

## Mathematics – Advanced Mathematical Modeling

All West Virginia teachers are responsible for classroom instruction that integrates content standards and mathematical habits of mind. Primary focal points of Advanced Mathematical Modeling include the analysis of information using statistical methods and probability, modeling change and mathematical relationships, mathematical decision making in finance, and spatial and geometric modeling for decision-making. Students will learn to become critical consumers of the quantitative data that surround them every day, knowledgeable decision makers who use logical reasoning and mathematical thinkers who can use their quantitative skills to solve problems related to a wide range of situations. As students solve problems in various applied situations, they will develop critical skills for success in college and careers, including investigation, research, collaboration and both written and oral communication of their work. As students work with these topics, they will rely on mathematical processes, including problem-solving techniques, appropriate mathematical language and communication skills, connections within and outside mathematics and reasoning. Students will use multiple representations, technology, applications and modeling and numerical fluency in problem-solving contexts. Mathematical habits of mind, which should be integrated in these content areas, include: making sense of problems and persevering in solving them, reasoning abstractly and quantitatively; constructing viable arguments and critiquing the reasoning of others; modeling with mathematics; using appropriate tools strategically; attending to precision, looking for and making use of structure; and looking for and expressing regularity in repeated reasoning. Students will continue developing mathematical proficiency in a developmentally-appropriate progressions of standards. Continuing the skill progressions from previous courses, the following chart represents the mathematical understandings that will be developed:

<p><b>Developing College and Career Skills</b></p> <ul style="list-style-type: none"> <li>Develop and apply skills used in college and careers, including reasoning, planning and communication, to make decisions and solve problems in applied situations.</li> </ul>	<p><b>Finance</b></p> <ul style="list-style-type: none"> <li>Create and analyze mathematical models to make decisions related to earning, investing, spending and borrowing money.</li> </ul>
<p><b>Probability</b></p> <ul style="list-style-type: none"> <li>Use basic rules of counting and probability to analyze and evaluate risk and return in the context of everyday situations.</li> </ul>	<p><b>Statistics</b></p> <ul style="list-style-type: none"> <li>Make decisions based on understanding, analysis and critique of reported statistical information and summaries.</li> </ul>
<p><b>Modeling</b></p> <ul style="list-style-type: none"> <li>Analyze numerical data in everyday situations using a variety of quantitative measures and numerical processes.</li> </ul>	<p><b>Networks</b></p> <ul style="list-style-type: none"> <li>Use a variety of network models represented graphically to organize data in quantitative situations, make informed decisions, and solve problems.</li> </ul>

<b>Social Decision Making</b>	<b>Geometry</b>
<ul style="list-style-type: none"> <li>Analyze the mathematics behind various methods of ranking and selection and consider the advantages/disadvantages of each method.</li> </ul>	<ul style="list-style-type: none"> <li>Solve geometric problems involving inaccessible distances.</li> <li>Use vectors to solve applied problems.</li> </ul>

### Numbering of Standards

The following Mathematics Standards will be numbered continuously. The following ranges relate to the clusters found within Mathematics:

<b>Developing College and Career Skills</b>	
Math as a language.	Standards 1-2
Tools for problem solving.	Standard 3
<b>Finance</b>	
Understanding financial models.	Standards 4-6
Personal use of finance.	Standards 7-8
<b>Probability</b>	
Analyzing information using probability and counting.	Standards 9-10
Managing uncertainty.	Standards 11-12
<b>Statistics</b>	
Critiquing statistics.	Standards 13-16
Conducting statistical analysis.	Standards 17-21
Communicating statistical information.	Standards 22-23
<b>Modeling</b>	
Managing numerical data.	Standards 24-25
Modeling data and change with functions.	Standards 26-30
<b>Networks</b>	
Networking for decision making.	Standards 31-32
<b>Social Decision Making</b>	
Making decisions using ranking and voting.	Standards 33-34
<b>Geometry</b>	
Concrete geometric representation (physical modeling).	Standards 35-36
Abstract geometric representation (matrix modeling).	Standards 37-38

## Developing College and Career Skills

<b>Cluster</b>	<b>Math as a language</b>
M.AMM.1	Demonstrate reasoning skills in developing, explaining and justifying sound mathematical arguments and analyze the soundness of mathematical arguments of others.
M.AMM.2	Communicate with and about mathematics orally and in writing as part of independent and collaborative work, including making accurate and clear presentations of solutions to problems.

<b>Cluster</b>	<b>Tools for problem solving</b>
M.AMM.3	Gather data, conduct investigations and apply mathematical concepts and models to solve problems in mathematics and other disciplines.

## Finance

<b>Cluster</b>	<b>Understanding financial models</b>
M.AMM.4	Determine, represent and analyze mathematical models for loan amortization and the effects of different payments and/or finance terms (e.g., Auto, Mortgage, and/or Credit Card).
M.AMM.5	Determine, represent and analyze mathematical models for investments involving simple and compound interest with and without additional deposits. (e.g., Savings accounts, bonds, and/or certificates of deposit.)
M.AMM.6	Determine, represent, and analyze mathematical models for Inflation and the Consumer Price Index using concepts of rate of change and percentage growth.

<b>Cluster</b>	<b>Personal use of finance</b>
M.AMM.7	Research and analyze personal budgets based on given parameters (e.g., Fixed and discretionary expenses, insurance, gross vs. net pay, types of income, wage, salary, commission), career choice, geographic region, retirement and/or investment planning, etc.).
M.AMM.8	Research and analyze taxes including payroll, sales, personal property, real estate and income tax returns.

## Probability

<b>Cluster</b>	<b>Analyzing information using probability and counting</b>
M.AMM.9	Use the Fundamental Counting Principle, Permutations and Combinations to determine all possible outcomes for an event; determine probability and odds of a simple event; explain the significance of the Law of Large Numbers.

M.AMM.10	Determine and interpret conditional probabilities and probabilities of compound events by constructing and analyzing representations, including tree diagrams, Venn diagrams, two-way frequency tables and area models, to make decisions in problem situations.
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<b>Cluster</b>	<b>Managing uncertainty</b>
M.AMM.11	Use probabilities to make and justify decisions about risks in everyday life.
M.AMM.12	Calculate expected value to analyze mathematical fairness, payoff and risk.

## Statistics

<b>Cluster</b>	<b>Critiquing statistics</b>
M.AMM.13	Identify limitations or lack of information in studies reporting statistical information, especially when studies are reported in condensed form.
M.AMM.14	Interpret and compare the results of polls, given a margin of error.
M.AMM.15	Identify uses and misuses of statistical analyses in studies reporting statistics or using statistics to justify particular conclusions, including assertions of cause and effect versus correlation.
M.AMM.16	Describe strengths and weaknesses of sampling techniques, data and graphical displays and interpretations of summary statistics and other results appearing in a study, including reports published in the media.

<b>Cluster</b>	<b>Conducting statistical analysis</b>
M.AMM.17	Identify the population of interest, select an appropriate sampling technique and collect data.
M.AMM.18	Identify the variables to be used in a study.
M.AMM.19	Determine possible sources of statistical bias in a study and how such bias may affect the ability to generalize the results.
M.AMM.20	Create data displays for given data sets to investigate, compare, and estimate center, shape, spread and unusual features.
M.AMM.21	Determine possible sources of variability of data, both those that can be controlled and those that cannot be controlled.

<b>Cluster</b>	<b>Communicating statistical information</b>
M.AMM.22	Report results of statistical studies to a particular audience, including selecting an appropriate presentation format, creating graphical data displays and interpreting results in terms of the question studied.
M.AMM.23	Communicate statistical results in both oral and written formats using appropriate statistical and nontechnical language.

## Modeling

Cluster	Managing numerical data
M.AMM.24	Solve problems involving large quantities that are not easily measured.
M.AMM.25	Use arrays to efficiently manage large collections of data and add, subtract, and multiply matrices to solve applied problems.

Cluster	Modeling data and change with functions
M.AMM.26	Determine or analyze an appropriate model for problem situations - including linear, quadratic, power, exponential, logarithmic and logistic functions (e.g., stopping distance, period of a pendulum, population growth, Richter Scale, and/or Fujita Tornado Scale).
M.AMM.27	Determine or analyze an appropriate cyclical model for problem situations that can be modeled with trigonometric functions (e.g., predator-prey models, tide heights, diurnal cycle, and/or music).
M.AMM.28	Determine or analyze an appropriate piecewise model for problem situations (e.g., postal rates, phase change graphs, sales tax, and/or utility usage rates).
M.AMM.29	Solve problems using recursion or iteration (e.g., fractals, compound interest, population growth or decline, and/or radioactive decay).
M.AMM.30	Collect numerical bivariate data; use the data to create a scatter plot; determine whether or not a relationship exists; if so, select a function to model the data, justify the selection and use the model to make predictions.

## Networks

Cluster	Networking for decision making
M.AMM.31	Solve problems involving scheduling or routing situations that can be represented by a vertex-edge graph; find critical paths, Euler paths, Hamiltonian paths, and minimal spanning trees (e.g., Konigsberg bridge problem, mail vs. Fed Ex delivery routes, kolam drawings of India, traveling salesman problem, and/or map coloring).
M.AMM.32	Construct, analyze, and interpret flow charts in order to develop and describe problem solving procedures.

## Social Decision Making

Cluster	Making decisions using ranking and voting
M.AMM.33	Apply and analyze various ranking algorithms to determine an appropriate method for a given situation (e.g., fair division, apportionment, and/or search engine results).
M.AMM.34	Analyze various voting and selection processes to determine an appropriate

	method for a given situation (e.g., preferential vs. non-preferential methods, and/or weighted voting).
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## Geometry

<b>Cluster</b>	<b>Concrete geometric representation (physical modeling)</b>
M.AMM.35	Create and use two- and three-dimensional representations of authentic situations using paper techniques or dynamic geometric environments for computer-aided design and other applications.
M.AMM.36	Solve geometric problems involving inaccessible distances.

<b>Cluster</b>	<b>Abstract geometric representation (matrix modeling)</b>
M.AMM.37	Use vectors to represent and solve applied problems.
M.AMM.38	Use matrices to represent geometric transformations and solve applied problems.