

The American Diploma Project Benchmarks in Mathematics are compared with the ACT *College Readiness Standards*.

ADP Benchmarks: Mathematics	ACT: College Readiness Standards
<p>Certain mathematics benchmarks are marked with an asterisk (*). These asterisked benchmarks represent content that is recommended for all students, but is required for those students who plan to take calculus in college, a requisite for mathematics and many mathematics intensive majors.</p>	<p>The coding schema corresponds to content domains and score ranges on ACT's 3 curriculum-based assessment programs: EXPLORE, PLAN, and ACT. The system works as follows: 200-level statements: score range 13-15; 300-level statements: score range 16-19; 400-level statements: score range 20-23; 500-level statements: score range 24-27; 600-level statements: score range 28-32; and 700-level statements: score range 33-36. Those statements noted as 700-level expectations or identified with a † are applicable to the ACT only. Statements identified as 600-level expectations or identified with an * apply to PLAN and ACT only.</p>
<p>I. Number Sense and Numerical Operations - The high school graduate can:</p>	
<p>I1. Compute with rational numbers fluently and accurately without a calculator:</p>	
<p>I1.1. Add, subtract, multiply and divide integers, fractions and decimals.</p>	<p>BOA 201. Perform one-operation computation with whole numbers and decimals</p>
	<p>BOA 202 Solve problems in one or two steps using whole numbers</p>
	<p>BOA 301 Solve routine one-step arithmetic problems (using whole numbers, fractions, and decimals) such as single-step percent</p>
	<p>BOA 302. Solve some routine two-step arithmetic problems</p>
	<p>NCP 603 Apply number properties involving positive/negative numbers</p>
<p>I1.2. Calculate and apply ratios, proportions, rates and percentages to solve problems.</p>	<p>BOA 401. Solve routine two-step or three-step arithmetic problems involving concepts such as rate and proportion, tax added, percentage off, and computing with a given average</p>
	<p>BOA 601. Solve word problems containing several rates, proportions, or percentages</p>
	<p>BOA 701 Solve complex arithmetic problems involving percent of increase or decrease and problems requiring integration of several concepts from pre-algebra and/or pre-geometry (e.g., comparing percentages or averages, using several ratios, and finding ratios in geometry settings</p>
	<p>XEI 502 Write expressions, equations, or inequalities with a single variable for common pre-algebra settings (e.g., rate and distance problems and problems that can be solved by using proportions)</p>
<p>I1.3. Use the correct order of operations to evaluate arithmetic expressions, including those containing parentheses.</p>	

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I1.4. Explain and apply basic number theory concepts such as prime number, factor, divisibility, least common multiple and greatest common divisor.	NCP 301 Recognize one-digit factors of a number
	NCP 401. Exhibit knowledge of elementary number concepts including rounding, the ordering of decimals, pattern identification, absolute value, primes, and greatest common factor
	NCP 501. Find and use the least common multiple
	NCP 503. Work with numerical factors
	NCP 601. Apply number properties involving prime factorization
	NCP 602 Apply number properties involving even/odd numbers and factors/multiples
I1.5. Multiply and divide numbers expressed in scientific notation.	NCP 504. Work with scientific notation
I2. Recognize and apply magnitude (absolute value) and ordering of real numbers:	
I2.1. Locate the position of a number on the number line, know that its distance from the origin is its absolute value and know that the distance between two numbers on the number line is the absolute value of their difference.	NCP 401. Exhibit knowledge of elementary number concepts including rounding, the ordering of decimals, pattern identification, absolute value, primes, and greatest common factor
I2.2. Determine the relative position on the number line of numbers and the relative magnitude of numbers expressed in fractional form, in decimal form, as roots or in scientific notation.	GRE 201. Identify the location of a point with a positive coordinate on the number line
	GRE 301. Locate points on the number line and in the first quadrant
	GRE 402. Comprehend the concept of length on the number line*
	NCP 502 Order fractions
I3. Understand that to solve certain problems and equations, number systems need to be extended from whole numbers to the set of all integers (positive, negative and zero), from integers to rational numbers, from rational numbers to real numbers (rational and irrational numbers) and from real numbers to complex numbers; define and give examples of each of these types of numbers.	NCP 509. Exhibit some knowledge of the complex numbers†
<i>(These expectations are consistent with, but extend beyond the scope of, this ADP benchmark.)</i>	NCP 703. Apply properties of complex numbers
<i>(This expectation is consistent with, but extends beyond the scope of, this ADP benchmark.)</i>	NCP 605. Multiply two complex numbers†
I4. Understand the capabilities and the limitations of calculators and computers in solving problems:	
I4.1. Use calculators appropriately and make estimations without a calculator	

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regularly to detect potential errors.	
I4.2. Use graphing calculators and computer spreadsheets.	
J. Algebra - The high school graduate can:	
J1. Perform basic operations on algebraic expressions fluently and accurately:	XEI 201 Exhibit knowledge of basic expressions (e.g., identify an expression for a total as $b + g$)
	NCP 508 Determine when an expression is undefined*
J1.1. Understand the properties of integer exponents and roots and apply these properties to simplify algebraic expressions.	NCP 604 Apply rules of exponents
	NCP 506 Work problems involving positive integer exponents*
	NCP 505 Work with squares and square roots of numbers
	NCP 507 Work with cubes and cube roots of numbers*
J1.2. * Understand the properties of rational exponents and apply these properties to simplify algebraic expressions.	
J1.3. Add, subtract and multiply polynomials; divide a polynomial by a low degree polynomial.	XEI 402. Add and subtract simple algebraic expressions
	XEI 303. Combine like terms (e.g., $2x + 5x$)
	XEI 405. Multiply two binomials*
	XEI 504. Add, subtract, and multiply polynomials*
J1.4. Factor polynomials by removing the greatest common factor; factor quadratic polynomials.	XEI 505. Factor simple quadratics (e.g., the difference of squares and perfect square trinomials)*
J1.5. Add, subtract, multiply, divide and simplify rational expressions.	
J1.6. Evaluate polynomial and rational expressions and expressions containing radicals and absolute values at specified values of their variables.	XEI 401. Evaluate algebraic expressions by substituting integers for unknown quantities
	XEI 301 Substitute whole numbers for unknown quantities to evaluate expressions
J1.7. * Derive and use the formulas for the general term and summation of finite arithmetic and geometric series; find the sum of an infinite geometric series whose common ratio, r , is in the interval $(-1, 1)$.	
J2 Understand functions, their representations and their properties:	
J2.1 Recognize whether a relationship given in symbolic or graphical form is a function	
J2.2. * Determine the domain of a function represented in either symbolic or graphical form.	
J2.3. Understand functional notation and evaluate a function at a specified point in its domain.	FUN 401. Evaluate quadratic functions, expressed in function notation, at integer values

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	FUN 501. Evaluate polynomial functions, expressed in function notation, at integer values
	FUN 601. Evaluate composite functions at integer values
J2.4. * Combine functions by composition, as well as by addition, subtraction, multiplication and division.	FUN 701 . Write an expression for the composite of two simple functions
J2.5. * Identify whether a function has an inverse and when functions are inverses of each other; explain why the graph of a function and its inverse are reflections of one another over the line $y = x$.	
J2.6. * Know the inverse of an exponential function is a logarithm, prove basic properties of a logarithm using properties of its inverse and apply those properties to solve problems.	NCP 702 . Exhibit knowledge of logarithms and geometric sequences
J3. Apply basic algebraic operations to solve equations and inequalities:	XEI 602 Write expressions, equations, and inequalities for common algebra settings
J3.1. Solve linear equations and inequalities in one variable including those involving the absolute value of a linear function.	XEI 202 Solve equations in the form $x + a = b$, where a and b are whole numbers or decimals
	XEI 302 Solve one-step equations having integer or decimal answers
	XEI 403. Solve routine first-degree equations
	XEI 506. Solve first-degree inequalities that do not require reversing the inequality sign*
	XEI 603. Solve linear inequalities that require reversing the inequality sign
	XEI 604. Solve absolute value equations
	XEI 703 . Solve simple absolute value inequalities
J3.2. Solve an equation involving several variables for one variable in terms of the others.	XEI 601. Manipulate expressions and equations
J3.3. Solve systems of two linear equations in two variables.	XEI 606. Find solutions to systems of linear equations
J3.4. * Solve systems of three linear equations in three variables.	XEI 606. Find solutions to systems of linear equations
J3.5. Solve quadratic equations in one variable.	XEI 503. Identify solutions to simple quadratic equations
	XEI 605. Solve quadratic equations
J4. Graph a variety of equations and inequalities in two variables, demonstrate understanding of the relationships between the algebraic properties of an equation and the geometric properties of its graph, and interpret a graph:	GRE 401 Locate points in the coordinate plane
J4.1. Graph a linear equation and demonstrate that it has a constant rate of change.	GRE 403 Exhibit knowledge of slope*
J4.2. Understand the relationship between the coefficients of a linear equation and the slope and x- and y-intercepts of its graph.	GRE 503 Match linear graphs with their equations*

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J4.3. Understand the relationship between a solution of a system of two linear equations in two variables and the graphs of the corresponding lines.	
J4.4. Graph the solution set of a linear inequality and identify whether the solution set is an open or a closed half-plane; graph the solution set of a system of two or three linear inequalities.	GRE 501. Identify the graph of a linear inequality on the number line*
J4.5. Graph a quadratic function and understand the relationship between its real zeros and the x-intercepts of its graph.	GRE 602 Match number line graphs with solution sets of linear inequalities GRE 701 . Match number line graphs with solution sets of simple quadratic inequalities
	GRE 702 . Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax^2 + c$
J4.6. * Graph ellipses and hyperbolas whose axes are parallel to the x and y axes and demonstrate understanding of the relationship between their standard algebraic form and their graphical characteristics.	
J4.7. Graph exponential functions and identify their key characteristics.	
J4.8. Read information and draw conclusions from graphs; identify properties of a graph that provide useful information about the original problem.	GRE 601. Interpret and use information from graphs in the coordinate plane
	GRE 704 . Analyze and draw conclusions based on information from graphs in the coordinate plane
J5. Solve problems by converting the verbal information given into an appropriate mathematical model involving equations or systems of equations; apply appropriate mathematical techniques to analyze these mathematical models; and interpret the solution obtained in written form using appropriate units of measurement:	
J5.1. Recognize and solve problems that can be modeled using a linear equation in one variable, such as time/rate/distance problems, percentage increase or decrease problems, and ratio and proportion problems.	XEI 404 Perform straightforward word -to-symbol translations
	XEI 502 Write expressions, equations, or inequalities with a single variable for common pre-algebra settings (e.g., rate and distance problems and problems that can be solved by using proportions)
	XEI 501 Solve real-world problems using first-degree equations
J5.2. Recognize and solve problems that can be modeled using a system of two equations in two variables, such as mixture problems.	
J5.3. Recognize and solve problems that can be modeled using a quadratic equation, such as the motion of an object under the force of gravity.	
J5.4. Recognize and solve problems that can be modeled using an exponential function, such as compound interest problems.	

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J5.5. * Recognize and solve problems that can be modeled using an exponential function but whose solution requires facility with logarithms, such as exponential growth and decay problems.	
J5.6. Recognize and solve problems that can be modeled using a finite geometric series, such as home mortgage problems and other compound interest problems.	NCP 702 . Exhibit knowledge of logarithms and geometric sequences
J6. * Understand the binomial theorem and its connections to combinatorics, Pascal’s triangle and probability.	
K. Geometry - The high school graduate can:	
K1. Understand the different roles played by axioms, definitions and theorems in the logical structure of mathematics, especially in geometry:	
K1.1. Identify, explain the necessity of and give examples of definitions, axioms and theorems.	
K1.2. State and prove key basic theorems in geometry such as the Pythagorean theorem, the sum of the angles of a triangle is 180 degrees, and the line joining the midpoints of two sides of a triangle is parallel to the third side and half its length.	
K1.3. Recognize that there are geometries, other than Euclidean geometry, in which the parallel postulate is not true.	
K2. Identify and apply the definitions related to lines and angles and use them to prove theorems in (Euclidean) geometry, solve problems, and perform basic geometric constructions using a straight edge and compass:	
K2.1. Identify and apply properties of and theorems about parallel lines and use them to prove theorems such as two lines parallel to a third are parallel to each other and to perform constructions such as a line parallel to a given line through a point not on the line.	
K2.2. Identify and apply properties of and theorems about perpendicular lines and use them to prove theorems such as the perpendicular bisectors of line segments are the set of all points equidistant from the two end points and to perform constructions such as the perpendicular bisector of a line segment.	
K2.3. Identify and apply properties of and theorems about angles and use them to prove theorems such as two lines are parallel exactly when the alternate interior angles they make with a transversal are equal and to perform constructions such as the bisector of an angle	PPF 301. Exhibit some knowledge of the angles associated with parallel lines
	PPF 501 Use several angle properties to find an unknown angle measure
	PPF 401. Find the measure of an angle using properties of parallel lines

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	PPF 402. Exhibit knowledge of basic angle properties and special sums of angle measures (e.g., 90°, 180°, and 360°)
K3. Know the basic theorems about congruent and similar triangles and use them to prove additional theorems and solve problems.	MEA 201. Estimate or calculate the length of a line segment based on other lengths given on a geometric figure
	PPF 503. Use properties of isosceles triangles*
	PPF 601. Apply properties of 30°-60°-90°, 45°-45°-90°, similar, and congruent triangles
K4. Know the definitions and basic properties of a circle and use them to prove basic theorems and solve problems.	GRE 605. Recognize special characteristics of parabolas and circles (e.g., the vertex of a parabola and the center or radius of a circle)†
	PPF 703 . Use relationships among angles, arcs, and distances in a circle
K5. Apply the Pythagorean theorem, its converse and properties of special right triangles to solve problems.	PPF 502 Recognize Pythagorean triples*
	PPF 601. Apply properties of -30°-60°-90°, 45°-45°-90, similar, and congruent triangles
	PPF 602. Use the Pythagorean theorem
K6. Use rigid motions (compositions of reflections, translations and rotations) to determine whether two geometric figures are congruent and to create and analyze geometric designs.	
K7. Know about the similarity of figures and use the scale factor to solve problems.	PPF 601. Apply properties of 30°-60°-90°, 45°-45°-90°, similar, and congruent triangles
	MEA 701 . Use scale factors to determine the magnitude of a size change
K8. Know that geometric measurements (length, area, perimeter, volume) depend on the choice of a unit and that measurements made on physical objects are approximations; calculate the measurements of common plane and solid geometric figures:	
K8.1. Understand that numerical values associated with measurements of physical quantities must be assigned units of measurement or dimensions; apply such units correctly in expressions, equations and problem solutions that involve measurements; and convert a measurement using one unit of measurement to another unit of measurement.	BOA 203. Perform common conversions (e.g., inches to feet or hours to minutes)
	BOA 501. Solve multistep arithmetic problems that involve planning or converting units of measure (e.g., feet per second to miles per hour)
K8.2. Determine the perimeter of a polygon and the circumference of a circle; the area of a rectangle, a circle, a triangle and a polygon with more than four sides by decomposing it into triangles; the surface area of a prism, a pyramid, a cone and a sphere; and the volume of a rectangular box, a prism, a pyramid, a cone and a sphere.	MEA 301. Compute the perimeter of polygons when all side lengths are given

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	MEA 302. Compute the area of rectangles when whole number dimensions are given
	MEA 401. Compute the area and perimeter of triangles and rectangles in simple problems
	MEA 402. Use geometric formulas when all necessary information is given
	MEA 501. Compute the area of triangles and rectangles when one or more additional simple steps are required
	MEA 502. Compute the area and circumference of circles after identifying necessary information
	MEA 503. Compute the perimeter of simple composite geometric figures with unknown side lengths*
	MEA 601. Use relationships involving area, perimeter, and volume of geometric figures to compute another measure
	MEA 702. Compute the area of composite geometric figures when planning or visualization is required
<p>K8.3. Know that the effect of a scale factor k on length, area and volume is to multiply each by k, k^2 and k^3, respectively.</p>	MEA 701. Use scale factors to determine the magnitude of a size change
<p>K9. Visualize solids and surfaces in three-dimensional space when given two-dimensional representations (e.g., nets, multiple views) and create two-dimensional representations for the surfaces of three-dimensional objects.</p>	
<p>K10. Represent geometric objects and figures algebraically using coordinates; use algebra to solve geometric problems:</p>	GRE 703. Solve problems integrating multiple algebraic and/or geometric concepts
<p>K10.1. Express the intuitive concept of the “slant” of a line in terms of the precise concept of slope, use the coordinates of two points on a line to define its slope, and use slope to express the parallelism and perpendicularity of lines.</p>	GRE 403. Exhibit knowledge of slope*
	GRE 502. Determine the slope of a line from points or equations*
	GRE 604. Use properties of parallel and perpendicular lines to determine an equation of a line or coordinates of a point
<p>K10.2. Describe a line by a linear equation.</p>	GRE 503. Match linear graphs with their equations
<p>K10.3. Find the distance between two points using their coordinates and the Pythagorean theorem.</p>	GRE 603. Use the distance formula
<p>K10.4. * Find an equation of a circle given its center and radius and, given an equation of a circle, find its center and radius.</p>	
<p>K11. Understand basic right-triangle trigonometry and apply it to solve problems:</p>	

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<p>K11.1. Understand how similarity of right triangles allows the trigonometric functions sine, cosine and tangent to be defined as ratios of sides and be able to use these functions to solve problems.</p>	<p>FUN 502. Express the sine, cosine, and tangent of an angle in a right triangle as a ratio of given side lengths</p>
<p>K11.2. Apply the trigonometric functions sine, cosine and tangent to solve for an unknown length of a side of a right triangle, given one of the acute angles and the length of another side.</p>	<p>FUN 602. Apply basic trigonometric ratios to solve right-triangle problems FUN 602. Apply basic trigonometric ratios to solve right-triangle problems</p>
<p>K11.3. Use the standard formula for the area of a triangle, $A = \frac{1}{2}bh$, to explain the area formula, $A = \frac{1}{2}absinC$ where a and b are the lengths of two sides of a triangle and C is the measure of the included angle formed by these two sides, and use it to find the area of a triangle when given the lengths of two of its sides and the included angle.</p>	
<p>K12. * Know how the trigonometric functions can be extended to periodic functions on the real line, derive basic formulas involving these functions, and use these functions and formulas to solve problems:</p>	
<p>K12.1. * Know that the trigonometric functions sine and cosine, and thus all trigonometric functions, can be extended to periodic functions on the real line by defining them as functions on the unit circle, that radian measure of an angle between 0 and 360 degrees is the arc length of the unit circle subtended by that central angle, and that by similarity, the arc length s of a circle of radius r subtended by a central angle of measure t radians is $s = rt$.</p>	<p>FUN 703 Exhibit knowledge of unit circle trigonometry</p>
<p>K12.2. * Know and use the basic identities, such as $\sin^2(x) + \cos^2(x) = 1$ and $\cos(\pi/2-x) = \sin(x)$ and formulas for sine and cosine, such as addition and double angle formulas.</p>	<p>FUN 702 Use trigonometric concepts and basic identities to solve problems</p>
<p>K12.3. * Graph sine, cosine and tangent as well as their reciprocals, secant, cosecant and cotangent; identify key characteristics.</p>	<p>FUN 704 Match graphs of basic trigonometric functions with their equations</p>
<p>K12.4. * Know and use the law of cosines and the law of sines to find missing sides and angles of a triangle.</p>	
<p>L. Data Interpretation, Statistics and Probability - The high school graduate can:</p>	
<p>L1. Explain and apply quantitative information:</p>	
<p>L1.1. Organize and display data using appropriate methods (including spreadsheets) to detect patterns and departures from patterns.</p>	
<p>L1.2. Read and interpret tables, charts and graphs.</p>	<p>PSD 202. Perform a single computation using information from a table or chart</p>
	<p>PSD 303. Read tables and graphs</p>
	<p>PSD 502 Manipulate data from tables and graphs</p>
	<p>PSD 602. Interpret and use information from figures, tables, and graphs</p>

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	PSD 702 Analyze and draw conclusions based on information from figures, tables, and graphs
L1.3. Compute and explain summary statistics for distributions of data including measures of center (mean, median) and spread (range, percentiles, variance, standard deviation).	PSD 201. Calculate the average of a list of positive whole numbers
	PSD 301 Calculate the average of a list of numbers
	PSD 302 Calculate the average, given the number of data values and the sum of the data values
	PSD 304. Perform computations on data from tables and graphs
	PSD 401 Calculate the missing data value, given the average and all data values but one
	PSD 501. Calculate the average, given the frequency counts of all the data values
	PSD 601 Calculate or use a weighted average
	PSD 701 Distinguish between mean, median, and mode for a list of numbers
L1.4. Compare data sets using graphs and summary statistics.	PSD 402 Translate from one representation of data to another (e.g., a bar graph to a circle graph)
L1.5. Create scatter plots, analyze patterns and describe relationships in paired data.	
L1.6. Know the characteristics of the Gaussian normal distribution (bell-shaped curve).	
L2. Explain and critique alternative ways of presenting and using information:	
L2.1. Evaluate reports based on data published in the media by considering the source of the data, the design of the study, and the way the data are analyzed and displayed.	
L2.2. Identify and explain misleading uses of data.	
L2.3. Recognize when arguments based on data confuse correlation with causation.	
L3. Explain the use of data and statistical thinking to draw inferences, make predictions and justify conclusions:	
L3.1. Explain the impact of sampling methods, bias and the phrasing of questions asked during data collection and the conclusions that can rightfully be made.	
L3.2. Design simple experiments or investigations to collect data to answer questions of interest.	

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L3.3. Explain the differences between randomized experiments and observational studies.	
L3.4. Construct a scatter plot of a set of paired data, and if it demonstrates a linear trend, use a graphing calculator to find the regression line that best fits this data; recognize that the correlation coefficient measures goodness of fit and explain when it is appropriate to use the regression line to make predictions	
L4. Explain and apply probability concepts and calculate simple probabilities:	
L4.1. Explain how probability quantifies the likelihood that an event occurs in terms of numbers.	PSD 305. Use the relationship between the probability of an event and the probability of its complement
L4.2. Explain how the relative frequency of a specified outcome of an event can be used to estimate the probability of the outcome.	PSD 404. Exhibit knowledge of simple counting techniques*
	PSD 603. Apply counting techniques
L4.3. Explain how the law of large numbers can be applied in simple examples.	
L4.4. Apply probability concepts such as conditional probability and independent events to calculate simple probabilities.	PSD 403. Determine the probability of a simple event
	PSD 703 Exhibit knowledge of conditional and joint probability
L4.5. Apply probability concepts to practical situations to make informed decisions.	PSD 503. Compute straightforward probabilities for common situations
	PSD 604. Compute a probability when the event and/or sample space are not given or obvious
Mathematical Reasoning: Woven throughout the four domains of mathematics — Number Sense and Numerical Operations; Algebra; Geometry; and Data Interpretation, Statistics and Probability — are the following mathematical reasoning skills:	
MR1. Using inductive and deductive reasoning to arrive at valid conclusions.	PPF 701 Draw conclusions based on a set of conditions
	NCP 701 Draw conclusions based on number concepts, algebraic properties, and/or relationships between expressions and numbers
MR2. Using multiple representations (literal, symbolic, graphic) to represent problems and solutions.	
MR3. Understanding the role of definitions, proofs and counterexamples in mathematical reasoning; constructing simple proofs.	
MR4. Using the special symbols of mathematics correctly and precisely.	
MR5. Recognizing when an estimate or approximation is more appropriate than	

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an exact answer and understanding the limits on precision of approximations.	
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MR6. Distinguishing relevant from irrelevant information, identifying missing information and either finding what is needed or making appropriate estimates.	
MR7. Recognizing and using the process of mathematical modeling: recognizing and clarifying mathematical structures that are embedded in other contexts, formulating a problem in mathematical terms, using mathematical strategies to reach a solution, and interpreting the solution in the context of the original problem.	XEI 701 Write expressions that require planning and/or manipulating to accurately model a situation
	XEI 702 Write equations and inequalities that require planning, manipulating, and/or solving
	PPF 702 . Solve multistep geometry problems that involve integrating concepts, planning, visualization, and/or making connections with other content areas
MR8. When solving problems, thinking ahead about strategy, testing ideas with special cases, trying different approaches, checking for errors and reasonableness of solutions as a regular part of routine work, and devising independent ways to verify results.	
MR9. Shifting regularly between the specific and the general, using examples to understand general ideas, and extending specific results to more general cases to gain insight.	
	NCP 201 Recognize equivalent fractions and fractions in lowest terms
	NCP 302 Identify a digit's place value
	GRE 504 Find the midpoint of a line segment
	PSD 504 Use Venn Diagrams in counting*