Mathematics Department

Millersville University

Master of Education in Mathematics (M.Ed.)

MASTER OF EDUCATION DEGREE IN MATHEMATICS

Contents

1. Introduction 3
- a. Millersville University
- b. The Mathematics Department
- c. The Field of Mathematics Education
  - Two-Year College Instructor
  - College or University Professor
  - Mathematics Education Researcher
  - Administrator or Supervisor in Mathematics Education

2. The M.Ed. in Mathematics Program at MU 5
- A. Objectives of the Program
- B. Admission Requirements – University Level
- C. Admission Requirements – Mathematics Department Level
- D. Application Procedure
- E. Additional Requirements
- F. Course of Study – Including an Overview of Courses 7
  - I. Mathematics Proficiency
  - II. Professional Core
  - III. Mathematics Courses
  - IV. Mathematics Education Courses
  - V. Degree qualifying review
  - VI. Final options (thesis vs. non-thesis)

3. Course Descriptions
- A. Mathematics 11
- B. Mathematics Education 14

4. Sample Programs of Study 17

5. Planning Guides 18

6. Graduate Faculty Listing 20

1. INTRODUCTION

a. Millersville University

Rated one of the finest regional universities in the country by US News and World Report, Millersville University has a tradition of graduate education that dates back nearly half a century. Established in 1855 as the Commonwealth's first normal school, Millersville University is one of the fourteen institutions in the Pennsylvania State System of Higher Education.

A multi-purpose university situated on a 250-acre campus, Millersville blends the spirit of innovation with the strength of tradition in academic and professional programs that serve a diverse regional population. The campus reflects a combination of the old and the new, with beautiful Victorian buildings and state-of-the-art research labs and technology centers.

The graduate enrollment includes students from numerous states and several foreign countries. Many graduate students are engaged in or intend to pursue careers in teaching, while others have achieved success in varying professions. Millersville University graduates have gone on to distinction at doctoral programs in the nation's finest universities. The Graduate Student Association represents the academic and social interests of the graduate student population.

b. The Department

The diverse backgrounds of the faculty in the Department of Mathematics at Millersville University allows candidates for the M.Ed. in Mathematics to gain a broad perspective or to focus on a specific area. Currently represented among the twenty-one full-time faculty members are four mathematics educators, four statisticians, four applied mathematics and nine pure mathematicians with varying specialties including (but not limited to) graph theory, discrete mathematics, analysis, algebra, algebraic topology, operator theory, algebraic geometry, and number theory.

c. The Field of Mathematics Education

Secondary School Teacher (Senior High, Junior High, or Middle School)

Teaching mathematics can be an exciting and rewarding career. Over the years, Millersville University has developed an outstanding reputation throughout its service area, and beyond, for its strong program of preparing secondary school mathematics teachers. Graduates of our BSE program in Mathematics Education hold responsible positions in many senior high, junior high, and middle schools located over a wide region. The primary mission of the M.Ed. program is the strengthening of area mathematics teachers' backgrounds. The M.Ed. in Mathematics at Millersville University is intended to broaden teachers' mathematical content and pedagogical knowledge through a wide range of courses in mathematics and mathematics education. A variety of offerings allows educators to concentrate in a specific area of interest or in areas not yet mastered. Since the program is primarily comprised of practicing mathematics teachers, class discussion and content often connect with their experience as secondary mathematics teachers. Courses in mathematics education

include (but are not limited to) problem solving strategies, issues and trends in secondary education, mathematical modeling, assessment strategies, the use of technology, advanced perspectives on teaching, and the teaching of Advanced Placement calculus. Additional opportunities to explore specific interests are available through individualized instruction.

Two-Year College Instructor

The essential criterion for employment as an instructor at a two-year college is a Master's degree in mathematics or mathematics education. In many community colleges, the mathematics courses are largely remedial for students who need to learn (or re-learn) elementary mathematics before going on to college-level courses. Because of the wide variety of student backgrounds and abilities, many experimental, individualized and non-traditional teaching techniques are often used. This may be one of the most fascinating aspects of the job. Teaching loads tend to be lighter than in secondary schools but heavier than in four-year colleges. Upon completion of the M.Ed. in Mathematics, candidates may be more marketable as a full-time or adjunct faculty member at a two-year college.

Four Year College or University Professor and/or Researcher

For a mathematics educator whose goal is to teach at the university level, or to pursue research in mathematics or mathematics education, a PhD in mathematics or mathematics education is essential. For an educator who wants to pursue a PhD in mathematics education, the M.Ed. program at Millersville provides coursework to enable that transition. Focusing on a blend of mathematics content and pedagogy, candidates for the M.Ed. degree will also be able to determine an initial area of interest that may be pursued further in a doctorate program. A professor of mathematics education at a major research-oriented university spends roughly half of his/her time in tasks related to teaching and the other half in mathematics education research. In recent years, the demand for PhD mathematics educators has far exceeded the supply – particularly for candidates with strong mathematics backgrounds and a variety of teaching experiences (including at the secondary level). By completing the M.Ed. thesis option, candidates will find themselves well-prepared for the rigors of a doctoral program in Mathematics Education.

Administration/Supervision

For mathematics educators desiring to work as an administrator or supervisor in mathematics within a local school district, an M.Ed. in mathematics education provides a balance of mathematical content and sound educational practices. In recent years, National and State Standards as well as High-Stakes Assessment has increased the demand for strong leadership in mathematics within local school districts.

2. THE MASTER of EDUCATION in MATHEMATICS PROGRAM at MILLERSVILLE UNIVERSITY

A. OBJECTIVES

The major strength of the M.Ed. program in Mathematics at Millersville University is the balance of mathematics content and pedagogy. Since undergraduate programs in mathematics education vary greatly, one goal of the M.Ed. is to enhance candidates' mathematical content knowledge. Additionally, the program offers a variety of mathematics education courses that allow graduate students to investigate the nature, teaching, and learning of mathematics and to apply this immediately in their own mathematics classrooms.

B. ADMISSION REQUIREMENTS – UNIVERSITY LEVEL

Admission to a graduate program is granted without regard to race, color, national origin, sex, or religious creed, but with regard to ability reflected in a record sufficiently strong to support confidence that the applicant can participate effectively in the graduate community and creditably complete the program of study for which application is made.

ADMISSION TO A MASTER'S DEGREE PROGRAM

Admission decisions are based upon a combination of factors that include: grade point average, letters of recommendation from those able to critically assess an applicant's ability to succeed in a graduate program, a written statement of purpose, standardized test scores, academic preparation for work in the proposed field, the applicant's interests as matched with those of faculty, and where appropriate, a successful interview. (*An interview is not required for admission to the M.Ed. in Mathematics Education.*)

REGULAR ADMISSION

To be eligible for regular admission, an applicant must have earned a bachelor's degree from an accredited four-year college or university in the United States or equivalent from a similar institution abroad. The applicant must demonstrate, in the opinion of the faculty and the dean of graduate studies, the ability to successfully complete a master's degree, and must have achieved at least a 2.75 undergraduate grade point average in all coursework attempted (unless otherwise specified by the academic program).

PROBATIONAL ADMISSION

Applicants who do not meet the minimum admission requirements, but who show promise of success in a graduate program, will be considered for admission. Such applicants may be admitted on a probational status, based on the departmental recommendation and a favorable review by the Dean of Graduate and Professional Studies. Applicants admitted on probational status will have conditions clearly stipulated in an offer of admission letter. Upon satisfying the probational conditions – and with the favorable recommendation of the department and with the graduate dean's concurrence, the student will be fully admitted and allowed to continue toward degree candidacy. If the student is unable to achieve a 3.0 graduate point average, he/she will be dismissed from the program.

C. ADMISSION REQUIREMENTS – MATHEMATICS DEPARTMENT LEVEL

Admission to the M.Ed. program in mathematics education is granted to those applicants whose mathematical preparation fulfills the mathematical proficiency requirement (see I below). This is usually accomplished through the successful completion of a rigorous course of study culminating in the awarding of a Bachelor's degree in mathematics. Conditional admission is granted to those applicants who have satisfactorily completed the following MU undergraduate mathematics courses or their equivalents: MATH 161, 211, 311 (Calculus I, II, and III) and MATH 322 (Linear Algebra). Such persons are granted full admission status upon fulfillment of the mathematical proficiency requirement.

D. APPLICATION PROCEDURE

Prospective students may apply electronically by visiting the Millersville graduate website at www.millersville.edu/admissions/graduate. For an application to be considered complete, the following must be submitted:

1. A nonrefundable application fee of $40 payable at the time of filing application *(application fee may be paid by check, money order, American Express, Master-Card, or Discover. Check or money order should be made payable to Millersville University; the expiration date must accompany credit card number).*
2. One official copy of an undergraduate transcript and official transcripts of any previous graduate work *(it is not necessary to send Millersville University transcripts.)*
3. Three letters of recommendation written by professors or others capable of assessing the applicant's potential for success in a graduate program.
4. A written statement of academic and professional goals.
5. An official score report on the Miller Analogies Test (MAT) or the Graduate Record Examination (GRE).
6. Applications are accepted throughout the year utilizing a system of rolling admissions to the program.
7. Admission to master's degree programs is contingent on the recommendation of the department in which the student proposes to study. After reviewing the application and supporting materials, the department may recommend regular or probational admission to a degree program. If the department recommends probational admission, the conditions shall be clearly stipulated. In either case, the applicant will be notified of admission status by the Office of Graduate Studies.
8. Upon admission, an applicant may be notified by the Department of Mathematics he/she will need to complete one or more of five required demonstrated proficiencies in order to complete the program. At most two of these proficiencies can be counted as part of the M.Ed. in Mathematics Education program.

E. ADDITIONAL REQUIREMENTS

1. To fulfill residency requirements, students must complete a minimum of two-thirds of their graduate degree or certification program at Millersville University.
2. Work toward the degree may be distributed over a maximum of five-years. The five-year period begins the semester a student is accepted into a degree program. A re-evaluation of course work taken prior to admission to a degree program and an extension of time, usually an additional year, beyond this five-year limit may be granted by the dean of graduate studies and research, at the request of the student, upon the recommendation of the adviser and graduate program coordinator.

F. COURSE OF STUDY

I. Mathematical Proficiency

Demonstrated proficiency in each of five areas of mathematics is required for the completion of the degree. Students who enter the program having earned a grade of A or B in the following undergraduate courses (or their equivalent) are considered to have met this requirement:

MATH 333 Introduction to Probability and Statistics
MATH 322 Linear Algebra I
MATH 345 Abstract Algebra I
MATH 464 Real Analysis I

and

One of the following:
MATH 353 Survey of Geometry or
MATH 355 Transformational Geometry

Students who are not proficient in one or more of these areas must complete the corresponding 50X course(s) with grade(s) of B- or higher by the completion of the degree. At most 6 of these credits may be applied towards the M.Ed. degree per guidelines in block III below. Note that only one of the two undergraduate Geometry courses (MATH 355) has a corresponding 50X course. Graduate students who wish to study the material in MATH 353 for graduate credit must request special permission to do so.

II. Professional Core (9 semester hours minimum required)

1. EDFN 601 Methods of Research (3) – MATH 535 may be substituted for EDFN 601

and

2. One of the following:
   - PSYC 525 Advanced Developmental Psychology (3)
   - PSYC 526 Advanced Adolescent Psychology (3)
   - EDFN 545 Advanced Educational Psychology (3)
   - PSYC 625 Human Growth and Development (3)

and

3. One of the following:
   - EDFN 511 Comparative Education (3)
   - EDFN 590 Social Foundations of Education (3)
   - EDFN 603 Philosophy of Education (3)
   - EDFN 604 Education and Public Policy (3)

III. Mathematics courses (12 semester hours minimum required)

Four (4) of the following; at least two (2) of which must be numbered 510 or higher:

MATH 502 Linear Algebra for Teachers (4)
MATH 503 Probability and Statistics for Teachers (4)
MATH 504 Modern Algebra for Teachers (3)
MATH 505 Transformational Geometry for Teachers (3)
MATH 506 Modern Analysis for Teachers (3)
MATH 520 Logic and the Foundations of Mathematics (3)
MATH 525 Axiomatic Development of Number Systems (3)
MATH 535 Statistical Methods I (3)
MATH 536 Statistical Methods II (3)
MATH 566 Complex Variables (3)
MATH 577 Problems in Applied Mathematics (3)
MATH 592 Graph Theory (3)
MATH 642 Linear Algebra (3)
MATH 645 Abstract Algebra (3)
MATH 650 Topics in Geometry (3)
MATH 664 Real Variables (3)
MATH 670 Operations Research (3)
MATH 675 Numerical Analysis (3)
MATH 683 Topology (3)
MATH 691 Combinatorics (3)
MATH 693 Number Theory (3)
MATH 695 Topics in Mathematics (3)
MATH 696 Independent Study in Mathematics (1-3)

NOTES:
(a) MATH 535 may not be double-counted under blocks II and III.

(b) Credits earned in 50X-numbered courses may be applied in block III provided the student earns a grade of A or B.

(c) Students may elect MATH 695 or 696 more than once, provided that the topics are different.

IV. Mathematics Education Courses (9 semester hours minimum required)

Three (3) of the following:

MATH 603 Equity Issues in Mathematics Education (3)
MATH 603 History of Mathematics (3)
MATH 606 Transitioning to the First Year in a High-Needs School District (3)
MATH 607 Moving to Tenure (3)
MATH 610 Problem Solving Seminar (3)
MATH 611 Psychology of Learning Mathematics (3)
MATH 612 Diagnostic and Prescriptive Mathematics (3)
MATH 614 Current Issues in Middle School Mathematics (3)
MATH 615 Current Issues in Secondary School Mathematics (3)
MATH 616 Teaching Advanced Placement (AP) Calculus in Secondary School (3)
MATH 617 Curricular Innovations in Middle & Secondary School Mathematics (3)
MATH 618 Assessment in the 7-12 Mathematics Classroom (3)
MATH 619 Advanced Perspectives for Teaching High School Mathematics (3)
MATH 622 Teaching Mathematics in the 21st Century (3)
MATH 672 Mathematical Modeling in the Secondary School Curriculum (3)
MATH 679 Using Technology in Secondary School Mathematics (3)
MATH 690 Topics in Discrete Mathematics for Teachers (3)
MATH 697 Topics in Mathematics Education (3)
MATH 698 Independent Study in Mathematics Education (1-3)

NOTE: Students may elect MATH 697 or 698 more than once, provided that the topics are different.

V. Degree Qualifying Review – Degree Candidacy

Degree candidacy will be granted to those students who have completed at least 24 semester hours of course work toward the program with B- or higher, and an overall GPA of at least 3.0.

VI. Final Options (Select One)

1. Non-Thesis (6 semester hours minimum required) Elect two (2) courses offered by the department at the 510 level or higher. The minimum course requirement for the degree with this option is 36 semester hours.
   - *NOTE: MATH 535 may not be double-counted in categories II and VI.*

2. Thesis (3 semester hours minimum required):
   MATH 699 Thesis
   - *NOTE: The minimum course requirement for the M.Ed. in Mathematics Education with this option is 30 semester hours plus thesis (3 or more credits).*

VII. **Additional Program Requirements**

_____ 1. Required Field Experience

Thesis _____; or

Research Project in Math Educ _____.

_____ 2. Required Capstone

Thesis _____; or

Comprehensive Oral Presentation _____.

3. COURSE DESCRIPTIONS – GRADUATE-LEVEL MATHEMATICS COURSES

a. *MATHEMATICS COURSES*

MATH 502 Linear Algebra for Teachers (4)
Systems of linear equations, matrix algebra, and determinants; real vector spaces, linear independence, basis and dimension; real inner product spaces, Gram-Schmidt orthogonalization; eigen theory and diagonalization; linear transformations and matrix representation.

MATH 503 Probability and Statistics for Teachers (4)
A rigorous one-semester study of probability, distribution theory and the basics of statistical inference. Topics include probability, expectation, discrete and continuous distributions, descriptive statistics and both estimation and hypothesis testing for one and two-sample problems.

MATH 504 Modern Algebra for Teachers (3)
Algebraic properties of complex number systems, set theory, groups, rings, integral domains and fields.

MATH 505 Transformational Geometry for Teachers (3)
Study of the real Euclidean plane in the spirit of Felix Kline: Geometry is the study of those properties left invariant under a group of transformations. Motions, similarities, affinities, projectivities. Offered in spring and periodically in summer.

MATH 506 Modern Analysis for Teachers (3)
Real number system, limits of sequences and functions, theory of differentiation, Reimann integration, infinite series.

MATH 520 Logic and the Foundations of Mathematics (3)
Theory of inference, symbolic logic, nature of axiom systems, validity of proofs, consistency, independence, completeness, theory of sets and cardinal numbers.

MATH 525 Axiomatic Development of Number Systems (3)
Axiomatic development of the real and complex number systems. Peano postulates, natural numbers, integers, rational numbers. Cauchy sequences and Dedekind cuts, real numbers, complex numbers. Offered infrequently.

MATH 535 Statistical Methods I (3)
Survey of statistical methods used in research, education, behavioral science and biomedical applications. Experimental designs discussed regarding advantages, disadvantages, sampling problems and analysis. Regression and analysis of variance. Prereq: An elementary probability or statistics course. Offered in fall and periodically in summer.

MATH 536 Statistical Methods II (3)
Continuation and extension of statistical methods introduced in Statistical Methods I (Math 535). Advanced topics in analysis of variance, randomized block designs and experimental designs. Prereq: Math 535 or permission of instructor. Offered in spring.

MATH 537 Statistical Problem Solving Seminar (1)
Capstone course designed to serve as outcome assessment for math majors enrolled in statistics option. Course involves problem solving, data analysis and statistical consulting. Materials drawn from real-world problems. Prereq: Math 535. Coreq: Math 536. Offered in spring.

MATH 566 Complex Variables (3)
Complex number system, analytic functions, elementary functions, contour integration, residues and poles, conformal mapping. Prereq: MATH 506 or equivalent. Offered infrequently.

MATH 577 Problems in Applied Mathematics (3)

An investigation of one or more topics of current interest in applied mathematics. Specific topics to be covered vary, but are announced each time the course is offered. Offered infrequently.

MATH 592 Graph Theory (3)

Finite graphs, multigraphs, digraphs, and networks from theoretical, practical and historical perspectives. Specific topics include isomorphisms, graph variants, planarity and nonplanarity, traversability, colorings, flows, matchings and optimization algorithms.

Prereq: MATH 502 or equivalent. Offered periodically.

MATH 642 Linear Algebra (3)

Vector spaces, linear transformations, matrices, systems of equations, determinants. Prereq: MATH 502 or equivalent. Offered infrequently.

MATH 645 Abstract Algebra (3)

Extended development of groups, rings and fields initiated in MATH 504. Prereq: MATH 504 or equivalent. Offered infrequently.

MATH 650 Topics in Geometry (3)

Topics selected from: the parallel postulate and models for Euclidean and non-Euclidean geometries; projective geometry; local geometry of smooth space curves; geometry of smooth surfaces in space; geometry of space-time; finite geometries; representation of a geometry as a group of transformations acting on a set. Prereq: Teaching experience or permission of instructor. Offered infrequently.

MATH 664 Real Variables (3)

Metric spaces, completeness, limits and continuity, compactness and connectedness, uniform continuity, derivative and integral, sequences and series of functions, uniform convergence. Prereq: MATH 502 and MATH 506 or equivalent. Offered infrequently.

MATH 670 Operations Research (3)

Principles of model building; examples from linear optimization, network analysis, dynamic programming, probabilistic decision theory, Markov chains, queuing theory, simulation and inventory models. Applications and theory. Prereq: Linear Algebra and a statistics course, or equivalent. Offered periodically.

MATH 675 Numerical Analysis (3)

Numerical treatment of equations, matrices and systems of equations. Interpolation and approximation by polynomials. Numerical integration. Method of Least Squares. Prereq: MATH 502 and MATH 506 or equivalent. Offered in fall.

MATH 683 General Topology (3)

Set theory, metric and topological spaces, cluster points, closure, interior and boundary, continuity, homeomorphisms, product and quotient spaces, separation, compactness, connectedness, completeness. Prereq: MATH 502, 504, and 506. Offered infrequently.

MATH 691 Combinatorics (3)

Counting techniques including the multiplication principle, the addition principle, the pigeon-hole principle, permutations, combinations, the principle of inclusion-exclusion, recurrence relations, generating functions and Polya's Theory of Enumeration.

Prereq: MATH 502 or equivalent. Offered periodically.

MATH 693 Number Theory (3)

The classic higher arithmetic of integers: mathematical induction, divisibility, congruences, prime numbers, diophantine equations. Euler-Fermat Theorem and quadratic reciprocity. Offered periodically.

MATH 695 Topics in Mathematics (3)

Investigation of one or more mathematical topics of current interest not covered in regular courses. Topics and methods of instruction may vary according to the needs and interests of students and faculty involved. Offered infrequently.

Sample of recent offerings of MATH 695:

- Nonlinear Dynamical Systems (2009)

Dynamical systems model the time evolution of systems. Examples are abundant in physics, biology, and chemistry as well as social sciences. This course will mainly focus on dynamical systems induced by (mostly, nonlinear) ordinary differential equations. We will start with one dimensional problems and move on to the (elegant) theory of two dimensional dynamical systems. Topics covered include phase plane analysis, stability theory, bifurcation analysis, and the Poincaré-Bendixson theory (2-dimensional case). This will be followed by an introduction to modern topics such as chaotic dynamics and strange attractors. The mathematical treatment will be friendly and informal. Most of the ideas and results will be motivated and demonstrated by a combination of geometric intuition (including computer aided graphics) and concrete examples. Application to various fields of sciences will be emphasized.

- Cryptography (2007, 2010, 2012)

Cryptography is the science of using mathematics to encrypt and decrypt data. Cryptography enables us to store sensitive information or transmit it across insecure networks (like the Internet) so that it cannot be read by anyone except the intended recipient. This course will introduce students to the art of confidential communications, the basic mathematical background for cryptography in number theory, modern algebra, probability and statistics, the Data Encryption Standard, the basic public key cryptosystems, the complexity of performing code encryption and decryption, and the basic skills making and breaking codes using public key cryptosystems.

- Financial Mathematics (2005)

The objectives of this course include introducing the students to the mathematical treatment of risk-neutral valuation, arbitrage, options, futures, and derivatives. One of the main mathematical results to be covered is the derivation, understanding, and use of the Black-Scholes formula for pricing options. A comparison of the assumptions underlying this pricing model and actual financial markets will be made to understand the utility and limitations of the Black-Scholes formula.

- Discrete Dynamical Systems (2004)

This course is an introduction to discrete dynamical systems. Topics include the qualitative behavior of orbits, graphical analysis, fixed points and periodic points, bifurcations, the quadratic family of maps, symbolic dynamics, chaos.theory and fractals. The material will be presented in an intuitive and friendly way with a combination of theory and computer experiments.

MATH 696 Independent Study in Mathematics (1-3) Selected topics. Prereq: Permission of chairperson. Offered infrequently.

b. *MATHEMATICS EDUCATION COURSES*

MATH 602 Equity Issues in Mathematics Education (3)
This course is designed for students with an interest in equity issues in mathematics education. In this course, we examine issues of equity in mathematics education from various theoretical and practical perspectives and along lines of race, gender, culture, and socioeconomic status. It is a reading-intensive course that spans such topics as the achievement gap, tracking, culturally-relevant pedagogy, multiculturalism, the nature of mathematics, and mathematics for democracy and social justice. Course assignments primarily involve presentations, discussions, writing, problem solving, and problem posing. Some assignments will be differentiated to ensure they are relevant to the concerns of both practicing teachers as well as students without a teaching background that intend to pursue further graduate study. Offered periodically.

MATH 603 History of Mathematics (3)
Evolution of mathematical concepts from antiquity to the present century. Emphasis on eras of great mathematical activity. Offered every fall and spring semester.

MATH 606 Transitioning to the First Year in a High-Needs School District (3)
Intended to address topics and concerns relevant to recently-certified secondary mathematics teachers from the MU Noyce program as they transition to their first year of teaching in a high-needs school district. Through readings, class discussions, individual presentations, and written assignments, participants reflect on their student teaching experiences, further explore challenges of working with diverse groups of students, and develop strategies to increase their effectiveness as a teacher in the context of a high-needs district.

MATH 607 Moving to Tenure (3)
MATH 607 is intended as an extension to MATH 606 and meant to address topics and concerns relevant to recently-certified NOYCE secondary mathematics teachers as they complete their first year of teaching in a high-needs school district. Through readings, class discussions, individual presentations, and written assignments, participants reflect on their experiences during the first year of teaching, further explore challenges of working with diverse groups of students, and develop strategies to increase their effectiveness as a teacher in the context of a high-needs district.

MATH 610 Problem Solving Seminar (3)
Develops students' problem-solving abilities in mathematics and teaching of problem-solving to high school students. Includes discussion of solutions to problems and the theories of problem-solving. For both teachers and non-teachers. Offered periodically.

MATH 611 The Psychology of Learning Mathematics (3)
Investigation of the learning theory of constructivism and its application to the learning of mathematics. Emphasis on higher order concept acquisition and schema development, and their relationship to mathematical instruction and teacher decision making. Individual differences in learning styles are also discussed. Prereq: Teaching experience or permission of the instructor. Offered periodically.

MATH 612 Diagnostic/Prescriptive Teaching of Mathematics (3)
Will develop expertise in diagnostic techniques to enable mathematics educators to use appropriate activities, strategies, and materials for effective instruction in mathematics. For elementary school, middle school, special education, high school general mathematics, and Chapter 1 teachers, administrators and supervisors. Prereq: Teaching experience or permission of instructor. Offered infrequently.

MATH 614 Current Issues in Middle School Mathematics (3)
Current issues relating to middle school mathematics instruction, including issues associated with teaching strategies as well as curricular issues. Central to this discussion will be the NCTM's Principles and

Standards for School Mathematics and the PA Academic Standards for Mathematics. Prereq: Teaching experience or permission of the instructor. Offered periodically.

MATH 615 Current Issues in Secondary School Mathematics (3)

Current issues relating to secondary school mathematics instruction, including issues associated with teaching strategies as well as curricular issues. Central to this discussion will be the NCTM's Principles and Standards for School Mathematics and the PA Academic Standards for Mathematics. Prereq: Teaching experience or permission of the instructor. Offered periodically.

MATH 616 Teaching Advanced Placement (AP) Calculus in the Secondary School (3)

Current issues associated with the teaching of Advanced Placement calculus in the secondary school, including issues associated with teaching strategies as well as curricular issues. Central to this discussion will be the College Board publications on the AP calculus curriculum, AP calculus exams, and the use of technology in the AP calculus classroom. Prereq: Teaching experience or permission of instructor. Offered periodically.

MATH 617 Curricular Innovations in Middle and Secondary School Mathematics (3)

Current curricular issues and teaching strategies associated with educational innovations that are invariant with respect to the middle school-secondary school boundary. Central to this discussion will be the NCTM's Principles and Standards for School Mathematics and the PA Academic Standards for Mathematics. Prereq: Teaching experience or permission of the instructor. Offered periodically.

MATH 618 Assessment in the 7-12 Mathematics Classroom

A course for secondary mathematics teachers who wish to explore the nature of the mathematics assessment from a variety of perspectives. The course will examine traditional and non-traditional forms of assessment as well as the purpose of formative and summative assessments – allowing for discussion of the pros and cons to each. The course will also examine the impact of assessment tools on individual classroom instruction as well as within local departments, schools, districts, states and national education issues. The course will seek to actively involve teachers in a productive dialogue about the mathematics that they teach and explore a variety of levels at which the mathematics can be assessed. In order to do this, it will be necessary at times to expand and explore K-16 mathematics assessment at some length. Offered periodically.

MATH 619 Advanced Perspectives for Teaching High School Mathematics

A course for secondary mathematics teachers at the middle or high school level who wish to explore the nature of the mathematics that they teach from a different viewpoint. The course will look at typical secondary mathematics topics including the real number system, polynomials, number theory, trigonometry and Euclidean geometry while examining concept analysis, problem analysis and mathematical connections. The course will actively involve in-service and pre-service teachers in a productive dialogue about the mathematics that they teach, and potential developmental or extensions that could be put into practice at each level. The class will also explore a variety of levels at which it may be appropriate to address these issues with their own students. Offered periodically.

MATH 622 Teaching Mathematics in the 21st Century

The intent of the course is to examine, study, and analyze teaching techniques and alternate approaches to teaching and learning mathematics in the 21st century. Students will experiment with a variety of pedagogies that are more in-line with the way in which 21st century students live rather than how they are often taught. Comparisons of multiple pedagogies (current, past and potential future) will be frequently made and discussed. Offered periodically.

MATH 672 Mathematical Modeling in the Secondary School Curriculum (3)

Investigation of the process of mathematical modeling. Creative and empirical model construction, model analysis and model research. Problems taken from a variety of disciplines. Some problems suitable for

algebra and geometry students, others require some knowledge of calculus and statistics. Prereq: MATH 502 or its equivalent. Offered periodically.

MATH 679 Technology in the Secondary Mathematics Classroom (3)
Introduction to technologies currently available for teaching secondary mathematics. Emphasis on the use of modern graphics calculators, although computer software is also presented. Capabilities of the technologies examined in depth, but emphasis will be on the use of this technology in the classroom. Mathematical topics selected from elementary algebra, geometry, algebra II, precalculus and calculus. Prereq: Secondary teaching experience. Offered periodically.

MATH 690 Topics in Discrete Mathematics for Teachers (3)
Provides high school mathematics teachers a variety of situations and problems requiring ideas and solutions from discrete mathematics. Includes problems represented by finite graphs, digraphs or networks; recurrence relations; matrices and generating functions. Solutions involve developing and understanding algorithms and inductive reasoning. Integrating discrete mathematics topics into the curriculum is emphasized. Prereq: MATH 502 or equivalent. Offered periodically.

MATH 697 Topics in Mathematics Education (3)
Investigation of one or more topics of current concern in mathematics education not covered in regular courses. Course content varies according to the needs and interests of students and faculty involved. Offered periodically.

Sample of recent offerings of MATH 697*:*

- Teaching AP Mathematics (2017)

The intent of the course is to examine, study, and analyze teaching techniques and alternate approaches to teaching Advanced Placement Mathematics. The course will focus on the pedagogy, objectives, and exam expectations for AP Calculus and AP Statistics courses. Content for each course will be broadly covered as it relates to the specific pedagogy employed by the participants. Projects and course activity will be developed to meet the needs, interest and experience of course participants. Each participant will be able to focus (if desired) on either calculus or statistics topics.

- Development and Use of Manipulative Materials in Teaching Mathematics (2012)

This course is devoted to the role of manipulative materials in promoting mathematics learning. A philosophy of using manipulatives is developed and integrated with a range of experiences proven effective in helping students learn mathematics. The topics and materials will range from primary to middle grades to secondary mathematics.

- Proportional Reasoning (2010, 2015)

Proportional reasoning is one of the fundamental reasoning skills which connects mathematical ideas from the upper elementary grades through high school and occurs across several topics in the mathematics curriculum. This course examines current research development of proportional reasoning from upper elementary grades through high school. In addition, the course explores the presence of proportional reasoning across a broad range of mathematics topics [e.g. ratios, rates, percent, linear functions, similar figures, probability, etc].

MATH 698 Independent Study in Mathematics Education (1-3)
Selected topics. Prereq: Permission of chairperson.

MATH 699 Thesis (3+)
Enroll as needed for completion of thesis. Minimum of three credits is needed for successful completion of any thesis.

4. SAMPLE PROGRAMS

Most students enrolled in the Master of Education in Mathematics Program at Millersville University complete the majority of their course-work during the summer months. Currently, there are three summer sessions. Two or three graduate courses in mathematics or mathematics education are typically offered during each of the sessions 2 and 3. The two outlines below indicate how one can complete the program over three consecutive summers. Graduate courses are also offered periodically in the evening during the Fall and Spring semesters, allowing for additional flexibility. Upon acceptance to the program, students are encouraged to sketch out a plan of study with their advisor.

Full-time Summer (3 years) – Non-thesis Option, 36 credits (proficiencies met on entry)

Year 1

Summer 2	Summer 3
MATH 502	MATH 505
EDFN 601 (MATH 535)	MATH 645

Year 2

Summer 2	Summer 3
MATH 670	MATH 603
EDFN 604	PSYC 525

Year 3

Summer 2	Summer 3
MATH 610	MATH 611
MATH 672	MATH 693

Full-time Summer (3 years) – Thesis Option, 30 credits (proficiencies met on entry)

Year 1

Summer 2	Summer 3
MATH 505	MATH 592
EDFN 601	MATH 645

Year 2

Summer 2	Summer 3
MATH 675	MATH 616
EDFN 511	EDFN 545
	Thesis planning

Year 3

Summer 2	Summer 3
MATH 679	MATH 699 (Thesis credits)
MATH 615	

Masters of Education in Mathematics (M.Ed.)

Major Sequence and Degree Requirements

Requirements: minimum 33-36 semester hours

I. Required Mathematics Proficiency

Demonstrated mathematical proficiency is required for the degree. Students who enter the program having earned at least a B- in the following undergraduate courses (or their equivalent) are considered to have met this requirement:

- _____ MATH 333 Introduction to Probability and Statistics
- _____ MATH 322 Linear Algebra I
- _____ MATH 345 Abstract Algebra I
- _____ MATH 464 Real Analysis I

and

- _____ MATH 353 Survey of Geometry

or

- _____ MATH 355 Transformational Geometry

II. Professional Core (3 courses)

1._____ EDFN 601 or _____ MATH 535

and

2.PSYC _____ or EDFN

and

3.EDFN _____.

III. Mathematics courses (minimum 4 courses)

At least 6 s.h. numbered 510 or higher:

MATH_____.

MATH_____.

MATH_____.

MATH_____.

NOTES*:*

- *MATH 535 may not be double-counted under blocks II, III, or VII.*
- *Credits earned in 50X-numbered courses may be applied in block III provided the student earns a grade of A or B.*
- *Students may elect MATH 695 or 696 more than once, provided that the topics are different.*

IV. Mathematics Education Courses (minimum 3 courses)

MATH_____.

MATH_____.

MATH_____.

NOTE*:*

- *Students may elect MATH 697 or 698 more than once, provided that the topics are different.*

V. Degree Qualifying Review

Degree candidacy will be granted to those students who have fulfilled the mathematics proficiency requirement and have completed at least 24 semester hours of course work at the 510 level or higher with grades of A or B, including one course from each of categories III and IV above.

VI. Final Options (Select One)

_____ Option 1. Non-Thesis (6 semester hours minimum required)

MATH_____.

MATH_____.

_____ Option 2. Thesis (3 semester hours minimum required)

_____ MATH 699 Thesis

VII. Additional Program Requirements

_____ 1. Required Field Experience

Thesis_____; or

Research Project in Math Educ_____.

_____ 2. Required Capstone

Thesis_____; or

Comprehensive Oral Presentation_____.

Courses Satisfying Requirements

I. Required Mathematics Proficiency

Demonstrated mathematical proficiency is required for the degree. Students who enter the program having earned a grade of A or B in the following undergraduate courses (or their equivalent) are considered to have met this requirement:

- MATH 333 Introduction to Probability and Statistics
- MATH 322 Linear Algebra I
- MATH 345 Abstract Algebra I
- MATH 464 Real Analysis I

and

- MATH 353 Survey of Geometry

or

- MATH 355 Transformational Geometry

II. Professional Core (3 courses)

1. EDFN 601: Methods of Research
   (Note: MATH 535 may be substituted for EDFN 601)

and

2. One of the following:
   - PSYC 525 : Advanced Developmental Psychology
   - PSYC 526: Advanced Adolescent Psychology
   - EDFN 545: Advanced Educational Psychology
   - PSYC 625: Human Growth and Development

and

3. One of the following:
   - EDFN 511: Comparative Education
   - EDFN 590: Social Foundations of Education
   - EDFN 603: Philosophy of Education
   - EDFN 604: Education and Public Policy

III. Mathematics courses (minimum 4 courses)

At least 6 s.h. numbered 510 or higher:

- MATH 502 Linear Algebra for Teachers
- MATH 503 Probability and Statistics for Teachers
- MATH 504 Modern Algebra for Teachers
- MATH 505 Transformational Geometry for Teachers
- MATH 506 Modern Analysis for Teachers
- MATH 520 Logic and the Foundations of Mathematics
- MATH 525 Axiomatic Development of Number Systems
- MATH 535 Statistical Methods I
- MATH 536 Statistical Methods II
- MATH 566 Complex Variables
- MATH 577 Problems in Applied Mathematics
- MATH 592 Graph Theory
- MATH 642 Linear Algebra
- MATH 645 Abstract Algebra
- MATH 650 Topics in Geometry
- MATH 664 Real Variables
- MATH 670 Operations Research
- MATH 675 Numerical Analysis
- MATH 683 Topology
- MATH 691 Combinatorics
- MATH 693 Number Theory
- MATH 695 Topics in Mathematics
- MATH 696 Independent Study in Mathematics

IV. Mathematics Education Courses (minimum 3 courses)

- MATH 602 Equity Issues in Mathematics Education
- MATH 603 History of Mathematics
- MATH 606 Transitioning to Tenure
- MATH 610 Problem Solving Seminar
- MATH 611 Psychology of Learning Mathematics
- MATH 612 Diagnostic and Prescriptive Mathematics
- MATH 614 Current Issues in Middle School Mathematics
- MATH 615 Current Issues in Secondary School Mathematics
- MATH 616 Teaching Advanced Placement (AP) Calculus in Secondary School
- MATH 617 Curricular Innovations in Middle & Secondary School Mathematics
- MATH 618 Assessment in the 7-12 Mathematics Classroom
- MATH 619 Advanced Perspectives for Teaching High School Mathematics
- MATH 622 Teaching Math in the 21st Century
- MATH 672 Mathematical Modeling in the Secondary School Curriculum
- MATH 679 Using Technology in Secondary School Mathematics
- MATH 690 Topics in Discrete Mathematics for Teachers
- MATH 697 Topics in Mathematics Education
- MATH 698 Independent Study in Mathematics Education (1-3s.h.)

6. GRADUATE FACULTY

Schultz, Delray J. (Department Chairperson).

Ph.D., Temple University, 1992. Statistics, Operations Research.

White, Janet A. (Assistant Department Chairperson).

Ph.D., American University, 2002. Mathematics Education.

Washington, Tyrone (Graduate Program Coordinator)

Ph.D., North Carolina State University, 2012. Mathematics Education.

Blum, Dorothee J. Ph.D., Virginia Polytechnic Institute and State University, 1982.

Discrete Mathematics, Graph Theory, Combinatorics.

Buchanan, J. Robert. Ph.D., North Carolina State University, 1993. Applied Mathematics.

Cardwell, Antonia E. Ph.D., Kent State University, 2005. Analysis.

Catepillán, Ximena. Ph.D., University of Iowa, 1991. Operator Theory.

Fenwick, James W. Ph.D., University of Wyoming, 1985. Statistics.

Han, Zhigang. Ph.D., Stony Brook University, 2006. Geometry, Topology.

Heitmann, Noel F. Ph.D., University of Pittsburgh, 2003. Applied Mathematics.

Ikenaga, Bruce M. Ph.D., Cornell University, 1982. Algebra.

Ma Baoling. Ph.D., University of Louisiana-Lafayette 2012, Applied Mathematics.

Moss, Erin R. Ph.D., Purdue University, 2009. Mathematics Education.

Robinson, Kevin S. Ph.D., University of Florida, 2000. Applied/Industrial Statistics.

Sell, Elizabeth. Ph.D., University of North Carolina – Chapel Hill, 2007. Algebraic Geometry.

Shao, Zhoude. Ph.D., University of Minnesota, 1994. Applied Mathematics.

Shoemaker, Lewis H. Ph.D., Pennsylvania State University, 1980. Statistics.

Taylor, Cynthia E. Ph.D., University of Missouri, 2011. Mathematics Education.

Umble, Ronald N. Ph.D., University of North Carolina – Chapel Hill, 1983. Algebraic Topology.

Wismer, Michael G. Ph.D., University of Delaware, 1996. Curriculum and Instruction (Mathematics Education).

Zhan, Mingquan. Ph.D., West Virginia University, 2003. Graph Theory, Matroid Theory.