function of time;

(b) write arithmetic and geometric sequences both recursively and with an explicit formula; use them to model situations from a variety of contexts (e.g.,

science, history, and culture, including those of the Montana American Indian); and translate between the two forms;

(c) identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $k f(x)$, $f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative); find the value of k given the graphs; experiment with cases and illustrate an explanation of the effects on the graph using technology; and include recognizing even and odd functions from their graphs and algebraic expressions for them;

(d) find inverse functions;

(i) solve an equation of the form $f(x) = c$ for a simple function f that has an inverse and write an expression for the inverse; for example, $f(x) = 2x^3$ or $f(x) = (x+1)/(x-1)$ for $x \neq 1$;

(ii) (+) verify by composition that one function is the inverse of another;

(iii) (+) read values of an inverse function from a graph or a table, given that the function has an inverse; and

(iv) (+) produce an invertible function from a noninvertible function by restricting the domain;

(e) (+) understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.

(3) Mathematics functions: linear, quadratic, and exponential models content standards for high school are:

(a) distinguish between situations that can be modeled with linear functions and with exponential functions;

(i) prove that linear functions grow by equal differences over equal intervals and that exponential functions grow by equal factors over equal intervals;

(ii) recognize situations in which one quantity changes at a constant rate per unit interval relative to another; and

(iii) recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another;

(b) construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table);

(c) observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function;

(d) for exponential models, express as a logarithm the solution to $ab^{ct} = d$ where a , c , and d are numbers and the base b is 2, 10, or e and evaluate the logarithm using technology; and

(e) interpret the parameters in a linear or exponential function in terms of a context.

(4) Mathematics functions: trigonometric functions content standards for high school are:

(a) understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle;

(b) 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;

(c) (+) use special triangles to determine geometrically the values of sine, cosine, tangent for $\pi/3$, $\pi/4$ and $\pi/6$ and use the unit circle to express the values of sine, cosines, and tangent for x , $\pi + x$, and $2\pi - x$ in terms of their values for x , where x is any real number;

(d) (+) use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions;

(e) choose trigonometric functions to model periodic phenomena from a variety of contexts (e.g. science, history, and culture, including those of the Montana American Indian) with specified amplitude, frequency, and midline;*

(f) (+) understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed;

(g) (+) use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology; and interpret them in terms of the context;*

(h) prove the Pythagorean identity $\sin^2(\theta) + \cos^2(\theta) = 1$ and use it to calculate trigonometric ratios; and

(i) (+) prove the addition and subtraction formulas for sine, cosine, and tangent and use them to solve problems.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE XV MONTANA HIGH SCHOOL MATHEMATICS MODELING CONTENT STANDARDS (1) Mathematics modeling content standards for high school are best interpreted in relation to other standards. Specific standards for modeling are indicated by a "*" symbol and appear throughout the high school standards.

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE XVI MONTANA HIGH SCHOOL MATHEMATICS GEOMETRY CONTENT STANDARDS (1) Mathematics geometry: congruence content standards for high school are:

(a) 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;

(b) represent transformations in the plane using transparencies and geometry software; describe transformations as functions that take points in the plane as inputs and give other points as outputs; and compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch);

(c) given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself;

(d) develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments;

(e) given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software and specify a sequence of transformations that will carry a given figure onto another;

(f) use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure and given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent;

(g) 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;

(h) explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions;

(i) prove theorems about lines and angles; theorems include: vertical angles are congruent, when a transversal crosses parallel lines, alternate interior angles are congruent, corresponding angles are congruent, and points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints;

(j) prove theorems about triangles; theorems include: measures of interior angles of a triangle sum to 180° , 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, and the medians of a triangle meet at a point;

(k) 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;

(l) make formal geometric constructions, including those representing Montana American Indians, 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; and

(m) construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.

(2) Mathematics geometry: similarity, right triangles, and trigonometry content standards for high school are:

(a) verify experimentally the properties of dilations given by a center and a scale factor:

(i) a dilation takes a line not passing through the center of the dilation to a parallel line and leaves a line passing through the center unchanged; and

(ii) the dilation of a line segment is longer or shorter in the ratio given by the scale factor;

(b) given two figures, use the definition of similarity in terms of similarity transformations to decide if they are similar and 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;

(c) use the properties of similarity transformations to establish the AA

criterion for two triangles to be similar;

(d) prove theorems about triangles; theorems include: a line parallel to one side of a triangle divides the other two proportionally and, conversely, the Pythagorean Theorem proved using triangle similarity;

(e) use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures;

(f) 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) explain and use the relationship between the sine and cosine of complementary angles;

(h) use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems;

(i) (+) derive the formula $A = \frac{1}{2} ab \sin(C)$ for the area of a triangle by drawing an auxiliary line from a vertex perpendicular to the opposite side;

(j) (+) prove the Laws of Sines and Cosines and use them to solve problems; and

(k) (+) understand and apply the Laws of Sines and Cosines to find unknown measurements in right and nonright triangles (e.g., surveying problems, resultant forces).

(3) Mathematics geometry: circles content standards for high school are:

(a) prove that all circles are similar;

(b) identify and describe relationships among inscribed angles, radii, and chords; include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; and the radius of a circle is perpendicular to the tangent where the radius intersects the circle;

(c) construct the inscribed and circumscribed circles of a triangle and prove properties of angles for a quadrilateral inscribed in a circle;

(d) (+) construct a tangent line from a point outside a given circle to the circle; and

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

(4) Mathematics geometry: expressing geometric properties with equations content standards for high school are:

(a) derive the equation of a circle of given center and radius using the Pythagorean Theorem and complete the square to find the center and radius of a circle given by an equation;

(b) derive the equation of a parabola given a focus and directrix;

(c) (+) derive the equations of ellipses and hyperbolas given the foci and directrices;

(d) use coordinates to prove simple geometric theorems algebraically; for example, prove or disprove that a figure defined by four given points in the coordinate plane is a rectangle and prove or disprove that the point $(1, \sqrt{3})$ lies on the circle centered at the origin and containing the point $(0, 2)$;

(e) 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);

(f) find the point on a directed line segment between two given points that partitions the segment in a given ratio; and

(g) use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.*

(5) Mathematics geometry: geometric measurement and dimension content standards for high school are:

(a) give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone and use dissection arguments, Cavalieri's principle, and informal limit arguments;

(b) (+) give an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures;

(c) use volume formulas for cylinders, pyramids, cones, and spheres to solve problems;* and

(d) identify the shapes of two-dimensional cross-sections of three-dimensional objects and identify three-dimensional objects generated by rotations of two-dimensional objects.

(6) Mathematics Geometry: modeling with geometry content standards for high school are:

(a) use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder; modeling a Montana American Indian tipi as a cone);*

(b) apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot);* and

(c) 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).*

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

NEW RULE XVII MONTANA HIGH SCHOOL MATHEMATICS STATISTICS AND PROBABILITY STANDARDS (1) Mathematics statistics and probability:

interpreting categorical and quantitative data content standards for high school are:

(a) represent data with plots on the real number line (dot plots, histograms, and box plots);

(b) 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;

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

(d) 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; and use calculators, spreadsheets, tables, and Montana American Indian data sources to estimate areas under the normal curve;

(e) 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); and recognize possible associations and trends in the data;

(f) represent data on two quantitative variables on a scatter plot and describe how the variables are related;

(i) fit a function to the data; use functions fitted to data to solve problems in the context of the data; use given functions or choose a function suggested by the context; and emphasize linear, quadratic, and exponential models;

(ii) informally assess the fit of a function by plotting and analyzing residuals; and

(iii) fit a linear function for a scatter plot that suggests a linear association;

(g) interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data;

(h) compute (using technology) and interpret the correlation coefficient of a linear fit; and

(i) distinguish between correlation and causation.

(2) Mathematics statistics and probability: making inferences and justifying conclusions content standards for high school are:

(a) understand statistics as a process for making inferences about population parameters based on a random sample from that population;

(b) decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation; for example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model?;

(c) recognize the purposes of and differences among sample surveys, experiments, and observational studies and explain how randomization relates to each;

(d) use data from a sample survey to estimate a population mean or proportion and develop a margin of error through the use of simulation models for random sampling;

(e) use data from a randomized experiment to compare two treatments and use simulations to decide if differences between parameters are significant; and

(f) evaluate reports based on data.

(3) Mathematics statistics and probability: conditional probability and the rules of probability content standards for high school are:

(a) 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");

(b) 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;

(c) understand the conditional probability of A given B as $P(A \text{ and } B)/P(B)$ and interpret independence of A and B as saying that the conditional probability of A given B is the same as the probability of A, and the conditional probability of B given A is the same as the probability of B;

(d) construct and interpret two-way frequency tables of data, including information from Montana American Indian data sources, 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; for example, collect data from a random sample of students in your school on their favorite subject among math, science, and English; estimate the probability that a randomly selected student from your school will favor science given that the student is in tenth grade; and do the same for other subjects and compare the results;

(e) recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations; for example, compare the chance of having lung cancer if you are a smoker with the chance of being a smoker if you have lung cancer;

(f) 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;

(g) apply the Addition Rule, $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$ and interpret the answer in terms of the model;

(h) (+) apply the general Multiplication Rule in a uniform probability model, $P(A \text{ and } B) = P(A)P(B|A) = P(B)P(A|B)$, and interpret the answer in terms of the model; and

(i) (+) use permutations and combinations to compute probabilities of compound events and solve problems.

(4) Mathematics statistics and probability: using probability to make decisions content standards for high school are:

(a) (+) define a random variable for a quantity of interest by assigning a numerical value to each event in a sample space and graph the corresponding probability distribution using the same graphical displays as for data distributions;

(b) (+) calculate the expected value of a random variable and interpret it as the mean of the probability distribution;

(c) (+) develop a probability distribution for a random variable defined for a sample space in which theoretical probabilities can be calculated and find the expected value; for example, find the theoretical probability distribution for the number of correct answers obtained by guessing on all five questions of a multiple-choice test where each question has four choices and find the expected grade under various grading schemes;

(d) (+) develop a probability distribution for a random variable defined for a sample space in which probabilities are assigned empirically and find the expected value; for example, find a current data distribution on the number of TV sets per household in the United States and calculate the expected number of sets per household. How many TV sets would you expect to find in 100 randomly selected households?;

(e) (+) weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values;

(i) find the expected payoff for a game of chance; for example, find the expected winnings from a state lottery ticket or a game at a fast-food restaurant; and

(ii) evaluate and compare strategies on the basis of expected values; for example, compare a high-deductible versus a low-deductible automobile insurance policy using various, but reasonable, chances of having a minor or a major accident;

(f) (+) use probabilities to make fair decisions (e.g., drawing by lots, using a

random number generator); and

(g) (+) analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).

AUTH: 20-2-114, MCA

IMP: 20-2-121, 20-3-106, 20-7-101, MCA

4. REASON: The proposed new rules on Common Core State Standards for Mathematics ("the standards") are the culmination of an extended, broad-based effort to fulfill the charge issued by the states to create the next generation of K-12 standards in order to help ensure that all students are college and career ready in mathematics no later than the end of high school.

The present work, led by the Council of Chief State School Officers (CCSSO) and the National Governors Association (NGA) builds on the foundation laid by states in their decades-long work on crafting high-quality education standards. The standards also draw on the most important international models as well as research and input from numerous sources, including state departments of education, scholars, assessment developers, professional organizations, educators from kindergarten through college, and parents, students, and other members of the public. In their design and content, refined through successive drafts and numerous rounds of feedback, the standards represent a synthesis of the best elements of standards-related work to date and an important advance over previous work.

The Montana Content Standards for mathematics reflect the constitutional mandate that all educators must provide instruction including the distinct and unique heritage and contemporary contributions of American Indians in a culturally responsive manner.

5. The board proposes to repeal the following rules:

10.54.4010 MATHEMATICS CONTENT STANDARD 1 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4011 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 1 FOR END OF GRADE 4 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4012 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 1 FOR END OF GRADE 8 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4013 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 1 UPON GRADUATION AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4020 MATHEMATICS CONTENT STANDARD 2 AUTH: 20-2-114,

MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4021 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 2 FOR END OF GRADE 4 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4022 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 2 FOR END OF GRADE 8 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4023 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 2 UPON GRADUATION AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4030 MATHEMATICS CONTENT STANDARD 3 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4031 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 3 FOR END OF GRADE 4 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4032 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 3 FOR END OF GRADE 8 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4033 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 3 UPON GRADUATION AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4040 MATHEMATICS CONTENT STANDARD 4 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4041 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 4 FOR END OF GRADE 4 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4042 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 4 FOR END OF GRADE 8 AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4043 BENCHMARK FOR MATHEMATICS CONTENT STANDARD 4 UPON GRADUATION AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4101 GRADE 4 PERFORMANCE DESCRIPTORS AT THE ADVANCED LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4102 GRADE 4 PERFORMANCE DESCRIPTORS AT THE PROFICIENT LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4103 GRADE 4 PERFORMANCE DESCRIPTORS AT THE NEARING PROFICIENT LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4104 GRADE 4 PERFORMANCE DESCRIPTORS AT THE NOVICE LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4105 GRADE 8 PERFORMANCE DESCRIPTORS AT THE ADVANCED LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4106 GRADE 8 PERFORMANCE DESCRIPTORS AT THE PROFICIENT LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4107 GRADE 8 PERFORMANCE DESCRIPTORS AT THE NEARING PROFICIENT LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4108 GRADE 8 PERFORMANCE DESCRIPTORS AT THE NOVICE LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4109 UPON GRADUATION PERFORMANCE DESCRIPTORS AT THE ADVANCED LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4110 UPON GRADUATION PERFORMANCE DESCRIPTORS AT THE PROFICIENT LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4111 UPON GRADUATION PERFORMANCE DESCRIPTORS AT THE NEARING PROFICIENT LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

10.54.4112 UPON GRADUATION PERFORMANCE DESCRIPTORS AT THE NOVICE LEVEL AUTH: 20-2-114, MCA; IMP, 20-2-121, 20-3-106, 20-7-101, MCA

6. REASON: The above rules are being repealed and replaced by the rules proposed for adoption in this notice.

7. Pursuant to the agreement between the Board of Public Education and the

Legislature, the board does anticipate implementation costs, and shall request and report in its adoption notice any cost estimates received from districts during the hearing. To allow for sufficient time to complete this process the effective date for the adoption and repeal of the above rules will be July 1, 2013.

8. Concerned persons may submit their data, views, or arguments either orally or in writing at the hearing. Written data, views, or arguments may also be submitted to: Peter Donovan, Executive Secretary, 46 North Last Chance Gulch, P.O. Box 200601, Helena, Montana, 59620-0601; telephone (406) 444-0302; fax (406) 444-0847; or e-mail pdonovan@mt.gov and must be received no later than 5:00 p.m., October 24, 2011.

9. Peter Donovan, Executive Secretary for the Board of Public Education has been designated to preside over and conduct this hearing.

10. The board maintains a list of interested persons who wish to receive notices of rulemaking actions proposed by the board. Persons who wish to have their name added to the list shall make a written request that includes the name, e-mail, and mailing address of the person to receive notices and specifies for which program the person wishes to receive notices. Notices will be sent by e-mail unless a mailing preference is noted in the request. Such written request may be mailed or delivered to the contact person in 8 above or may be made by completing a request form at any rules hearing held by the board.

11. An electronic copy of this proposal notice is available through the Secretary of State's web site at <http://sos.mt.gov/ARM/Register>. The Secretary of State strives to make the electronic copy of the notice conform to the official version of the notice, as printed in the Montana Administrative Register, but advises all concerned persons that in the event of a discrepancy between the official printed text of the notice and the electronic version of the notice, only the official printed text will be considered. In addition, although the Secretary of State works to keep its web site accessible at all times, concerned persons should be aware that the web site may be unavailable during some periods, due to system maintenance or technical problems.

12. The bill sponsor contact requirements of 2-4-302, MCA, do not apply.

/s/ Peter Donovan
Peter Donovan
Rule Reviewer

/s/ Patty Myers
Patty Myers, Chair
Board of Public Education

Certified to the Secretary of State September 12, 2011.