WEST VIRGINIA HIGHER EDUCATION POLICY COMMISSION

WEST VIRGINIA MATHEMATICS TASK FORCE REPORT ON MATHEMATICS IN WV HIGHER EDUCATION

Report to the
Legislative Oversight Commission on Education Accountability
November 15, 2002

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Introduction

At the direction of Chancellor J. Michael Mullen, Dr. Bruce Flack, Director of Academic Affairs of the West Virginia Higher Education Policy Commission, appointed members to the West Virginia Mathematics Task Force in December 2001.

The group was charged to address the following issues:

1. Appropriate mathematics skills for entering college students
2. Appropriate entry-level college course(s) for:
   Students needing calculus in their programs
   Students who do not need calculus
3. Appropriate math content in teacher certification programs

The group divided into three subgroups based on these three important Topics. For the first two months, the Mathematics Task Force (MTF) concentrated on national research relative to these issues. (See references listed in Appendix D.) They also planned the first WV Mathematics Forum of mathematics educators from all colleges and universities in West Virginia and sent several surveys to mathematics departments of all institutions of Higher Education. (The survey questions and results appear in Appendices A & B.)

The Mathematics Forum was held on the Sunday afternoon preceding the WV Higher Education Symposium in February 2002. Members of the MTF led break-out sessions centered around the three charges of the group. Each focus group attempted to answer one question that related to the purpose of the three MTF subcommittees. (1) Why do West Virginia students score below the national average in mathematics on the Math ACT test? (2) Is there a gap in the curriculum from high school to college in mathematics? (3) Do we need to examine the methods of teaching mathematics in higher education, as well as high school? The chair of the MTF used the informal answers to these questions as a basis for refining the work of the group for the remainder of the year.

Math Forum participants from 18 institutions of higher education participated in an ice-breaker designed to align the objectives of existing courses in college algebra, college trigonometry and college precalculus with the new Content Standards and Objectives (CSOs) of the West Virginia Department of Education. As a result, the WV Mathematics Task Force discovered that a student who masters these high school CSOs should be ready for college calculus.

Several persons who attended the Forum volunteered to assist the MTF with its work. Appendix C included appointed members of the Mathematics Task force, as well as those who joined the group in March or April.

Executive Summary

The detailed reports of all subgroups follow the Executive Summary. The reader should consult those sections of this document to clarify the recommendations from any subgroup. The entire Mathematics Task Force approved all recommendations in the Executive Summary.

Task I: To recommend appropriate mathematics skills for entering college students

Subcommittee I worked with Subcommittee II in developing survey questions that were sent to the mathematics departments of all West Virginia institutions of higher education. While deciding what the appropriate mathematic skills were for entering college students, Subgroup I compared high school standards with present entry-level requirements for college mathematics courses. This subcommittee also did research to try to find reasons why the math ACT scores of West Virginia students are lower than the national average.

Summary of Recommendations from Subcommittee I

- A minimum of four mathematics credit courses should be required to graduate from high school and at least one mathematics course should be taken in each year. Among these courses should be Algebra I, Algebra II and Geometry.
- Students contemplating higher education should begin the study of Algebra I no later than ninth grade.
- For those students entering a liberal arts/business major, it is strongly recommended that the senior year course promote algebraic thinking skills.
- Students choosing a field that requires the college algebra/calculus sequence should successfully complete trigonometry and pre-calculus.
- There should be a seamless pathway for students who move from high school mathematics courses to entry-level higher education mathematics courses. Both types of courses should reflect standards-based recommendations from the National Council of Teachers of Mathematics, the Mathematics Association of America, and the American Mathematics Association of Two Year Colleges.
- An on-going math forum should be developed which brings together mathematicians, mathematics educators, administrators, and professional support staff from both higher education and the K-12 community.
- The current ACT math placement minimum score requirement for students admitted to associate and baccalaureate level math courses should be raised from 19 to 20 by Fall 2008. With the implementation of new baccalaureate admission standards which call for four units of mathematics in high school for entering college freshmen in Fall 2008, a higher placement score for entry into credit-bearing college math courses is warranted.

Task II: To recommend appropriate entry-level college courses for students needing calculus in their programs and for students who do not need calculus in their programs

Subcommittee II spent a significant amount of time developing and analyzing surveys they had sent to the institutions of higher education in West Virginia. This group was concerned about determining the present status of mathematics education in West Virginia. It also studied national standards for mathematics education and looked at reports from other state task forces dealing with similar issues.

Summary of Recommendations of Subcommittee II

- Calculus should be the appropriate entry-level course for students majoring in Mathematics or a math related field requiring calculus.
- Students majoring in Liberal or Creative Arts should complete a liberal arts course in mathematics. Requirements to transfer within the state should not exceed what the institution designates as the appropriate course. (For example, an institution should not require college algebra as the first transfer course for students in this area.)

- Students majoring in Social and Life Sciences or Business should have college algebra, but this course may differ substantially from the traditional algebra course. This course, an applied college algebra course, should focus on real world applications, integrate technology in a meaningful way, and address concepts from multiple perspectives including verbal, numeric, graphic, and algebraic.
- Because there is a significant disparity in teacher education preparation in West Virginia with respect to mathematics, a more uniform approach should be developed to address the mathematics needs of teachers. (See the recommendations from subcommittee III for more detailed recommendations.)
- It is recommended that additional analysis of survey data be completed by institutional program faculty to determine what the common goals of Liberal Arts Math, Intermediate Algebra, College Algebra, and Trigonometry are currently, as well as what they should be.
- It is recommended that the following **Math ACT scores** (or equivalent SAT scores or scores from other appropriate placement instruments) be required for students to enroll in the introductory mathematics courses.

Liberal Arts	ACT 19
Applied College Algebra	ACT 21
College Algebra	ACT 23
Applied Calculus	ACT 25
Calculus I	ACT 27

Task III: To recommend appropriate math content in teacher certification programs

Subcommittee III spent several months doing research relative to national standards for teachers of mathematics at all grade levels. In preparing these recommendations, the committee relied heavily on reports from the National Council of Teachers of Mathematics (NCTM) and the AMS/MAA report on the Mathematical Education of Teachers (MET). Both are available in electronic form. The specific references are found in Appendix D.

Summary of Recommendations of Subcommittee III

Recommendations for K-6 Teachers:

- A minimum of nine hours of college-level mathematics courses should be taken.
- Math methods courses should be additional.
- Mathematics courses should be taught using NCATE/NCTM Standards.
- Mathematics courses should integrate the strands from the MET Report and NCATE. (Number/Operations, Algebra/Functions, Geometry/Measurement, Data Analysis/Statistics/Probability)

Recommendations for K-6 Mathematics Specialists: [new certification]

- A minimum of twelve hours of college-level mathematics courses should be taken.
- A 3-hour course in mathematics methods should be additional.
- Mathematics courses should be taught using NCATE/NCTM Standards.
- Mathematics courses should integrate the strands from the MET Report and NCATE. (Number/Operations, Algebra/Functions, Geometry/Measurement, Data Analysis/Statistics/Probability)

Recommendations for Middle School Mathematics Teachers:

- A minimum of 21 hours of college-level mathematics courses should be taken.
- A 3-hour course in mathematics methods should be additional (or integrated into the 21 hours of classes).
- Mathematics courses should be taught using NCATE/NCTM Standards.
- Mathematics courses should integrate the strands from the MET Report and NCATE. (Number/Operations, Algebra/Functions, Geometry/Measurement, Data Analysis/Statistics/Probability)

- The program requirements should build on the requirements for K-6 Mathematics Specialist.
- More sophisticated topics should be included in the mathematics coursework and must include Discrete Math and the Mathematics of Change (calculus). Other recommended courses are: Number Theory, Axiomatic Geometry, Linear Algebra, Abstract Algebra, Probability & Statistics
- NCTM Process Standards (communication, problem solving, reasoning, connections and representation), technology, modeling, and History of Math should be integrated throughout the coursework.

Recommendations for Secondary Mathematics Teachers:

- Prospective teachers should take the equivalent of an undergraduate major in mathematics which includes a minimum of 36 hours of math including a capstone course connecting college mathematics with the high school curriculum.
- Mathematics courses should integrate the strands recommended by the MET Report (Discrete Math; Algebra and Number Theory; Data Analysis, Statistics, and Probability; Geometry and Trigonometry; Functions and Analysis).
- **Discrete Math**. Requires successful completion of at least a 3-hour course in discrete mathematics, and a 3-hour course in computer programming. Difference equations and dynamical systems should be included in the discrete math course, in the calculus sequence, or in the capstone course.
- **Algebra and Number Theory**. Requires successful completion of a 3-hour course in linear algebra and a 3-hour course in abstract algebra. Additional topics, such as the basic theorems of number theory, may be explored in the capstone experience.
- **Data Analysis, Statistics, and Probability.** Requires successful completion of six hours of coursework in data analysis, probability and statistics. Expertise with spreadsheets is expected.
- **Geometry and Trigonometry.** Requires successful completion of at least a 3-hour course which includes the basic concepts of Euclidean geometry and an introduction to other geometries. Additional geometric and trigonometric topics should be included in the capstone experience. The courses should develop facility with inductive and deductive reasoning, fractals, transformational geometry, and tessellations. Courses should be presented with dynamic drawing tools such as *Geometer's Sketchpad* or *Cabri Geometry* and should emphasize applications.
- **Functions and Analysis.** Requires successful completion of a 3-semester course sequence in calculus. Students are encouraged to take calculus courses that emphasize applications and the use of technology.
- **Elective coursework.** At least three hours should be required. Recommended electives are advanced courses in functions and sets, number theory, advanced geometry, or differential equations.
- **Capstone course.** The course should emphasize math methods and include mathematics content valuable to secondary teachers, but not covered in regular mathematics courses (such as additional geometry topics and NCTM Standards). It should ensure facility with technology useful for teaching mathematics.

General Recommendations:

- The Higher Education Policy Commission should work with the West Virginia Department of Education and the West Virginia Board of Education to develop any necessary policies based on the Math Task Force recommendations.
- All education majors should take a minimum of six hours of college level mathematics.
- Incentives (such as recognition for scholarly activity) need to be developed to encourage higher education faculty to have significant involvement in PreK-12 initiatives.
- High schools should be encouraged to provide after-school or weekend review sessions for all juniors or seniors the semester in which ACT tests are taken.
- College program mathematics prerequisites should be made available to all high school students.

In conjunction with the American Mathematical Association of Two-Year Colleges position statement on the use of technology in the college mathematics classroom (**http://www.amatyc.org**), the WV Mathematics Task Force presents the following recommendations:

- Graphing Technology, including calculators and computer algebra systems, should be used routinely in the mathematics classroom.

- Mathematics faculty should have access to appropriate technology, including calculators and computers, to facilitate their preparation of classroom materials and presentations.

- All mathematics faculty should be provided training in the use of technology and a forum should be available for discussing necessary changes in the curriculum.

- Assessment of student learning should include the use of appropriate technology.

Detailed Report of Subcommittee I

Task I: To recommend appropriate mathematics skills for entering college students

Subcommittee Members: Laura Pyzdrowski (Chair), Barbara Crist, Carol Perry and Mark Goldstein

Explanation and Recommendations:

College freshmen choose one of two academic strands when entering a program of study in higher education. The two strands include mathematics courses to prepare liberal arts/ business majors or those to prepare the mathematics, science, technology and engineering majors. Two different types of entry-level mathematics courses are appropriate for the two strands. The liberal arts/business strand typically consists of mathematics courses such as finite math or college algebra with applications and often requires only one mathematics course for program completion. The scientific strand however, requires a sequence of traditional mathematics courses including at least college algebra through calculus.

Because the West Virginia average American College Testing (ACT) composite score is 20.3 and the Mathematics ACT average is 19.1, most entering freshman are placed into a before calculus type course, either through placement testing or ACT/SAT math scores. We recommend that all students entering higher education complete four years of mathematics courses, and have a minimum of Algebra I, Algebra II and Geometry and that those students choosing a field that requires the college algebra/calculus sequence should also successfully complete trigonometry and pre-calculus.

In the Year 2000 *High Schools That Work* report, the Southern Regional Education Board found that 52% of West Virginia students reported that they were not taking a mathematics course in their senior year and that 29% indicated that they were never encouraged to take more than the minimum high school mathematics requirement for graduation. Only 84% of the students completed the recommended curriculum in mathematics, and only 75% completed College Preparatory Algebra I.

Therefore, we recommend that a minimum of 4 mathematics credit courses be successfully completed as a requirement for graduation from high school and that at least one mathematics course be taken in each year. In addition, we recommend that all students contemplating higher education begin the study of Algebra I no later than ninth grade. For those students entering a liberal arts/business major we strongly recommend that the senior year course promote algebraic thinking skills. Seniors entering the mathematics, science, technology and engineering strand should be enrolled in pre-calculus or beyond. In addition, we recommend that there should be a seamless pathway for students moving from high school mathematics courses to entry-level higher education mathematics courses; a pathway that reflects standards-based recommendations from the National Council of Teachers of Mathematics (NCTM) , the Mathematics Association of America (MAA), and the American Mathematics Association of Two Year Colleges (AMATYC). It is important for the Higher Education Policy Commission to support continuing professional development for mathematics faculty of all levels in order to affect positively student success.

We recommend that a math forum be developed which brings together mathematicians, mathematics educators, administrators, and professional support staff from both higher education and the 5-12 community. We recommend that members of the forum be given the opportunity to interact with other professionals and reflect upon and gain awareness of important current issues. These issues include diagnostic/placement instruments that might benefit students in transition into higher education mathematics, P-12 State Content Standards and Objectives, and articulation of higher education mathematics courses. This forum should provide ongoing professional development opportunities for professionals. Collaborative projects could be undertaken by members of the forum that would help professionals better serve the students of West Virginia. For example, we recommend that a study of the effect of block scheduling versus traditional scheduling be conducted to determine if it affects mathematics preparedness.

We are aware that the West Virginia Department of Education is developing end-of-course exams in Algebra I, Algebra II, and Geometry. There is also a 10^{th} grade assessment being developed. The results of these tests are proposed to make up 15% of the course grade for a student. It is recommended that the Higher Education Policy Commission closely work with the West Virginia Department of Education during the development and implementation of these tests so that the results can provide a better picture of students' backgrounds as they seek placement into entry level mathematics courses in higher education. For instance, mastery on these tests could be an entry requirement for college level mathematics, (A mastery score should be defined once the tests are developed, for instance a score of 70%.) At the very least, the mastery test should be used as an indicator of students at risk. If a student does not meet the mastery score, there should be an adopted retest policy, and the student should be given the opportunity to repeat the test and/or repeat course.

The state requires that a student enrolling in a college credit math course must have at least a 19 on the Math ACT. Colleges have different ACT requirements for students enrolling in the different types of entry-level courses. For example, a student enrolling in Calculus I must have a higher Math ACT than a student enrolling in the Liberal Arts math course. It is recommended that the state adopt uniform standards for prerequisites for entry-level courses. Further, it is recommended that the minimum ACT score for placement in a mathematics course for students enrolled in associate and baccalaureate programs be raised from 19 to 20 by Fall 2008.

Based on the correlation of necessary entry-level skills to ACT mathematics standards, we recommend that a minimum ACT math score of 23 be used to enter a traditional college algebra course and a minimum of 27 be used for admittance to a Calculus I course. (See question 6 of the report from Subcommittee II.) We also recommend that students be permitted to enter mathematics courses via alternative placement paths as designated by higher education institutions. However, higher education institutions should form a subcommittee of the Math Forum, mentioned above, to discuss common alternative pathways into entry-level mathematics courses, and the Forum may decide to recommend policy changes about such items.

The following is a list of skills needed to attain the specific Mathematics ACT scores listed. This list is adapted from the ACT Curriculum Worksheets.

ACT scores 20 - 23 or lower (Liberal Arts, Non-Traditional College Algebra Course)

- Perform arithmetic operations on whole numbers, fractions and decimals and apply them to real world problems.
- Interpret graphs, analyze data, and translate between multiple representations.
- Manipulate basic algebraic expressions

- Perform straightforward word to symbol translations
- Solve proportions that result in linear equations
- Solve linear equations, and apply to real world situations
- Exhibit knowledge of horizontal and vertical lines, and equations that represent them
- Determine slope
- Exhibit knowledge of basic angle properties and sums of special angle measures
- Compute area and perimeter of triangles, rectangles, and circles
- Use geometric formulas when all necessary information is given
- Have a working knowledge of function notation in evaluation and definitions of domain and range.

ACT scores 24 – 27 (College Algebra, Trigonometry, Pre-Calculus)

- Convert units of measures and apply to real world problems
- Work problems involving positive integer exponents, ordering fractions, numerical factors, least common multiples, and square roots
- Determine when an expression or real life situation is undefined, meaningless, or unreasonable
- Factor simple quadratics
- Add, subtract, multiply and divide monomials and polynomials
- Solve real world problems using first and second degree equations and inequalities as models
- Find solutions to linear, absolute value and quadratic equations
- Graph linear equations and inequalities
- Determine the slope of a line from points or equations
- Find the length and midpoint of a line segment
- Apply properties of isosceles and equilateral triangles to find solutions to real world problems.
- Recognize Pythagorean triplets and use the Pythagorean Theorem to solve problems
- Write expressions, equations and inequalities for common algebra settings
- Understand absolute value
- Find solutions to systems of linear equations
- Use properties of parallel and perpendicular lines to determine the equation of a line or coordinates of a point.
- Apply properties of special triangles including similar and congruent

ACT scores 28-32 (Calculus I)

- Solve word problems containing several rates, proportions, or percentages.
- Interpret graphs including graphs in the coordinate plane.
- Apply counting techniques and compute the probability of an event.
- Apply the rules of exponents and number properties to solve problems involving even/odd, positive/negative numbers, factors/multiples and prime factorizations.
- Perform operations on complex numbers.
- Write equations and inequalities for common algebraic settings.
- Solve absolute value and quadratic equations.
- Solve linear inequalities involving reversal of the inequality sign and graph the solution.
- Solve systems of equations.
- Use the distance formula.

- Use properties of parallel and perpendicular lines to determine the equation of a line or coordinates of a point.
- Find the center of a circle and vertex of a parabola.
- Apply properties of special triangles and congruent triangles.
- Use the Pythagorean theorem.
- Use area, perimeter, and volume of geometric figures to compute other measures.
- Evaluate composite functions.
- Apply basic trigonometric rations to solve right triangle problems.

ACT scores 33-36 (Calculus I or above)

- Solve complex arithmetic problems involving several concepts.
- Analyze and draw conclusions based on information from figures, tables, or graphs.
- Exhibit knowledge of conditional and joint probability.
- Exhibit knowledge of logarithms and geometric sequences.
- Apply properties of complex numbers.
- Solve simple absolute value inequalities.
- Write equations and inequalities that require thinking and planning.
- Identify characteristics of graphs.
- Solve problems integrating multiple algebraic and/or geometric concepts.
- Draw conditions based on a set of conditions.
- Solve multi-step geometry problems
- Use relationships among angles, arcs, and distances in a circle.
- Use scale factors to determine the magnitude of change.
- Compute the area of composite geometric figures.
- Write an expression for the composite of two simple functions.
- Use trigonometric concepts and basic identities to solve problems.
- Exhibit knowledge of unit circle trigonometry.
- Graph trigonometric functions.

West Virginia colleges and universities responded to a survey question asking for five skills considered important for students entering each type of entry-level college mathematics course. Responses to the entire survey are included in Appendix A and are summarized in Question 6 Subcommittee II report.

Recommendations

- A minimum of four mathematics credit courses should be required to graduate from high school and at least one mathematics course should be taken in each year. Among these courses should be Algebra I, Algebra II and Geometry.`
- Students contemplating higher education should begin the study of Algebra I no later than ninth grade.
- For those students entering a liberal arts/business major we strongly recommend that the senior year course promote algebraic thinking skills.
- Students choosing a field that requires the college algebra/calculus sequence should successfully complete trigonometry and pre-calculus.
- Seniors entering the mathematics, science, technology and engineering strand should complete precalculus or above.
- The current ACT math placement minimum score requirement for students admitted to associate and baccalaureate level math courses should be raised from 19 to 20 by Fall 2008. With the implementation of new baccalaureate admission standards which call for

four units of mathematics in high school, a higher placement score for entry into credit-bearing college math courses is warranted.

General Recommendations

- We recommend that there should be a seamless pathway for students moving from high school mathematics courses to entry level higher education mathematics courses. Both types of courses should reflect standards based recommendations from the National Council of Teachers of Mathematics, the Mathematics Association of America, and the American Mathematics Association of Two Year Colleges.
- We recommend that a Math Forum be developed, which brings together mathematicians, mathematics educators, administrators, and professional support staff from both higher education and 5-12 as members.
- The minimum ACT requirement for entry into a traditional College Algebra course should be a Math score of 23.
- The minimum ACT requirement for entry into Calculus I should be a Math score of 27. (Note: These last two recommendations are also part the report from Subcommittee II.)

References

1. West Virginia Department of Education. *WVDE News 08-15-2001 - 2001 West Virginia High School Graduates Maintain Record High Score on ACT***.** http://wvde.state.wv.us/news/356/. 2001.

2. American College Testing (ACT). ACT Assessment, Curriculum Review Worksheets, 2001. ACT home page: http://www.act.org.

3. Southern Regional Education Board*. High Schools That Work. State Composite: All Students.* Report # 49000, 2000

Detailed Report of Subcommittee II

Task II: To recommend appropriate entry-level college courses for students needing calculus in their programs and for students who do not need calculus in their program

Subcommittee Members: Robert Mayes (Chair), Mark Stotler, Melinda Saunders, Victor Hughes, III, Huey M. Lee and Judy Carney

Explanation and Recommendations:

A survey was made to examine articulation issues in mathematics through high school into college. The information was gathered by sending surveys to fourteen public higher education institutions in West Virginia. Thirteen out of fourteen institutions responded to the initial survey. A follow-up survey requesting more detailed information on freshman level math courses resulted in a response of twelve completed surveys. Nine of these twelve completed course checklists, and two did not respond to the follow-up survey. The following is an overview of the results from those surveys, which provides information on the current articulation situation in West Virginia.

The survey consisted of eight questions including a detailed checklist of objectives for entry-level freshman math courses. The following is a summary of the questions contained in the survey.

1. What is the appropriate entry-level course at your institution for first-year college students majoring in mathematics or a math related field requiring technical calculus (i.e.: math, physics, chemistry, biology, engineering, computer science)?

2. What is the appropriate entry-level course at your institution for first-year college students majoring in the liberal or creative arts, which require minimal mathematics (i.e.: music, dance, English, language, history, ethnic studies, religious studies, philosophy, political science, communication studies, P.E.)?

3. What is the appropriate entry-level course at your institution for first-year college students majoring in social and life sciences and/or business, which requires more than a topics course (i.e.: economics, accounting, marketing, geoscience, geography, psychology, anthropology, pre-med, nursing)?

4. What is the appropriate entry-level course at your institution for first-year college students majoring in education? Please indicate the entry level for elementary education, secondary education other than math, and secondary mathematics education.

5. The common entry-level courses for non-math majors include Liberal Arts Mathematics, Intermediate Algebra or Applied Algebra, College Algebra, and College Trigonometry. Attached is a checklist of skills and concepts that may be taught in these courses. Please complete a checklist indicating what skills and concepts are taught in these courses at your institution. This checklist should give a high school teacher a list of competencies that students should attain in order to succeed in their first college mathematics course.

6. For each of your entry-level mathematics courses, please list at least five content skills students should possess prior to each of these courses in order to be successful.

7. What are the ACT/SAT/Placement Test requirements for entry-level mathematics courses? Please identify your placement test and indicate the score required to qualify for the course. In the last column indicate the percent of freshmen enrolled in each course in a typical semester.

8. There are a number of national recommendations that have been made on how to improve mathematics curriculum alignment and reduce student remediation at the college level. Please rate the national recommendations from 0 (for not important) to 5(for very important) based on your mathematics department's view.

We now provide a summary of the responses to these eight questions.

Question 1:

What is the appropriate entry-level course at your institution for first-year college students majoring in mathematics or a math related field requiring technical calculus?

The two most common responses for the introductory course in the technical calculus track were Technical Calculus (6 of 16) and College Algebra (5 of 16). Other indicated courses for the technical calculus track were Precalculus (2 of 16), College Trigonometry (1 of 16), Applied Calculus (1 of 16) and Technical Math I (1 of 16). Several institutions replied with multiple responses accounting for the sixteen total responses.

If we consider the highest-level course recommended when multiple courses were given, then 7 of 11 (64%) indicated that Calculus was the appropriate entry-level course for students in this area. However, College Algebra is the entry-level course in 3 of 11 institutions (27%) , and 1 of 11 (9%) had precalculus as the entry-level course.

RECOMMENDATION: Calculus should be the appropriate entry-level course for students majoring in mathematics or a math related field requiring calculus.

Question 2:

What is the appropriate entry-level course at your institution for the first-year college students majoring in liberal or creative arts, which require minimal mathematics?

The most common response for the liberal arts entry-level course requiring minimal math was Liberal Arts Math (12 of 16). Other responses were College Algebra (3 of 16), and Statistics (1 of 16).

If we take the minimal requirement when multiple responses are given, then 11 of 11 (100%) responded with some version of a liberal arts math course.

RECOMMENDATION: Students majoring in the liberal or creative arts should complete a liberal arts course in mathematics. Requirements to transfer within the state should not exceed what the institution designates as the appropriate course. For example, an institution should not require College Algebra as the first transfer course for students in this area.

Question 3:

What is the appropriate entry-level course at your institution for first-year college students majoring in social and life sciences and/or business, which require more than a topics course?

The most common entry-level course for students majoring in social and life sciences, or business was College Algebra (11 of 21). Other indicated courses were Liberal Arts Math (5 of 22), Statistics (3 of 22), Applied Calculus (2 of 22) and Precalculus (1 of 22).

Ten of 11 (91%) institutions had some variation of college algebra as the entry-level course.

RECOMMENDATION: Students majoring in social and life sciences and/or business should have College Algebra, but this course may differ substantially from the traditional algebra course. We recommend an algebra course that focuses on real world applications, integrates technology in a meaningful way, and address concepts from multiple perspectives including verbal, numeric, graphic, and algebraic.

Question 4:

What is the appropriate entry-level course at your institution for first-year college students majoring in education?

The most common entry-level course for first-year education majors was Liberal Arts Math (8 of 26). Other courses designated for education majors were College Algebra (5 of 26), Calculus (5

of 26), specific education courses for majors (4 of 26), College Trigonometry (1 of 26), Precalculus (1 of 26), and Statistics (1 of 26).

The data indicates there is no common entry-level course for education majors. It appears that the introductory content course, for elementary majors and secondary majors not in mathematics, is College Algebra or a liberal arts math course. The introductory course for secondary mathematics education is Calculus.

RECOMMENDATION: Because there is significant disparity in teacher education preparation in West Virginia with respect to mathematics, we recommend developing a more uniform approach to address the mathematics needs of teachers. (See the recommendations from subcommittee III for more detailed recommendations.)

Question 5:

The common entry-level courses for non-math majors include Liberal Arts Mathematics, Intermediate Algebra or Applied Algebra, College Algebra, and College Trigonometry. A checklist of skills and concepts that may be taught in these courses is shown in Appendix B. Respondents were requested to complete a checklist indicating what skills and concepts are taught in these courses at their institution. This checklist gives high school teachers a list of competencies that students should attain in order to succeed in their first college mathematics course.

Appendix B contains a summary of the topics taught in these four courses as indicated by the nine higher education institutions completing the checklist. The number teaching a topic within a course is indicated in the summary checklist.

RECOMMENDATION: We recommend that additional analysis of survey data be completed by institutional program faculty to determine the common goals of Liberal Arts Math, Intermediate Algebra, College Algebra, and Trigonometry, as well as what they should be.

Question 6:

For each of your entry-level mathematics courses, please list at least five content skills students should possess prior to each of these courses in order to be successful.

Liberal Arts Math

For the Liberal Arts Math course, skills expected include the knowledge of basic arithmetic and geometry skills; algebraic manipulation of polynomials; properties of exponents; methods of solving linear, quadratic and rational equations; order of operations; interpretation graphs; order of operations; and factoring.

College Algebra

For the College Algebra course, a student is expected to have a basic knowledge of fractions, factoring, exponents, polynomials, the slope and equations of a line, graphing and writing the equation of a line, conic sections, functions, radicals and rational expressions, absolute value equations and inequalities, factoring, solving linear, quadratic and systems of equations, logarithmic and exponential functions, complex numbers, and graphing.

Trigonometry

For the Trigonometry course, a student is expected to have critical thinking skills and a knowledge of solving right triangles, exponential and logarithmic functions, solving linear and quadratic equations, rational expressions, factoring, radicals, and functions.

Precalculus

For the Precalculus course, a student should have the same skills as those listed above for the College Algebra and Trigonometry courses.

Question 7:

What are the ACT/SAT/Placement Test requirements for the following entry-level mathematics courses? Please identify your placement test and indicate the score required to qualify for the course. In the last column indicate the percent of freshmen enrolled in each course in a typical semester.

Pre-college level courses that are for noncredit include Developmental Arithmetic, Developmental Algebra, Basic Math, Basic Algebra, Pre-algebra, Introductory Algebra, and Fundamentals of Algebra. These courses have the highest percentage of freshmen (34% to 58 %) for all reporting institutions. The West Virginia Educational Report Card states that 23% of baccalaureate students and 49% of community college students took developmental courses in the fall of 2000. Statewide, 30% of students take developmental courses. Assignment into these courses is triggered by an ACT Math score below 19 or a SAT Math score below 460. Students may opt out of remedial courses by taking placement tests such as Compass (1), ASSET (2), Accuplacer (2), or an in-house test (3). However, there is a lack of consistency in the cutoff scores for placing students in Arithmetic versus Developmental Algebra.

Liberal arts math courses include General Math, Finite Math, Nature of Math, and Introduction to Concepts of Math. Little data was provided on the percent of students enrolled in these courses, but national trends indicate that a large percentage of students are taking them. The entry-level requirements for liberal arts math courses are an ACT Math score between 19 and 22, or a SAT Math score between 460 and 520. The most prevalent ACT Math score required was 19 (9 of 14), which is equivalent to a 460 on the SAT Math. Placement tests for these courses include Compass, ASSET, Accuplacer, or an in-house test.

The Intermediate Algebra course is noncredit in some institutions and credit bearing in others. In one institution, Intermediate Algebra is being used as the non-majors algebra course. Little data was provided on the percent of students attending these courses. The entry-level requirements for these courses are an ACT Math score between 16 and 19 or an SAT Math score between 330 and 460. The most prevalent ACT Math score required was 19 (4 of 5), which is equivalent to a 460 on the SAT Math. Placement tests for these courses include Compass, ASSET, Accuplacer, or an in-house test.

The College Algebra course has three types – traditional, traditional with extended contact (5 days a week versus 3), and College Algebra for the social and life sciences and/or business. Little data was provided on the percent of students enrolled in these courses, but national data indicates that College Algebra is the largest enrollment mathematics course. The entry-level requirements for these courses are an ACT Math score between 19 and 23 or a SAT Math score between 460 and 540. A lower ACT Math score (19-20) was usually required for the extended college algebra or college algebra for social/life/business. The traditional college

algebra often required an ACT Math score of 21-23. Placement tests for these courses include Compass, Accuplacer, or an in-house test.

The College Trigonometry course appears to be consistent across institutions. Little data was provided on the percent of students enrolled in these courses, but national data indicates that College Trigonometry is dropping in enrollment. The entry-level requirements for this course are an ACT Math score between 19 and 23 or a SAT Math score between 460 and 540. The ACT Math score required was almost evenly split between 19 (5) and 23 (3). Placement tests for this course include Compass, Accuplacer, or an in-house test.

The Precalculus course appears to be consistent across institutions, serving as a one-semester college algebra and trigonometry course. Little data was provided on the percent of students enrolled in these courses, but national data indicates that Precalculus is dropping in enrollment. The entry-level requirements for this course are an ACT Math score between 19 and 24 or a SAT Math score between 460 and 560. The ACT Math score required was primarily 22-24 (4 of 8). Placement tests for this course include Compass, Accuplacer, or an in-house test.

The Applied Calculus course includes courses called Applied Calculus, Applied Technical Math, or Introduction to Calculus. Little data was provided on the percent of students enrolled in these courses. The entry-level requirements for this course are an ACT Math score between 19 and 26 or a SAT Math score between 460 and 580. The ACT Math score required was primarily 23-26 (6 of 7). Placement tests for this course include Compass, Accuplacer, or an in-house test.

The Technical Calculus course appears to be consistent across institutions. Little data was provided on the percent of students enrolled in these courses, but national data indicates that Calculus is maintaining enrollment, but is not increasing. The entry-level requirements for this course are an ACT Math score between 19 and 30 or a SAT Math score between 460 and 620. The ACT Math score required was primarily 25-30 (5 of 7). Placement tests for this course include Compass, Accuplacer, or an in-house test.

The Statistics course serves as an introduction to statistical processes and is offered for social/life/business majors. Little data was provided on the percent of students enrolled in these courses. The entry-level requirements for this course are an ACT Math score between 19 and 22 or a SAT Math score between 460 and 520. The ACT Math score required was primarily 19 (3 of 4). The only placement test indicated for this course was Accuplacer.

RECOMMENDATION: Placement scores on the ACT Math and SAT Math vary widely across institutions. In addition, many believe that the placement scores are too low, allowing students who are under-prepared to enroll in these classes. The state should make recommendations on the ACT and SAT scores required for students to enroll in these introductory mathematics courses. These recommendations should be based on a deeper understanding of what the scores represent. For example, an entry-level course that requires an ACT Math score of 19 is only requiring students to have arithmetic skills and a very basic understanding of equations. This means the student is functioning at about a 7th grade mathematics level. It is not surprising that students with this level of mathematics background are struggling in beginning college courses.

Recommendation:

Liberal Arts	**ACT 19**
Applied College Algebra	**ACT 21**
College Algebra	**ACT 23**

Applied Calculus	**ACT 25**
Calculus	**ACT 27**

Question 8:

There are a number of national recommendations that have been made on how to improve mathematics curriculum alignment and reduce student remediation at the college level. The average of the institution responses to the national recommendations are provided below (0 for not important to 5 for very important).

RECOMMENDATION	AVERAGE RATING
Prepare all students to begin studying high school Algebra 1 no later than 9th grade.	4.5
Require students to demonstrate competencies at each level of math before they pass to the next level.	4.4
Require high school students to take math courses every year they are in high school.	4.5
Require testing in mathematics at the 10th grade and 11th grade to identify and remediate deficiencies before college.	3.9
Require an exit test for seniors evaluating the student's mathematics ability.	2.6
Teach mathematics on K-16 level using a variety of techniques to reach students with different learning styles.	3.8
Teach mathematics on K-16 level using real world problems so students will see the utility of math.	3.5
Provide ongoing professional development for K-16 teachers.	4.7
Offer different sequential series of mathematics courses to address the needs of all students, regardless of major.	2.2
Align content to create a seamless curriculum across high school and college.	3.5
Ensure that topics, concepts, and applications are uniformly covered by secondary schools.	3.9
Align high school assessments and college placement assessments.	3.4
Improve student placement in college classes by relying on more than ACT/SAT scores.	3.5

The national recommendations receiving the highest support among respondents were continued professional development of teachers and requiring earlier and more mathematics for students in high school. The national recommendations receiving the least support were offering different course sequences for different majors and requiring an exit test for seniors.

RECOMMENDATION: The opinions of the professionals completing this part of the survey support the need for continued professional development for teachers and increased exposure to requirements for future courses. The national recommendations receiving the highest support among respondents were those requiring earlier and more mathematics for students. Subcommittee I provided specific recommendations relative to this topic.

Detailed Report of Subcommittee III

Task III: To recommend appropriate math content in teacher certification programs

Subcommittee Members: Judy Silver (chair), Elizabeth Frye, Murrel Hoover, Suda Kunyosying, Wayne Akey, Lucy Refsland and Larry Lamb

Explanation and Recommendations:

The subcommittee has made separate recommendations for each of the following existing educational levels in the State of West Virginia: K-6, Middle School (5-8 or 5-9), and secondary (9-12). An additional certification, K-6 Mathematics Specialist, is also recommended. General recommendations follow at the end of this document.

In preparing these recommendations, the committee relied heavily on reports from the National Council of Teachers of Mathematics (NCTM) and the AMS/MAA report on the Mathematical Education of Teachers (MET). Both are available in electronic form. (In this section of the report, the author cited two references frequently. These appear at the end of this section and in Appendix D.)

Recommendations for K-6 Teachers:

- A minimum of nine hours of college-level mathematics courses should be taken.
- Math methods courses should be additional.
- Mathematics courses should be taught using NCATE/NCTM Standards [1].
- Mathematics courses should integrate the strands from the MET Report [2] and NCATE [1]. (Number/Operations, Algebra/Functions, Geometry/Measurement, Data Analysis/Statistics/Probability)

Recommendations for K-6 Mathematics Specialists: [new certification]

- A minimum of twelve hours of college-level mathematics courses should be taken.
- A 3-hour course in mathematics methods should be additional.
- Mathematics courses should be taught using NCATE/NCTM Standards [1].
- Mathematics courses should integrate the strands from the MET Report [2] and NCATE [1]. (Number/Operations, Algebra/Functions, Geometry/Measurement, Data Analysis/Statistics/Probability)

Recommendations for Middle School Mathematics Teachers:

- A minimum of 21 hours of college-level mathematics courses should be taken.
- A 3-hour course in mathematics methods should be additional (or integrated).
- Mathematics courses should be taught using NCATE/NCTM Standards [1].
- Mathematics courses should integrate the strands from the MET Report [2] and NCATE [1]. (Number/Operations, Algebra/Functions, Geometry/Measurement, Data Analysis/Statistics/Probability)
- Program requirements should build on the requirements for PreK-6 Mathematics Specialist.
- More sophisticated topics should be included in the mathematics coursework and must include Discrete Math and the Mathematics of Change (calculus). Other recommended

courses are: Number Theory, Axiomatic Geometry, Linear Algebra, Abstract Algebra, Probability & Statistics
- NCTM Process Standards (communication, problem solving, reasoning, connections and representation), technology, modeling, and history of math should be integrated throughout the coursework.

Recommendations for Secondary Mathematics Teachers:

- Prospective teachers should take the equivalent of an undergraduate major in mathematics which includes a minimum of 36 hours of math including a capstone course [2] connecting college mathematics with the high school curriculum.
- Mathematics courses should integrate the strands recommended by the MET Report (Discrete Math; Algebra and Number Theory; Data Analysis, Statistics, and Probability; Geometry and Trigonometry; Functions and Analysis) [2].
- **Discrete Math**. Requires successful completion of at least a 3-hour course in discrete mathematics, and a 3-hour course in computer programming. Differential equations and dynamical systems should be included in the discrete math course, in the calculus sequence, or in the capstone course.
- **Algebra and Number Theory**. Requires successful completion of a 3-hour course in linear algebra and a 3-hour course in abstract algebra. Additional topics, such as the basic theorems of number theory, may be explored in the capstone experience.
- **Data Analysis, Statistics, and Probability.** Requires successful completion of six hours of coursework in data analysis, probability and statistics. Expertise with spreadsheets is expected.
- **Geometry and Trigonometry.** Requires successful completion of at least a 3-hour course which includes the basic concepts of Euclidean geometry and an introduction to other geometries. Additional geometric and trigonometric topics should be included in the capstone experience. The courses must develop facility with inductive and deductive reasoning, fractals, transformational geometry, and tessellations. Courses should be presented with dynamic drawing tools such as *Geometer's Sketchpad* or *Cabri Geometry* and should emphasize applications.
- **Functions and Analysis.** Requires successful completion of a 3-semester course sequence in calculus. Students are encouraged to take calculus courses that emphasize applications and the use of technology.
- **Elective coursework.** At least three hours should be required. Recommended electives are advanced courses in functions and sets, number theory, advanced geometry, or differential equations.
- **Capstone course.** The course should emphasize math methods and include mathematics content valuable to secondary teachers, but not covered in regular mathematics courses (such as additional geometry topics and NCTM Standards). It should ensure facility with technology useful for teaching mathematics.

General Recommendations:

- The Higher Education Policy Commission should work with the West Virginia Department of Education and the West Virginia Board of Education to develop any necessary policies based on the Math Task Force recommendations.
- All education majors should take a minimum of six hours of college level mathematics.
- Incentives (such as recognition for scholarly activity) need to be developed to encourage higher education faculty to have significant involvement in K-12 initiatives.
- High schools should be encouraged to provide after school or weekend review sessions for all juniors or seniors the semester of their ACT Test.

- College program mathematics prerequisites should be made available to all high school students.

References:

1. National Council of Teachers of Mathematics. *NCATE Mathematics Program Standards.* Available at http://www.nctm.org/corners/ncate. 2002.

2. Conference Board of the Mathematical Sciences. *The Mathematical Education of Teachers.* American Mathematical Society and Mathematical Association of America. Available at http://www.maa.org/cbms. 2001.

Background Information Relative to Technology General Recommendation

The appropriate use of technology plays a key role in teaching students how to visualize and explore mathematics concepts as well as develop appropriate problem-solving skills. Part of the survey sent to the colleges and universities of West Virginia explored the current level of technology use in the mathematics classroom. In Appendix B, representatives of each institution of higher learning indicated objectives covered within, in order, liberal arts mathematics, intermediate algebra, college algebra, and trigonometry. Of the nine institutions responding, there is a marked split in whether or not concepts are taught using technology. A small excerpt contrasting similar objectives taught with and without technology is given below: The entries indicate the number of institutions using that type of technology in a particular course.

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Use a graphing utility to graph functions.	2	2	6	3
Write a trig equation which represents a given table or verbal representation of periodic data without use of a graphing utility.	2	2	5	3
Use the sine regression feature of a graphing utility to find a model for periodic data.	0	0	0	6
Use a graphing utility to graph polar functions.	0	0	0	4
Plot polar coordinates.	0	0	0	7
Solve quadratic equations using the quadratic formula.	2	4	9	2
Solve quadratic equations using the zero factor method.	2	4	9	1
Solve quadratic equations by completing the square.	0	2	8	2
Solve quadratic equations graphically using a graphing utility.	1	2	5	0
Approximate solutions of linear systems using manual graphing techniques.	3	3	6	0
Find the solution of a linear system using substitution.	3	2	8	0
Find the solution of a linear system using elimination.	3	2	8	0
Use the table feature of a graphing utility to solve systems of equations.	0	1	2	0
Use the graph and intersection feature of a graphing utility to approximate solutions of systems of equations	0	1	3	2

Analysis of these results shows that while all nine respondents are teaching students in college algebra how to solve quadratic equations using algebraic techniques, only five of nine are teaching this same topic using a graphing utility. Further, while eight of nine are teaching students to solve systems of equations using traditional algebraic methods, only three are utilizing the numeric and graphic techniques offered by the graphing utility.

The role of technology in the teaching of mathematics is extremely valuable. Mathematics curricula should be designed to incorporate the pedagogical advantages of technology. Students learn mathematics most effectively when it is taught using verbal, numeric, graphical, and algebraic techniques. Graphing utilities when used effectively maximize the ability of students to explore mathematics from all four of these approaches.

In conjunction with the AMATYC position statement on the use of technology in the mathematics classroom (**http://www.amatyc.org**), the WV Math Task Force presents the following recommendations:

- Graphing Technology, including calculators and computer algebra systems, should be used routinely in the mathematics classroom.

- Mathematics faculty should have access to appropriate technology, including calculators and computers, to facilitate their preparation of classroom materials and presentations.

- All mathematics faculty should be provided training in the use of technology and a forum for discussing necessary changes in the curriculum.

- Assessment of student learning should include the use of appropriate technology.

APPENDIX A ALIGNMENT SURVEY FOLLOW-UP SUMMARY

1. What is the appropriate entry-level course at your institution for first-year college students majoring in Mathematics or a math related field requiring technical calculus?

Institution		Liberal Arts Math	College Algebra	College Trigonometry	Precalculus	Statistics	Applied Calculus	Technical Calculus	Other
BSC			Algebra						
CC			Math 103-College Alg.						
FSC								Calculus I-Math 140	
GSC			College Algebra						
MUCTC									Technical Math I (MAT145)
MU								Calculus w/ Analytic Geom.	
SC					Precalculus (Math 108)		Calculus w/ App.(Math 205)		
SWVCTC			College Algebra						Calculus I (if 4 year or math major)
WLSC				College Trigonometry	Precalculus				
WVSC									
WVU								Calculus I	
WVUIT								Calculus I (Math 151)	
WVNCC									
WVUP			College Algebra (Math 126)					Calculus I (Math 155)	

2. What is the appropriate entry-level course at your institution for first-year college students majoring in Liberal Arts or Creative Arts, which require minimal mathematics?

Institution		Liberal Arts Math	College Algebra	College Trigonometry	Precalculus	Statistics	Applied Calculus	Technical Calculus	Other
BSC		General Mathematics							
CC		Math 101-Gen. Math.							
FSC		Math 107-Fund. Concepts of Math							
GSC		Liberal Arts Math							
MUCTC									
MU									Concepts & App. Of Mathematics
SC		Intro. To Math (Math 101)							
SWVCTC		College Math for Gen. Ed.	College Algebra						
WLSC		Nature of Mathematics	Low level College Algebra			Intro to Statistics			
WVSC									
WVU		Intro to Concepts of Math							
WVUIT		Basic Math 1(Math121)							Finite Math I (Math 136)
WVNCC									
WVUP		Intro to Math (Math 121)	College Algebra (Math 126)						

3. What is the appropriate entry-level course at your institution for first-year college students majoring in Social and Life Sciences or Business, which require more than a topics course?

Institution		Liberal Arts Math	College Algebra	College Trigonometry	Precalculus	Statistics	Applied Calculus	Technical Calculus	Other
BSC			Algebra						
CC			Math 103-College Algebra						
FSC			Math 112-College Algebra						
GSC			College Algebra						
MUCTC									
MU			College Algebra, Select Topics						Concepts & App. Of Mathematics
SC		Finite Mathematics(Math 156)				Statistics (Math 314)			
SWVCTC		College Math for Gen. Ed.	College Algebra				App. Calc. (some Bus. Majors)		
WLSC		Nature of Mathematics	Low level College Algebra		Precalculus Algebra	Intro to Statistics			
WVSC									
WVU			College Algebra						College Alg. with Applications
WVUIT			College Algebra(Math 126)						Finite Math I (Math 136)
WVNCC									
WVUP			College Algebra (Math 126)			Math 211	Intro to Calculus (Math 150)		

4. What is the appropriate entry-level course at your institution for first-year college students majoring in Education?

Institution		Liberal Arts Math	College Algebra	College Trigonometry	Precalculus	Statistics	Applied Calculus	Technical Calculus	Other
BSC		Gen. Math - Elem. Ed.							
CC			Math 101- Gen. Math.						
FSC		Math107-Fund. Concepts of Math -Sec. Ed.						Calculus I-Math major Sec. Ed.	Math for Elem. Ed- Math110 - Elem. Ed.
GSC		Liberal Arts Math							
MUCTC									
MU								Calc. With Anal Geom- S.Ed.Math	Concepts with Apps.-Elem & Sec. Ed.
SC		Intro. To Math (Math 101)							
SWVCTC		College Math for Gen. Ed. (Elem. Ed. Or Sec. Ed.)							Calculus I (Sec. Ed. Math)
WLSC		Nature of Mathematics		Trigonometry (Sec Ed Math)	Precal. Alg. (Sec Ed Math)	Intro to Statistics			Part I&II for Elem Ed majors
WVSC									
WVU		Secondary, General	Elementary Ed					Secondary, Math	
WVUIT		Finite Math I (Math 136)	College Algebra(Math 126)	Trig. (Math 128)				Calculus I(Math 151	Basic math (Math121)
WVNCC									
WVUP		Intro to Math (Math 121)	College Algebra (Math 126)						

6. For each of your entry-level mathematics courses, please list at least 5 content skills students should possess prior to each of these courses in order to be successful.

Liberal Arts Math

Institution		Skill 1	Skill 2	Skill 3	Skill 4	Skill 5
BSC	N/A					
CC		Fractions	Sets	Function Notation	Basic algebra	Basic geometry
FSC	N/A					
GSC		Basic geometry-area	arithmetic skills	solve linear equations	Interpret graphs	Determine validity of an argument
MUCTC	N/A					
MU	N/A					
SC		Solve linear equations in one variable	Understand real number line	Know prime numbers	Know order of operations	Apply exponent rules
SWVCTC		Solve linear equations in one variable	Manipulate to isolate variable	Order of operations	Arithmetic operations on rationals	Operations with signed numbers
WLSC		Basic factoring	Solve simple linear & quadratic equations	Use of substitution in alg. expressions	Use of properties of exponents	Read & writing of mathematics
WVSC						
WVU						
WVUIT		Algebraic manipulation of polynomials	alg. manipulation of expressions-frac & neg. exp.	solving simple equations	graphing of linear functions	critical thinking & solving word problems
WVNCC						
WVU-P		basic arithmetic	properties of exponents	solve linear, quadratic, rational equations	college level reading	model algebraic equations

N/A = No response from the institution

College Algebra

Institution		Skill 1	Skill 2	Skill 3	Skill 4	Skill 5
BSC	N/A					
CC		Fractions	Exponents	Polynomials	Graphs	Basic algebra
FSC	N/A					
GSC		Combine like terms	Apply rules of exponents	Graph linear equations	Solve llinear equations	Factor polynomials
MUCTC	N/A					
MU	N/A					
SC						
SWVCTC		Determine the slope of a line	Use slope intercept form to graph linear equations	Solve quadratic equations by factoring	Solve simple systems of linear equations	Identify the physical significance of slope
WLSC		Basic factoring	Solve simple linear & quadratic equations	Use of substitutuion in alg. expressions	Use of properties of exponents	Read & writing of mathematics
WVSC						
WVU						
WVUIT		alg. manipulation of expressions-frac & neg. exp.	basic knowledge of conic sections	working with linear functions & polynomials	simplifying frac. exp. & solving frac. equations	working with exp. And log. Functions
WVNCC						
WVU-P		rational expressions	work with radicals	abs-value equations & inequalities	complex numbers	solve quadratics

N/A = No response from the institution

College Trigonometry

Institution		Skill 1	Skill 2	Skill 3	Skill 4	Skill 5
BSC	N/A					
CC						
FSC	N/A					
GSC						
MUCTC	N/A					
MU	N/A					
SC						
SWVCTC						
WLSC		Higher level of the basics above.				
WVSC						
WVU						
WVUIT		solving right triangles-using law sines/law cosines	proving trig identities	using exponential & logarithmic functions	critical thinking & solving word problems	
WVNCC						
WVU-P		solve linear & quadratic equations	rational expression	factoring	work with radicals	graphing functions & functions in general
	N/A = No response from the institution					

Precalculus

Institution		Skill 1	Skill 2	Skill 3	Skill 4	Skill 5
BSC	N/A					
CC						
FSC	N/A					
GSC						
MUCTC	N/A					
MU	N/A					
SC		graph simple linear equations	factor expressions	multiply/divide polynomials	Quadratic formula	*Understand FUNCTION concepts!
SWVCTC						
WLSC		Higher level of the basics above.				
WVSC						
WVU						
WVUIT						
WVNCC						
WVU-P						
	N/A = No response from the institution					

Statistics

Institution		Skill 1	Skill 2	Skill 3	Skill 4	Skill 5
BSC	N/A					
CC						
FSC	N/A					
GSC						
MUCTC	N/A					
MU	N/A					
SC						
SWVCTC						
WLSC						
WVSC						
WVU						
WVUIT						
WVNCC						
WVU-P						
	N/A = No response from the institution					

Applied Calculus

Institution		Skill 1	Skill 2	Skill 3	Skill 4	Skill 5
BSC	N/A					
CC						
FSC	N/A					
GSC						
MUCTC	N/A					
MU	N/A					
SC						
SWVCTC						
WLSC						
WVSC						
WVU						
WVUIT						
WVNCC						
WVU-P						
	N/A = No response from the institution					

Technical Calculus

Institution		Skill 1	Skill 2	Skill 3	Skill 4	Skill 5
BSC	N/A					
CC						
FSC	N/A					
GSC						
MUCTC	N/A					
MU	N/A					
SC						
SWVCTC						
WLSC						
WVSC						
WVU						
WVUIT		All knowledge & skills listed in Alg. & Trig.				
WVNCC						
WVU-P						

N/A = No response from the institution

7. What are the ACT/SAT/Placement Test requirements for the following entry-level mathematics courses?

Pre-College Level Courses (Noncredit) - can list up to 3 courses

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC		Developmental Arithmetic	Less than 15		Compass 30 or less	
		Developmental Algebra	15 - 18		Compass 31 - 58	
CC		Basic Math (Math 090)				22%
		Basic Algebra (Math 091)			In-house test	17%
FSC		Pre Algebra				
		Algebra				
GSC		Dev. Mathematics-Arithmetic				39%
		Dev. Mathematics-Algebra			ASSET Numerical skills - 39+	10%
MUCTC		Developmental Math				
		Developmental Algebra				
		Developmental Geometry				
MU		Developmental Math				
		Developmental Algebra				
		Developmental Geometry				
SC		Basic Math (ACFN 060)	<19	<430R, <460	Asset <40 Numer. skills, Accuplacer <85 Arith.	33.30%
		PreAlg. & Basic Alg. (ACFN 070, 080)			Asset >40 n.s.<84 elem. Alg.	1%
		Int. Alg. (ACFN 090)			In-house algebra test , part 1 >= 60%	
SWVCTC		Basic Mathematics	<16		Accuplacer (Arithemetic <85)	58%
		Studying Math & Reasoning Together	>16		Transition to Introductory Algebra	<10%
		Introductory Algebra	<19		Accuplacer (Elem. Alg. <84)	80% c (?)
WLSC		Fundamentals of Algebra				50%
WVSC						
WVU		Algebra (Math 22)	<=19	<=480	WVU placement - less than 10	
WVUIT		Pre-Algebra (Math 020)	<14			
		Elementary Alg. (Math 030)	14-16			
		Intermediate Alg. (Math 040)	17-18			
WVNCC						
WVU-P		Arithmetic (Math 011)	<19	<460	Accuplacer - <84	19%
		Elementary Algebra (Math 021)	<19	<460	Accuplacer - >=85 Arith. 0-69 on Elem alg.	36%

Liberal Arts Math -can list up to 2 courses

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC		General Mathematics				
CC		General Math (Math 101)	19	460		6%
FSC		Fund. Concepts of Math(Math107)	19	430	Compass 36	
GSC		The Nature of Math	19	460	ASSET Algebra - 38+	
MUCTC		Pre-Algebra	16-18	330-460	Accuplacer - 48	
		Technical Math I(MAT145)	19	460	Accuplacer - 97-120	
MU		Concepts & App. Of Math (Math 121)				
		Selected Topics in Coll. Alg.(Math 123)				
SC		Intro to Math (Math 101)	>=22	>=490R, >=520		
		Finite Math (Math 154)	>=22	>=490R, >=520		
SWVCTC		College Math for Gen Ed	>=19		Accuplacer (>=85 Arith. , >=84 Elem Alg)	4% (total student body)
WLSC			19			5%
WVSC						
WVU		Intro concepts of math(Math121)	none	none		
		College Alg.for Applications (Math124)	20+	480+	WVU placement - 10 or 11	
WVUIT		Basic Math I (Math 121)	19			
		Finite Math I (Math 136)	19			
WVNCC						
WVU-P		Introductions to Math (Math 121)	19	460	no accuplacer score-noted	0.50%

Intermediate Algebra

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC						
CC						
FSC		Int. Algebra (Math 111)	19	430	Compass - 36	
GSC			19	460	ASSET Algebra - 38+	
MUCTC						
MU			16-18	330-460	Accuplacer - 48	
SC						
SWVCTC		Intermediate Algebra	>=19		Accuplacer (>=85 arith, >=84 elem alg)	7% (total student body)
WLSC			n/a			
WVSC						
WVU						
WVUIT		(noncredit - see above)				
WVNCC						
WVU-P		Math 114	<19	<460	Accuplacer - elm alg 70-83, >=85 arith.	20%

College Algebra

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC		Algebra	19	431	Compass 59	
CC		College Algebra (Math 103)	19	460		11%
FSC		College Algebra (Math 112)	21	470	Compass - 49	
GSC		College Algebra	21	500		
MUCTC						
MU		Coll. Alg. Expanded version(Math 130)	19	460	Accuplacer - 86	
		College Algebra (Math 130)				
SC		Math 105	19-21	430-480R, 460-500		
SWVCTC		College Algebra	>=19		Accuplacer (>=85 arith, >=84 elem alg)	5% (total student body)
WLSC			19			10%
WVSC						
WVU		College Alg. (Math 126)	23+	540+	WVU Placement - 12 +	
		College Algebra - 5 day	20+	480+	WVU Placement - 10 or 11	
WVUIT		College Algebra (Math 126)	23			
		Basic College Alg. (Math 125)-5 hrs.	19-22			
WVNCC						
WVU-P		College Alg. (Math 126)	19	460	Accuplacer->=84 Elem alg.	3%

College Trigonometry

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC		Trigonometry	19	431	Compass - 59	
CC						
FSC		Trig. & Elem Functions (Math 115)	23	510	Compass - 63	
GSC		College Trigonometry	19	460		
MUCTC						
MU			21	500	Accuplacer - 86	
SC						
SWVCTC		Trigonometry	>=23		Prereq. Int. Alg. or College Alg.	1% (total student body)
WLSC			19			3%
WVSC						
WVU		Plane Trigonometry (Math 128)	23+	540+	WVU Placement - 12 +	
WVUIT		Trigonometry (Math 128)1	19			
WVNCC						
WVU-P		College Trig. (Math 116)	19	460	Accuplacer->=84 Elem alg.	0.20%

Precalculus

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC		Precalculus	19	431	Compass - 59	
CC						
FSC		Intro to Math Analysis(Math 170)	23	510	Compass - 63	
GSC						
MUCTC						
MU			21	500	Accuplacer - 86	
SC		Math 108 -Precalculus	>=22	>=490R,>=520		
SWVCTC		Precalculus	>=23		Prereq. Inter.Alg.	1% (total student body)
WLSC			19			10%
WVSC						
WVU		Pre-Calculus Mathematics (Math 129)	24+	560+	WVU Placement - 14+	
WVUIT						
WVNCC						
WVU-P		Math 129	19	460	Accuplacer->=84 Elem alg. &HS Trig.	0%

Applied Calculus

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC		Applied Calculus	26	540	Compass-Trig. Min. - 46	
CC						
FSC		Applied Technical Math I (Math 101)	24		Compass - 67	
GSC						
MUCTC						
MU			23	540	Accuplacer - 86	
SC		Math 207-Calculus I	>=25	>=520R,>=580	Precalc or Anal. Geom. In High School	
SWVCTC		Calculus Applications	>=23		Prereq. Inter.Alg.	<1% (total student body)
WLSC						
WVSC						
WVU		Intro to Calculus (Math 150)	25+	580+	WVU Placement - 16+	
WVUIT		Technical Calc. (Math 117)			taken after Math 113 & Math 114	
WVNCC						
WVU-P		Intro to calculus(Math 150)	19	460	Math 126 prerequisite	0%

Technical Calculus

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC		Technical Calculus	26	540	Compass-Trig. Min. - 46	
CC						
FSC		Calculus I (Math 190)	25		Compass - 73	
GSC						
MUCTC						
MU		Calc. With Analytic Geom.(Math 229)	27	620	Accuplacer - 103	
SC						
SWVCTC		Technical Calculus	>=23		Prereq. College Alg orTrig. Or Precalc.	<1% (total student body)
WLSC						
WVSC						
WVU		Calculus 1 (Math 155)	26+	600+	WVU Placement - 16+	
WVUIT		Calculus I (Math 151)	30			
WVNCC						
WVU-P		Calculus I (Math 155)	19	460	Accuplacer->=84 Elem alg. & H.S. Calc.	0%

Statistics

Institution		Course Title at Your Institute	ACT Score	SAT Score	Placement Test Name (Score)	% of Freshmen Enrolled
BSC						
CC						
FSC						
GSC						
MUCTC						
MU						
SC		Math 314(Gen. Studies Course)	>=22	>=490R, >=520		
SWVCTC		Elem. Statistics	>=19		Accuplacer (>=85 arith, >=84 elem alg)	5% (total student body)
WLSC			19			15%
WVSC						
WVU						
WVUIT						
WVNCC						
WVU-P		Statistics (Math 211)	19	460	Accuplacer->=84 Elem alg.	0%

8. There are a number of national recommendations that have been made on how to improve mathematics curriculum alignment and reduce student remediation at the college level.

Institution		A	B	C	D	E	F	G	H	I	J	K	L	M
BSC	N/A													
CC		3	5	4	4	2	4	4	5	1	4	4	4	4
FSC		5		4	4		2	3	5	0	0	3	2	2
GSC		5	5	4	3	3	4	5	3	4	2	1	3	3
MUCTC		5		5	5		4	4	4	3	5	4	4	4
MU		4		5	5		4	3	5	3	4	4	4	5
SC		5	4	4	2	3	4	3	5	1	2	4	2	5
SWVCTC		4	5	5	4		5	5	5	1	5	5	4	3
WLSC		5	5	4	5	1	5	3	5	3	4	5	4	1
WVSC														
WVU		5	4	5	5	4	2	2	5	4	3	5	3	5
WVUIT		4	4	5	2	2	4	4	5	2	4	4	3	2
WVNCC														
WVU-P		5	3	5	4	3	4	3	5	2	5	4	4	5

** Ratings are from 0 for not important to 5 for very important based on your mathematics department's view.

Recommendations:

A. Prepare all students to begin studying high school Algebra 1 no later than 9th grade.

B. Require students to demonstrate competencies at each level of math before they pass to the next level.

C. Require high school students to take math courses every year they are in high school.

D. Require testing in mathematics at the 10th grade and 11th grade to identify and remediate deficiencies before college.

E. Require an exit test for seniors evaluating the student's mathematics ability.

F. Teach mathematics on K-16 level using a variety of techniques to reach students with different learning styles.

G. Teach mathematics on K-16 level using real world problems so students will see the utility of math.

H. Provide ongoing professional development for K-16 teachers.

J. Align content to create a seamless curriculum across high school and college.

K. Ensure that topics, concepts, and applications are uniformly covered by secondary schools.

L. Align high school assessments and college placement assessments.

M. Improve student placement in college classes by relying on more than ACT/SAT scores.

Appendix B: Course Goals Checklist

Common Course Goals

Please identify the goals covered within each indicated course by checking the appropriate column. Identify the particular name/number of the course at your institution that you are identifying as each course in the space provided beneath each title

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Put the name/number of the course at your institution in the appropriate column on this line.				
Define function.	5	4	8	7
Identify whether or not a relationship specifies the rule for a function when the relationship is given: verbally, numerically, graphically, or algebraically.	4	4	9	4
Given the rule of a function verbally, numerically, graphically, or algebraically, express the rule for the function using the other modes of expression.	5	4	9	4
Evaluate functions numerically, verbally, graphically, and algebraically.	5	4	9	8
Use function notation.	5	4	9	7
Find the value(s) of the domain for which a function has a specified range value.	4	4	9	6
Evaluate numerical expressions containing simple radicals and fractional exponents.	3	6	9	5
Develop formulas for the area of a square, area of a circle, and circumference of a circle.	4	4	4	1
Define linear function.	5	3	9	2
Collect data and generate a table of values for analysis.	2	2	1	1
Graph data on a Cartesian coordinate plane by identifying and using an appropriate scale, labeling axes appropriately including units.	4	4	9	4
Approximate the line of best fit for a set of experimental data manually.	0	1	2	2
Calculate the slope of a line given two points through which the line passes.	4	5	9	2
Calculate the slope of a line given a graph of the line.	5	5	9	2
Identify the slope of a line given the equation of the line in standard form, general form, or slope-intercept form.	5	5	9	2
Approximate the slope, including units, of a line given a table or graph of data that is approximately or exactly linear.	1	2	4	1
Explain the physical significance of the slope given a table of data or a graph of data.	2	4	6	1
Identify the slope and write the equation of a horizontal line.	4	6	8	2
Identify the slope and write the equation of a vertical line.	4	6	8	2

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Graph linear equations using slope-intercept method, x-y intercept method, and point plotting.	4	6	8	2
Solve linear equations.	7	5	9	3
Solve linear inequalities.	4	5	9	2
Graph the solution to a linear inequality on a number line.	4	5	9	0
Use interval notation to express the solutions of linear inequalities and compound linear inequalities.	3	4	9	2
Use set-builder notation to express the solutions of linear inequalities and compound linear inequalities.	3	3	9	2
Identify the domain and range of a function given verbally, numerically, graphically, or algebraically using set-builder and interval notations.	3	3	9	4
Recognize data as related by direct or inverse variation.	3	1	4	0
Find the constant of variation.	4	1	6	0
Given a table of data, write the equation for a direct variation function.	2	1	3	0
Given a table of data, write the equation for an inverse variation function.	2	1	3	0
Write the equation of a line given a point through which it passes and its slope.	3	3	9	1
Write the equation of a line given the graph.	2	3	9	1
Write the equation of a line perpendicular to line 1 given the line 1's graph, equation, or slope and a point through which the line passes.	2	3	8	1
Write the equation of a line given two points.	4	3	9	1
Write the equation of a line parallel to line 1 given the line 1's graph, equation, or slope and a point through which the line passes.	2	3	8	1
Graph linear inequalities in two variables.	2	2	5	0
Construct cost, revenue, and profit functions.	2	1	2	0
Approximate solutions of linear systems using manual graphing techniques.	3	3	6	0
Find the solution of a linear system using substitution.	3	2	8	0
Find the solution of a linear system using elimination.	3	2	8	0
Classify systems of linear equations as dependent/independent and consistent/inconsistent.	3	2	6	0
Find the break-even point of a cost/revenue system of linear functions.	3	1	4	0
Compare power and exponential functions.	0	1	7	3
Find examples of linear, constant, and nonlinear functions in real life.	3	2	4	0
Given the rule for a linear function graphically, verbally, or numerically, write an equation for the function.	2	2	7	1
Given the rule for a constant function graphically, verbally, or numerically, write an equation for the function.	3	3	6	1
Given the rule for a quadratic function graphically, verbally, or numerically, write an equation for the function.	2	1	8	1

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Given the rule for an exponential function graphically, verbally, or numerically, write an equation for the function.	1	1	6	1
Given the rule for a logarithmic function graphically, verbally, or numerically, write an equation for the function.	1	1	6	1
Given the rule for a piecewise function graphically, verbally, or numerically, write an equation for the function.	1	0	5	2
Interchange graphical, numerical, and algebraic expressions of the rule for a greatest integer function.	0	0	3	0
Solve compound inequalities.	2	4	7	1
Solve absolute value inequalities.	1	3	9	2
Solve quadratic inequalities.	0	2	7	1
Solve rational inequalities.	0	2	6	2
Solve absolute value equations.	0	3	9	2
Solve quadratic equations using the quadratic formula.	2	4	9	2
Classify solutions to a quadratic equation using the discriminant.	2	3	8	2
Solve quadratic equations using the zero factor method.	2	4	9	1
Solve quadratic equations by completing the square.	0	2	8	2
Solve quadratic equations graphically using a graphing utility.	1	2	5	0
Simplify the solutions of a quadratic equation when they involve reducible radicals and/or complex expressions.	1	2	9	2
Use graph-shifting techniques to graph functions manually.	1	0	5	2
Identify functions given algebraically or graphically as even, odd, or neither.	0	0	5	2
Use symmetry and even/odd properties to graph functions.	0	0	6	2
Graph conic sections --parabolas, circles, ellipses, and hyperbolas --using completing the square and graph-shifting techniques.	0	0	2	0
Write the equation of a conic section given its graph.	0	0	3	0
Identify the x-intercept(s), y-intercept, and vertex of a parabola given its graph or equation.	2	1	7	0
Solve systems of nonlinear equations in two variables using elimination, substitution, and graphing.	0	0	5	0
Solve systems of linear inequalities.	2	1	2	0
Solve systems of linear equations in three variables by elimination.	2	0	7	0
Solve systems of linear equations in multiple variables using Gaussian elimination.	2	0	2	0
Perform addition, subtraction, scalar multiplication, and multiplication of matrices manually.	2	0	3	0
Perform addition, subtraction, scalar multiplication, and multiplication of matrices using a graphing utility.	1	0	2	0
Find the determinant of 2x2 and 3x3 matrices manually.	1	0	4	0
Find the determinant of 2x2 and 3x3 matrices using a graphing utility.	0	0	2	0
Use Cramer's rule to solve systems of linear equations in two or three variables.	1	0	3	0
Identify the dimensions of a matrix.	2	0	4	0

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Represent a system of linear equations using an augmented matrix.	2	0	4	0
Given a table of data, use modeling techniques to determine the type of function which most fits the data and find the equation of the function.	0	1	2	0
Use the regression feature of a graphing utility to fit linear, exponential, and quadratic data.	0	1	2	0
Given the rule of a function graphically, numerically, or algebraically, find the inverse of the function.	0	1	6	2
Perform arithmetic operations on functions algebraically and graphically.	2	1	7	3
Solve problems using linear programming.	2	0	0	0
Given two functions expressed algebraically, graphically, or numerically, find a composite function and express it algebraically, numerically, and graphically.	0	0	7	3
Graph logarithm functions.	1	1	6	1
Interchange logarithmic and exponential forms of equations.	1	1	6	1
Solve logarithm equations.	1	1	5	1
Use the change of base formula.	1	0	5	1
Solve application problems involving exponential functions and logarithms.	1	1	6	1
Use the properties of logarithms to expand/contract logarithmic expressions.	1	0	6	1
Solve exponential equations.	1	2	6	1
Evaluate the common logarithm, natural logarithm, and logarithms to other bases using a calculator.	2	1	5	1
Use written communication skills to express mathematical ideas.	7	3	6	5
Use a graphing utility to find the x and y intercepts of a function.	2	2	6	3
Predict the end behavior of a polynomial.	0	0	6	0
Use the table feature of a graphing utility to solve systems of equations.	0	1	2	0
Use a graphing utility to graph functions.	2	2	5	3
Use the graph and intersection feature of a graphing utility to approximate solutions of systems of equations.	0	1	3	2
Sketch angles and triangles to scale.	0	0	0	6
Define the six trigonometric ratios.	0	0	0	9
Interchange radian measure with degrees, minutes, and seconds.	0	0	0	9
Solve right triangles.	1	0	3	9
Use the Pythagorean Theorem.	4	4	6	9
Use the relationship between arc length, radius, and central angle subtended by an arc.	0	0	0	8
Solve application problems involving right triangles.	0	1	1	9
Given one trig ratio, find the value(s) of the other five trig ratios.	0	0	0	9
Solve applications problems involving rotational motion.	0	0	0	7

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Use cofunction relationships of trig ratios.	0	0	0	9
Use reciprocal relationships of trig ratios.	0	0	0	9
Find the exact value of the trig ratios of a 30-60-90 triangle.	0	0	0	9
Find the exact value of the trig ratios of a 45-45-90 triangle.	0	0	0	9
Find the exact value of the trig ratios of any integer multiple of pi/2.	0	0	0	9
Find the exact value of the trig ratios of any integer multiple of pi.	0	0	0	9
Use reference angles to evaluate exact values of trig ratios involving special triangles.	0	0	0	9
Use a calculator to find approximate values of trig ratios when the angle is given in degrees.	0	0	0	9
Use a calculator to find approximate values of trig ratios when the angle is given in radians.	0	0	0	9
Identify measure of all angles conterminal with a given angle.	0	0	0	8
Identify the sign of the trig ratio given the quadrant in which the terminal side of the angle in standard position lies.	0	0	0	9
Sketch the graph of the six basic trig functions.	0	0	0	9
Sketch the graph of y=D+AsinB(x+C); y=D+AcosB(x+C); y=D+AtanB(x+C); y=D+AsecB(x+C); y=D+AcscB(x+C); y=D+AcotB(x+C); y=D+AsinB(x+C).	0	0	0	8
Identify the domain and range of any trig function given graphically or algebraically using set-builder and interval notations.	0	0	0	7
Identify the amplitude of a sine or cosine wave given the function expressed algebraically or graphically.	0	0	0	9
Identify the phase shift of any trig function given the function expressed algebraically or graphically.	0	0	0	8
Identify the vertical shift of any trig function given the function expressed algebraically or graphically.	0	0	0	8
Identify the period of any trig function given the function expressed algebraically or graphically.	0	0	0	8
Identify asymptotes of any tangent, cotangent, secant, or cosecant function expressed algebraically or graphically.	0	0	0	7
Identify the zeros of any trig function given the function expressed algebraically or graphically.	0	0	0	9
Use set-builder notation and/or interval notation.	2	1	5	7
Write a trig equation which represents a given table or verbal representation of periodic data without use of a graphing utility.	0	0	0	6
Use the sine regression feature of a graphing utility to find a model for periodic data.	0	0	0	2
Graph combined trig functions using addition of ordinates.	0	0	0	5
Verify trig identities using basic identities, Pythagorean identities, sum and difference identities, identities for negatives, double angle identities, half angle identities, and algebraic manipulation.	0	0	0	9
Use the sum and difference identities for sine, cosine, and tangent to find the exact value of trig ratios of an angle.	0	0	0	9

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Use the half angle identities to find exact values of trig ratios of an angle.	0	0	0	9
Use the double angle identities to find exact values of trig ratios of an angle.	0	0	0	9
Use the product to sum identities.	0	0	0	8
Use the sum to product identities.	0	0	0	7
Identify the domain of the six inverse trig functions.	0	0	0	8
Sketch a graph of the six inverse trig functions.	0	0	0	7
Evaluate inverse trig functions exactly as real numbers.	0	0	0	7
Find exact values of expressions involving trig functions and their inverses.	0	0	0	7
Find exact solutions of trig equations over restricted intervals.	0	0	0	9
Find exact solutions of trig equations over all real numbers.	0	0	0	8
Find approximate solutions of trig equations over all real numbers.	0	0	0	7
Use Heron's formula to find the area of a triangle.	0	0	0	6
Solve triangles using the law of sines and law of cosines.	0	0	0	8
Add vectors graphically.	0	0	0	6
Add vectors algebraically.	0	0	0	6
Find the norm of a vector.	0	0	0	6
Find the components of a vector.	0	0	0	6
Use the addition properties of vectors.	0	0	0	5
Use the scalar multiplication properties of vectors.	0	0	0	5
Find the dot product of two vectors.	0	0	0	5
Interchange polar and rectangular coordinates.	0	0	0	5
Sketch polar equations using rapid sketching techniques.	0	0	0	4
Use a graphing utility to graph polar functions.	0	0	0	4
Plot polar coordinates.	0	0	0	7
Interchange equations given in rectangular form with equations given in polar form.	0	0	0	7
Plot numbers in a complex plane.	0	1	2	6
Interchange complex numbers expressed in rectangular form with complex numbers expressed in polar form.	0	0	0	6
Use cis notation.	0	0	0	6
Use De Moivre's theorem to evaluate expressions given in rectangular or polar form.	0	0	0	5
Classify numbers as whole, natural, integer, rational, irrational, real.	6	3	7	1
Use inductive reasoning to predict the next numbers or figures of a pattern.	3	0	0	1
Use estimation techniques to assess the reasonableness of an answer to an arithmetic problem.	5	3	4	3
Use DeMorgan's Laws as related to sets.	5	0	0	0
Evaluate set intersections, unions, and complements	6	2	1	0
Find the cardinality of a set given the verbal, roster, or set-builder representation of the set.	7	0	0	0
Express the elements of a set using set-builder notation.	7	2	2	2

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Solve applications of set problems using Venn diagrams.	7	0	0	0
Recognize and use appropriate set symbols.	7	1	0	0
Identify subsets and proper subsets of a given set.	7	1	0	0
Find the cardinality of subsets and proper subsets of a given set.	7	0	0	0
Use DeMorgan's Laws as applied to logic problems.	5	0	0	0
Use connectives to construct and evaluate truth tables.	5	0	0	0
Write converse, inverse, and contrapositive statements given a conditional statement.	5	1	0	0
Assess the validity of an argument.	4	0	0	0
Negate logic statements using quantifiers.	3	0	0	0
Convert base ten numbers to other bases.	4	0	1	0
Express natural numbers using prime factorization.	5	2	3	0
Identify and use the properties of real numbers.	5	2	4	3
Solve application problems involving direct and inverse variation.	3	1	4	0
Interchange metric-English units of measure.	5	0	0	0
Perform conversions within the metric system using relationships of the metric prefixes.	5	0	0	0
Calculate the volume of basic geometric shapes.	5	0	3	0
Calculate the area of basic geometric shapes.	5	2	4	2
Solve applications problems involving area or volume.	6	4	7	3
Manipulate formulas to solve for the indicated variable.	5	5	8	4
Classify angles as acute, right, obtuse, or straight.	4	0	1	6
Find the measure of the complement and supplement of an angle.	3	0	1	6
Use similar triangles to solve for unknown measures.	1	1	2	4
Find the measure of an angle in a triangle given the measure of the other two angles.	2	0	1	5
Find the measure of an angle in a triangle given the measure of one of the other angles and a remote exterior angle.	1	0	1	4
Use angle relationships of parallel lines cut by a transversal to find missing angle measures.	1	0	1	4
Use vertical angle congruence to find missing angle measures.	1	0	1	3
Solve application problems involving simple interest.	6	2	3	0
Solve percent of increase/decrease applications problems.	6	2	4	1
Find the empirical probability of an event given a set of experimental data.	4	0	1	2
Find the theoretical probability of an event given a verbal description or list of outcomes of an experiment.	5	0	1	1
Find the odds in favor of/against an event.	6	0	1	1
Determine whether or not a game is fair using expectation.	5	0	0	0
List the sample space of an experiment using a tree diagram.	4	0	1	0
Find the measures of central tendency given a table of data.	6	0	0	1
Find the standard deviation of a set of data.	6	0	0	1
Interpret the physical meaning of standard deviation.	5	0	0	1

	Liberal Arts Math	Intermediate Algebra	College Algebra	Trig
Read and interpret data expressed using bar graphs, circle graphs, and line graphs.	6	1	0	0
Calculate z-scores.	4	0	0	0
Use z-scores to determine the percent of data within a specified range given the standard deviation of a set of data.	4	0	0	0
Construct histograms.	5	0	0	0
Use early numeration systems.	3	0	0	0
Find the Cartesian product of 2 given sets.	5	0	0	0
Solve proportional problems.	4	2	5	2
Construct the counting set of other bases.	3	0	0	0
Perform addition, subtraction, multiplying and division in other bases.	3	0	0	0
Differentiate between inductive and deductive reasoning.	3	0	0	1
Find the missing term of sequences and patterns.	4	1	0	0
Identify arithmetic and geometric sequences.	4	1	1	0
Use Polya's problem solving strategies for working word problems.	3	0	1	2
Use symbolic logic to describe circuits.	0	0	0	0
Design circuits to find specific truth tables.	0	0	0	0
Compare De Morgan's Laws for sets and for logic propositions.	2	0	0	0
Complete truth tables for conditional and bi-conditional statements.	3	0	0	0
Use sigma notation to find the sum of a finite sequence.	3	0	1	0
Compute amortization values.	1	0	0	0
Compute the present value for annuities.	0	1	1	0
Solve simple algebraic equations.	8	4	7	5
Explore the history of calculation devices.	1	0	0	0
Solve problems using order of operations rules.	7	3	6	3
In the space below, please identify any goals not included above that are part of the liberal arts math, intermediate algebra, trigonometry, or college algebra courses at your institution.				
Normal curve	1	0	0	0
Measure of position (rank and percentile rank)	1	0	0	0
Algebraic manipulation and simplification of expressions and equations involving radicals	1	1	1	0
Algebraic manipulation and simplification of expressions and equations involving fractional and negative exponents	1	1	1	0

APPENDIX C

MEMBERS, WEST VIRGINIA MATHEMATICS TASK FORCE

Barbara Crist	Associate Professor of Math/Computer Science, WVU Institute of Technology
Elizabeth W. Frye, Chair	Professor of Mathematics, Fairmont State College
Murrel Hoover	Program Coordinator, Project MERIT, WVDE
Suda Kunyosying	Mathematics Department, Shepherd College
Larry Lamb	Mathematics Coordinator, WVDE
Robert Mayes	Director, Institute for Math Learning, Mathematics Department, West Virginia University
Carol Perry	Director, General Studies Division Marshall University Community & Technical College
Laura Pyzdrowski	Assistant Professor of Mathematics, West Virginia University
Judith A. Silver	Interim Head, Division of Mathematics & Applied Science, Marshall University
Mark W. Stotler	Assistant Director of Academic Affairs, WV Higher Education Policy Commission

VOLUNTEER MATHEMATICS TASK FORCE MEMBERS

Wayne Akey	Mathematics Department, West Virginia State College
Judy E. Carney	Assistant Professor of Mathematics, West Liberty State College
Mark Goldstein	Mathematics Department, WV Northern Community College
Victor Hughes, III	Mathematics Department, Shepherd College
Huey Miin Lee	Math and Technology Department, Salem International University

Lucie T. Refsland	Mathematics Department, Bluefield State College, Greenbrier Community College Center
Melinda Sanders	Assistant Professor of Mathematics, Southern WV Community and Technical College

APPENDIX D

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