History (3) Investigation of a particular topic, problem, or issue in United States history, European history, or the history of the Atlantic World, with emphasis on topics, specialties, and material not covered in other courses. Exact content will be announced before each offering.

A total of 9 credits may be earned, but no more than 3 in any one semester or term.

631 Studies in Early European History (3) Studies of selected problems in early European history with special attention to discussion of historiography and current trends in scholarship. Exact content will be announced before each offering.

632 Studies in Modern European History (3) Studies of selected problems in modern European history with special attention to discussion of historiography and current trends in scholarship. Exact content will be announced before each offering.

633 Special Topics in Comparative History (3) Investigation of topics, problems, and issues in comparative history with emphasis on topics, specialties, and material not covered in other courses and which cross traditional geographic and chronological boundaries. Special attention will be devoted to discussion of historiography and current trends in scholarship. Exact content will be announced before each offering.

A total of 6 credits may be earned, but no more than 3 in any one semester or term.

641 Studies in World History (3) Studies of selected problems in world history with special attention to discussion of historiography and current trends in scholarship. Exact content will be announced before each offering.

A total of 6 credits may be earned, but no more than 3 in any one semester or term.

650 Special Studies (1-6) Directed study of special problems by individuals or groups of students. Ordinarily not available until students have earned 12 graduate credits in history.

Prerequisite: permission of the department chairperson.

A total of 6 credits may be earned with permission of the department chairperson.

661 Seminar in Digital History (3) Explores the current and potential impact of digital media on the theory and practice of history. Students will examine significant digital history scholarship and study how digital tools and resources are enabling both new methods for analysis in traditional print scholarship and possibilities for new forms of scholarship. The seminar will culminate in the creation of an advanced digital research module on a topic in American, European, or world history.

SOCIAL STUDIES (SS)

650 Independent Study in Social Science Education (1-6) Directed study of special problems or research in social science education by individuals or groups of students. Topics to be investigated will be chosen after consultation with an instructor with special competence in the topic involved.

Prerequisite: permission of the department chairperson.

A total of 6 credits may be earned.

691 Teaching Social Studies Skills in Secondary Schools (3) Preparation for teaching social studies skills to meet individual and group needs. Emphasizes skills related to problem solving, critical thinking, reading and interpreting materials, using pictorial representations, and finding and using information.

692 Teaching Social Studies Skills in Junior High/Middle Schools (3) Preparation for teaching social studies skills to meet individual and group needs. Emphasizes skills related to problem solving, critical thinking, reading and interpreting materials, using pictorial representations, and finding and using information.

MATHEMATICAL SCIENCES

www.bsu.edu/math
Robert Bell Building 465, 765-285-8640

PROGRAMS

Master of arts (MA) in actuarial science, in mathematics, in mathematics education, post-secondary foundational mathematics teaching, and in statistics; master of science (MS) in mathematics and in statistics.

See the Science listing under the College of Sciences and Humanities, page 155, for the doctoral programs in science education and philosophy in environmental science.

MASTER OF ARTS IN ACTUARIAL SCIENCE, 30-33 credits

The master’s program in actuarial science provides training for careers that involve analyzing and solving financial, business, and social problems related to economic risk. The program includes course work that prepares students for the professional examinations given by the Society of Actuaries and the Casualty Actuarial Society.
Admission requirements

Applicants must meet the regular admission requirements of the Graduate School. It is also expected that students will have had three semesters of calculus, a course in linear algebra, at least one semester of probability and one semester of statistics.

Degree requirements

<table>
<thead>
<tr>
<th>PREFIX</th>
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<th>SHORT TITLE</th>
<th>CREDITS</th>
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</thead>
</table>
| Financial Mathematics, 3-4 credits
| MATH 551 | Mathematics of Finance (4)   | 3-4     |
|        |     | (Program advisor will approve 3-4 credit substitution in financial mathematics for students who have passed Exam FM.) |
| MATH 552 | Life Contingencies 1        | 4       |
| MATH 553 | Life Contingencies 2        | 4       |
| Probability, 3-4 credits
| MATH 620 | Probability and Random Vars (4) | 3-4     |
|        |     | (Program advisor will approve 600-level 3-4 credit substitution in probability/statistics for students who have passed Exam P.) |
| MATH 557 | Actuarial Models 1         | 4       |
| MATH 559 | Models in Financial Economics | 3       |
| MATH 692 | Actuarial Science Exit Survey | 0       |
| 3-8 credits from
| FIN 500 | Corporation Finance (3) |         |
| MATH 528 | Regression Time Series Models (3) |         |
| MATH 554 | Mathematics of Investments (3) |         |
| MATH 558 | Actuarial Models 2 (3) |         |
| MATH 621 | Theory of Statistics (4) |         |
| MATH 624 | Intro to Statistical Learning (3) |         |
| MATH 626 | Stochastic Processes (3) |         |
| MATH 627 | General Linear Model Applicat (3) |         |
| MATH 628 | Comput Methods in Statistics (3) |         |
| MATH 655 | Topics in Actuarial Science (1-4) |         |
| MATH 658 | Risk Theory (3) |         |
| RMI 570 | Risk Management and Insurance (3) | 3-8     |
| More credits from this list will be required if courses are waived due to undergraduate or actuarial exam credit. |

Research component, 3-6 credits from

| MATH 659 | Research in Actuarial Science (3) |         |
| THES 698 | Thesis (1-6) | 3-6     |

**30-33 crs**

MASTERS IN MATHEMATICS, 30-32 credits

The masters degree in mathematics provides students with a broad graduate-level mathematical background suitable for community college teaching, for pursuing a PhD degree in the mathematical sciences, or for seeking employment in business, industry, or government. Students pursuing the master of science degree will be required to write a 6-credit thesis.

Admission requirements

Applicants must meet the regular admission requirements of the Graduate School and have an undergraduate major in mathematics or an equivalent background as determined by the Department of Mathematical Sciences.

Master of Arts in Mathematics, 30-32 credits

Degree requirements

<table>
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<tr>
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</table>
| Algebra, 6 credits
| MATH 511 | Abstract Algebra 1                | 3       |
| MATH 512 | Abstract Algebra 2                | 3       |
| MATH 571 | Real Analysis 1 (4)               |         |
| MATH 572 | Real Analysis 2 (3)               | 6-7     |
| MATH 645 | Topology 1                        | 3       |
| MATH 675 | Measure Thry and Integration 1    | 3       |
| MATH 677 | Complex Variables 1               | 3       |
| MATH 515 | Coding and Communication (3)      |         |
| MATH 516 | Theory of Numbers (3)             |         |
| MATH 541 | Geometry and Topology (3)         |         |
| MATH 545 | Differential Geometry (3)         |         |
| MATH 556 | Intro Operations Research (3)     |         |
| MATH 562 | Numerical Analysis 1 (3)          |         |
| MATH 563 | Numerical Analysis 2 (3)          |         |
| MATH 573 | Boundary Value Problems (3)       |         |
| MATH 575 | Topics Partial Dif Equations (3)  |         |
| MATH 620 | Probability and Random Vars (4)   |         |
| MATH 626 | Stochastic Processes (3)          |         |
| MATH 646 | Topology 2 (3)                    |         |
| MATH 676 | Measure Thry and Integration 2    |         |
| MATH 678 | Complex Variables 2 (3)           | 3-7     |
| 3-7 credits from
| MATH 689 | Research Methods Math Stats (3)   |         |
| MATH 694 | Research Methods Math Educat (3)  |         |
| THES 698 | Thesis (1-6) | 3-6     |

**30-32 crs**
Master of Science in Mathematics, 30-32 credits

Degree requirements

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<tr>
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(If the undergraduate equivalent is not complete. Otherwise course substitutions in algebra will be made in conjunction with the program advisor.)

Analysis, 6-7 credits from

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<tr>
<td>MATH</td>
<td>Analysis</td>
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<tr>
<td>571</td>
<td>Real Analysis 1 (4)</td>
<td>6-7</td>
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<tr>
<td>572</td>
<td>Real Analysis 2 (3)</td>
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(If the undergraduate equivalent is not complete. Otherwise 3-credit course substitutions in analysis will be made in conjunction with the program advisor.)

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<tbody>
<tr>
<td>MATH</td>
<td>Topology 1</td>
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<tr>
<td>645</td>
<td>Measure Thry and Integration 1</td>
<td>3</td>
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<tr>
<td>677</td>
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3-4 credits from

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<tr>
<td>MATH</td>
<td>Coding and Communication (3)</td>
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<tr>
<td>515</td>
<td>Theory of Numbers (3)</td>
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<td>541</td>
<td>Geometry and Topology (3)</td>
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<td>Differential Geometry (3)</td>
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<td>Intro Operations Research (3)</td>
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<tr>
<td>573</td>
<td>Boundary Value Problems (3)</td>
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<td>575</td>
<td>Topics Partial Dif Equations (3)</td>
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<td>620</td>
<td>Probability and Random Vars (4)</td>
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<td>626</td>
<td>Stochastic Processes (3)</td>
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<td>Topology 2 (3)</td>
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<tr>
<td>676</td>
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<td>Complex Variables 2 (3)</td>
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<tbody>
<tr>
<td>MATH</td>
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</tr>
</tbody>
</table>

THES 698 Thesis (1-6) 6

30-32 crs

MASTER OF ARTS IN MATHEMATICS EDUCATION, 30-36 credits

The master of arts in mathematics education provides opportunities for elementary, middle school, and high school teachers to examine various issues related to the teaching and learning of mathematics while continuing to develop their own mathematical content knowledge.

Concentration 1: Elementary and middle school mathematics, 30 credits

Admission requirements

Applicants must meet the regular admission requirements of the Graduate School; hold a current elementary, middle special education teaching license; and have at least one year of elementary or middle school teaching experience.

Degree requirements

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>MATH</td>
<td>Content knowledge for teaching math</td>
<td></td>
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<tr>
<td>514</td>
<td>Alg Res Elm Mid Fnd Math Teach (3)</td>
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<tr>
<td>517</td>
<td>Num Concpts and Num Thry Teach (3)</td>
<td></td>
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<tr>
<td>518</td>
<td>Rat Num Prop El Mid Fnd Tch (3)</td>
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<tr>
<td>542</td>
<td>Geo Meas Ele Mid Fnd Math Tch (3)</td>
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</tr>
<tr>
<td>623</td>
<td>Data Probability Teach (3)</td>
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Research and pedagogical knowledge for teaching mathematics, 12 credits

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<tr>
<td>MATH</td>
<td>Curriculum Instruct Math Ed</td>
<td>3</td>
</tr>
<tr>
<td>690</td>
<td>Teaching Math Prob Solving</td>
<td>3</td>
</tr>
<tr>
<td>694</td>
<td>Research Methods Math Educat</td>
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</tr>
<tr>
<td>696</td>
<td>Action Research Math Education</td>
<td>3</td>
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</table>

Electives in content or pedagogical knowledge for teaching mathematics, 6 credits (as approved by advisor) from

<table>
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<tbody>
<tr>
<td>MATH</td>
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<td>Num Concpts and Num Thry Teach (3)</td>
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<td>518</td>
<td>Rat Num Prop El Mid Fnd Tch (3)</td>
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<tr>
<td>542</td>
<td>Geo Meas Ele Mid Fnd Math Tch (3)</td>
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</tr>
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<td>623</td>
<td>Data Probability Teach (3)</td>
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<td>631</td>
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<td>632</td>
<td>Assessment Math Education (3)</td>
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<tr>
<td>641</td>
<td>Topics in Geometry (3)</td>
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<tr>
<td>680</td>
<td>Special Studies Teaching Math (3)</td>
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</tr>
<tr>
<td>695</td>
<td>Math Learners and Learning (3)</td>
<td></td>
</tr>
<tr>
<td>697</td>
<td>Math Teacher Leadership 1 (3)</td>
<td>6</td>
</tr>
</tbody>
</table>

30 crs

Concentration 2: Secondary mathematics, 30 credits

Admission requirements

Applicants must meet the regular admission requirements of the Graduate School; have an undergraduate major in mathematics or an equivalent background as determined by the Department of Mathematical Sciences; hold a current secondary mathematics teaching license; and have at least one year of secondary mathematics teaching experience.

Degree requirements

Content knowledge for teaching mathematics, 9 credits

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<tbody>
<tr>
<td>MATH</td>
<td>Topics in Geometry</td>
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Take the following unless the undergraduate equivalent is completed.

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<tbody>
<tr>
<td>MATH</td>
<td>Abstract Algebra 1</td>
<td>3</td>
</tr>
<tr>
<td>570</td>
<td>Intermediate Analysis Teachers</td>
<td>3</td>
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</table>
Electives in content knowledge for teaching mathematics, 6-12 credits (as approved by advisor) from the following (if undergraduate equivalent is not completed)

MATH 512 Abstract Algebra 2 (3)  
516 Theory of Numbers (3)  
517 Num Concepts and Num Thry Teach (3)  
560 History of Mathematics (3)  
620 Probability and Random Vars (4)  
621 Theory of Statistics (4)  
623 Data Probability Teach (3)  
645 Topology 1 (3)  
677 Complex Variables 1 (3)  

Research and pedagogical knowledge for teaching mathematics, 12 credits

MATH 690 Curriculum Instruct Math Ed 3  
693 Teaching Math Prob Solving 3  
694 Research Methods Math Educat 3  
696 Action Research Math Education 3

Electives in pedagogical knowledge for teaching mathematics, 3 credits (as approved by advisor) from

MATH 631 Technology Mathematics Teach (3)  
632 Assessment Math Education (3)  
695 Math Learners and Learning (3)  
697 Math Teacher Leadership 1 (3)  

30 crs

Concentration 3: Elementary/middle school mathematics specialist, 36 credits

Admission requirements

Applicants must meet the regular admission requirements of the Graduate School; hold a current middle school mathematics or elementary teaching license; and have at least three years of middle school mathematics or elementary teaching experience.

Content knowledge for teaching mathematics, 15 credits

MATH 514 Alg Res Elm Mid Fnd Math Teach 3  
517 Num Concepts and Num Thry Teach 3  
518 Rat Num Prop El Mid Fnd Tch 3  
542 Geo Meas Ele Mid Fnd Math Tch 3  
623 Data Probability Teach 3

Pedagogical knowledge for teaching mathematics, 12 credits

MATH 632 Assessment Math Education 3  
690 Curriculum Instruct Math Ed 3  
693 Teaching Math Prob Solving 3  
695 Math Learners and Learning 3

Research, 3 credits

MATH 694 Research Methods Math Educat 3

Leadership knowledge and skills, 6 credits

MATH 697 Math Teacher Leadership 1 3  
698 Math Teacher Leadership 2 3  

36 crs

MASTER OF ARTS IN POST-SECONDARY FOUNDATIONAL MATHEMATICS TEACHING, 30 credits

Admission requirements

Applicants must meet the regular admission requirements of the Graduate School. Applicants also must meet one of the following criteria: 1) have a current teaching license and at least one year of teaching experience; 2) be currently teaching at a community college; 3) have permission of the department chairperson.

This program is offered on-line only.

Degree requirements

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<tbody>
<tr>
<td></td>
<td></td>
<td>Content knowledge for teaching mathematics, 6 credits</td>
<td></td>
</tr>
<tr>
<td>MATH</td>
<td>514</td>
<td>Alg Res Elm Mid Fnd Math Teach</td>
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<td></td>
<td>519</td>
<td>Quantitative Reason Teachers</td>
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</tr>
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</table>

Research and pedagogical knowledge for teaching mathematics, 9 credits

MATH 631 Technology Mathematics Teach 3  
693 Teaching Math Prob Solving 3  
694 Research Methods Math Educat 3

Pedagogical knowledge for teaching adults, 6 credits from

EDAC 631 Adult and Community Education (3)  
634 The Adult as a Learner (3)  
635 Strategies for Teaching Adults (3)  

Electives, (as approved by advisor), 9 credits from

MATH 517 Num Concepts and Num Thry Teach (3)  
518 Rat Num Prop El Mid Fnd Tch (3)  
542 Geo Meas Ele Mid Fnd Math Tch (3)  
623 Data Probability Teach (3)  

30 crs

MASTERS IN STATISTICS, 32 credits

The master’s program in statistics provides students with the background suitable for employment as a statistician in business, industry, or government. The degree also provides suitable preparation for pursuing a PhD degree in statistics. Students pursuing the master of science degree will be required to complete a 6-credit thesis.

Admission requirements
Applicants must meet the regular admission requirements of the Graduate School. It is also expected that students will have had three semesters of calculus and a course in linear algebra.

**Master of Arts in Statistics, 32 credits**

**Degree requirements**

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<td>Theory of Statistics</td>
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<td></td>
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<td>Intro to Statistical Learning</td>
<td>3</td>
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<td>Research Methods Math Stats</td>
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9 credits from

| MATH   | 522| Theory Sampling and Surveys (3)           | 3       |
|        | 523| Environmental Statistics (3)              | 3       |
|        | 529| Analysis Variance Exp Design (3)          | 3       |
|        | 626| Stochastic Processes (3)                  | 3       |
|        | 675| Measure Thry and Integration 1 (3)         | 9       |

32 crs

**Certificate in Middle School Mathematics Education, 15 credits**

Provides students with both breadth and depth of mathematical expertise in middle school education. Students will engage in significant mathematical problem solving as they also learn to teach mathematics through problem solving, thereby giving them depth. Students also will expand their foundational knowledge by taking several mathematics content classes that cover the breadth of middle school mathematics.

**Admission requirements**

Applicants must meet the regular admission requirements of the Graduate School. Applicants must also have a current elementary, middle school, or special education teaching license and at least one year of teaching experience.

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<tr>
<td>MATH</td>
<td>693</td>
<td>Teaching Math Prob Solving</td>
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</table>

12 credits from

| MATH   | 514| Alg Res Elm Mid Fnd Math Teach (3)         | 3       |
|        | 517| Num Concpts and Num Thry Teach (3)          | 3       |
|        | 518| Rat Num Prop El Mid Fnd Tch (3)             | 3       |
|        | 542| Geo Meas Ele Mid Fnd Math Tch (3)           | 3       |
|        | 623| Data Probability Teach (3)                  | 6       |

15 crs

Students need to achieve a grade-point average of 3.0 to receive their certificate, and no grade lower than C will count. Transfer credit is not accepted.

**Certificate in Post-secondary Foundational Mathematics Teaching, 15 credits**

**Admission requirements**

Applicants must meet the regular admission requirements of the Graduate School. Applicants also must meet one of the following criteria: 1) have a current teaching license and at least one year of teaching experience. 2) be currently teaching at a community college. 3) have permission of the department chairperson.

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<tr>
<td>MATH</td>
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<td>Curriculum Instruct Math Ed</td>
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<tr>
<td></td>
<td>697</td>
<td>Math Teacher Leadership 1</td>
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6 credits from

| MATH   | 514| Alg Res Elm Mid Fnd Math Teach (3)         | 3       |
|        | 517| Num Concpts and Num Thry Teach (3)          | 3       |
|        | 518| Rat Num Prop El Mid Fnd Tch (3)             | 3       |
|        | 542| Geo Meas Ele Mid Fnd Math Tch (3)           | 3       |
|        | 623| Data Probability Teach (3)                  | 6       |

15 crs

Students need to achieve a grade-point average of 3.0 to receive their certificate, and no grade lower than C will count. Transfer credit is not accepted.
This certificate is offered on-line only.

**PREFIX NO SHORT TITLE CREDITS**

MATH 514 Alg Res Elm Mid Fnd Math Teach 3
519 Qualitative Reason Teachers 3
631 Technology Mathematics Teach 3
693 Teaching Math Prob Solving 3

3 credits from

MATH 517 Num Concpts and Num Thry Teach (3)
518 Rat Num Prop El Mid Fnd Tch (3)
542 Geo Meas Ele Mid Fnd Math Tch (3)
623 Data Probability Teach (3) 3

15 crs

### Certificate in Statistical Modeling, 12 credits

The Certificate in Statistical Modeling provides students with the statistical modeling expertise that is part of the Master’s in Statistics. All 12 credits of this certificate can be applied to the MA/MS in Statistics programs.

**Admission requirements**

Applicants must meet the regular admission requirements of the Graduate School. It is also expected that students will have had three semesters of calculus, one semester of linear algebra, one semester of probability, and one semester of statistics.

**PREFIX NO SHORT TITLE CREDITS**

MATH 528 Regression Time Series Models 3
529 Analysis Variance Exp Design 3
627 General Linear Model Applicat 3
628 Comput Methods in Statistics 3

12 crs

### MIDDLE SCHOOL/JUNIOR HIGH MATHEMATICS LICENSE (GRADUATE LEVEL), 37-38 credits

**Admission requirements**

*Open only to* candidates who currently hold an elementary, middle school, or special education license. Middle school/junior high licensure in mathematics will be granted when the following criteria are met:

- completion of the following mathematics content courses with a 3.0 minimum GPA, with grade of C- or better in 100- and 200-level mathematics content courses and grade of C or better in 500- and 600-level mathematics content courses;
- completion of the following professional education courses with a 3.0 minimum GPA, with grade of C or better in all professional education courses;
- passing score on Praxis II for Middle School Mathematics; and

- Decision Point Requirements.

**PREFIX NO SHORT TITLE CREDITS**

Mathematics content

MATH 201 Num Oper Alg Reas Elem Teach 4
202 Data Geo Meas Elem Teach 3

MATH 161 Applied Calculus 1 (3)
165 Calculus 1 (4) 3-4

MATH 514 Alg Res Elm Mid Fnd Math Teach 3
517 Num Concpts and Num Thry Teach 3
542 Geo Meas Ele Mid Fnd Math Tch 3
623 Data Probability Teach 3
631 Technology Mathematics Teach 3

Professional education

EDJH 512 Inst Strtgs Apprchs JH and MS 3
690 Pract JH and MS Ed (1-9) 6
MATH 690 Curriculum Instruct Math Ed 3

37-38 hrs

### MATHEMATICAL SCIENCES (MATH)

**511 Abstract Algebra 1 (3)** The theory of groups, including subgroups, cyclic groups, normal subgroups, cosets, Lagrange’s Theorem, quotient structures, homomorphism, automorphisms, group actions, Sylow’s Theorems, structure of finite abelian groups, generators, and relations.

*Prerequisite recommended: MATH 311.*

*Not open to* students who have credit in MATH 411.


*Prerequisite: MATH 411 or 511, or permission of the department chairperson.*

*Not open to* students who have credit in MATH 412.

**514 Algebraic Reasoning for Elementary, Middle School, and Foundational Mathematics Teachers (3)** Algebra as the study of patterns, as a symbolic language, as a tool for problem solving, as the study of functions, as generalized arithmetic, and as a way of modeling physical situations.

*Prerequisite: at least one year of teaching experience or permission of the department chairperson.*

**515 Mathematics of Coding and Communication (3)** Exploration of applications of number theory, group theory and linear algebra to areas such as cryptography and error-correcting codes; applications of graph theory to resource allocation and route planning; other possible topics selected by the instructor.
516 Theory of Numbers (3) Topics include the division algorithm; positional notation; divisibility; primes; congruences; divisibility criteria; the sigma, divisor, and phi functions; Diophantine equations; linear, polynomial, and simultaneous congruences; theorems of Fermat, Euler, Lagrange, and Wilson; quadratic reciprocity.

Prerequisite: MATH 215 or the equivalent.
Not open to students who have credit in MATH 415.

517 Number Concepts and Number Theory for Teachers (3) Number development, number systems, properties and characteristics of classes of numbers, number sense, number theory, operations and their relationships, and algorithms.

Prerequisite: at least one year of teaching experience or permission of the department chairperson.

518 Rational Numbers and Proportionality for Elementary, Middle School, and Foundational Math Teachers (3) An in-depth study of rational number concepts and operations and the development of proportional reasoning. Also, issues related to teaching.

Prerequisite: at least one year of teaching experience or permission of the department chairperson.

519 Quantitative Reasoning for Teachers (3) Interpreting and using quantitative information in authentic contexts involving number, algebra, measurement, data analysis, and chance; representing quantitative information with mathematical models, and using quantitative information to analyze and construct written arguments. Includes explorations of pedagogical issues and design of teaching materials for the development of quantitative literacy.

520 Theory of Sampling and Surveys (3) Survey designs; simple random, stratified, cluster, and systematic sampling; ratio estimates; regression estimates; cost and variance functions.

Prerequisite: MATH 321 or the equivalent.
Not open to students who have credit in MATH 422.

521 Environmental Statistics (3) Aims to provide an introduction to the types of statistical analyses used in environmental studies. Topics include collecting environmental data with special emphasis on inaccessible and sensitive data, population size estimation, sampling in the wild such as quadrat, recapture, transect and adaptive sampling, composite sampling, ranked set sampling, examining environmental effects by regression-type models, statistical verifiability of environmental standards and regulations, time series, longitudinal, spatial, and temporal methods for the environmental processes.

Prerequisite: MATH 320 or permission of the department chairperson.

522 Regression and Time Series Models (3) Addresses regression topics that include simple and multiple linear regression, polynomial regression, regression diagnostics, and forecasting. Also introduces time series topics that include exponential smoothing, auto-regressive, integrated, moving average (ARIMA) models, and forecasting.

Prerequisite: MATH 321 or the equivalent.
Not open to students who have credit in MATH 428.

523 Analysis of Variance in Experimental Design Models (3) Multivariate normal distribution; quadratic forms; linear models; simple random, randomized block, Latin squares, factorial, split-plot, balanced incomplete block designs; analysis of covariance; confounding; and multiple comparison tests.

Prerequisite: MATH 321 or equivalent.
Not open to students who have credit in MATH 429.

524 Geometry and Measurement for Elementary, Middle School, and Foundational Mathematics Teachers (3) Students will develop visualization skills; identify two- and three- dimensional shapes and know their properties; connect geometry to other mathematical topics; research historical topics relevant to elementary and middle school geometry.

Prerequisite: at least one year of teaching experience or permission of the department chairperson.

525 Differential Geometry (3) Fundamentals of differential geometry, as an extensive study of curves and surfaces in 3-space. Includes the use of computer visualization and emphasizes the importance of differential geometry in areas like relativity theory and modern physics.

Prerequisite recommended: MATH 415.
Not open to students who have credit in MATH 445.

526 Mathematics of Finance (4) Mathematical theory of compound interest, force of interest, annuities, equations of value, yield rates, amortization, sinking funds, bonds, market derivatives, depreciation, and current topics in finance.

Prerequisite recommended: MATH 166.
Not open to students who have credit in MATH 351.

527 Mathematics of Life Contingencies 1 (4) Survival distributions, life tables; the mathematics of life insurance, life annuities, net premiums, and net premium reserves.

Prerequisite: MATH 321.
Prerequisite or parallel: MATH 551.
Not open to students who have credit in MATH 452.

528 Mathematics of Life Contingencies 2 (4) Mathematics of expense loaded premiums and reserves, asset shares, multiple life functions, multiple decrement models, discrete time Markov Chain models, and simulation.

Prerequisite: MATH 552.
Not open to students who have credit in MATH 453.
554 Mathematics of Investments (3) Mathematical analysis and actuarial principles of investments and asset management. 
Prerequisite: MATH 320 or 620, 351 or 551; or permission of the department chairperson.
Not open to students who have credit in MATH 454.

555 Topics in Actuarial Science (2) Selected topics in actuarial science with emphasis on individualized study for the actuarial exams given by the Society of Actuaries and the Casualty Actuarial Society. 
Prerequisite: permission of the department chairperson.

556 Introduction to Operations Research (3) Topics include linear programming models, the simplex method, duality theory, transportation and assignment problems, network optimization models. 
Prerequisite recommended: MATH 162 or 166; 217.
Not open to students who have credit in MATH 456.

557 Actuarial Models 1 (4) Loss and frequency distributions, limited expected value, effects of inflation, parametric and non-parametric models, identification procedures for insurance company data, bootstrapping, Bayesian analysis, compound frequency, methods for censored and truncated data, classical and Bayesian credibility models, experience rating. 
Prerequisite: MATH 321 or 620.
Not open to students who have credit in MATH 457.

558 Actuarial Models 2 (3) Basic functions related to actuarial models, common parametric models, maximum likelihood estimation for censored or truncated data, nonparametric estimation, hypothesis testing, models with co-variables, simulation, and other topics as time permits. 
Prerequisite: MATH 321, 557; one year of mathematical probability and statistics.
Not open to students who have credit in MATH 458.

559 Models in Financial Economics (3) Mathematical and economic analysis of financial instruments and the management of financial and investment risk. 
Prerequisite: MATH 320 or 620 and 351 or 551; or permission of the department chairperson.
Not open to students who have credit in MATH 459.

560 History of Mathematics (3) The development of mathematics from pre-history to the seventeenth century. Topics may include number concepts and numeration, algebra, geometry, trigonometry, analytic geometry, and calculus. 
Prerequisite recommended: MATH 161 or 165.
Not open to students who have credit in MATH 460.

562 Numerical Analysis 1 (3) Topics include error analysis, locating roots of equations, interpolation, numerical differentiation and integration, spline functions, smoothing of data. Includes programming of numerical algorithms. 
Prerequisite recommended: MATH 162 or 166; MATH 259 or CS 120.
Not open to students who have credit in MATH 362.

563 Numerical Analysis 2 (3) Topics include direct and iterative methods for solving systems of linear equations, eigenvalue problems; minimization of functions and linear programming. Includes programming of numerical algorithms. 
Prerequisite: MATH 362 or 562.
Prerequisite recommended: MATH 217.
Not open to students who have credit in MATH 363.

568 Unpaid Professional Experience in Mathematical Sciences (1-8) Supervised unpaid work and learning experience as a practicing mathematician, statistician, or actuarial scientist. Practical problem-solving experience will be gained through an internship, practicum, or other such situation. 
Prerequisite: permission of the department chairperson.
A total of 8 credits may be earned.
A total of 8 credits may be earned in MATH 568 and 569 combined. No more than 3 credits can be counted as electives toward a departmental major or minor.

569 Paid Professional Experience in Mathematical Sciences (1-8) Supervised paid work and learning experience as a practicing mathematician, statistician, or actuarial scientist. Practical problem-solving experience will be gained through an internship, practicum, or other such situation. 
Prerequisite: permission of the department chairperson.
A total of 8 credits may be earned.
A total of 8 credits may be earned in MATH 568 and 569 combined. No more than 3 credits can be counted as electives toward a departmental major or minor.

570 Intermediate Analysis for Teachers (3) Introduction to basic concepts of analysis: the real numbers, sequences, continuous functions, the derivative, and the Riemann integral. 
Prerequisite recommended: MATH 166 and 215.
Not open to students who have credit in MATH 470.

571 Real Analysis 1 (4) Real and complex number systems: ordered sets, least upper bound property, fields, Archimedean property; Basic topology: cardinality, metric spaces, completeness, compactness, connectedness; Numerical sequences and series: convergence tests, upper-lower limits; Continuity: continuous functions, uniform continuity, Intermediate and Extreme Value Theorems; Differentiation: derivative, Mean Value Theorem, l’Hospital’s Rule, Taylor’s Theorem. 
Prerequisite recommended: MATH 215 and 267.
Not open to students who have credit in MATH 471.

Prerequisite: MATH 471 or 571.
Not open to students who have credit in MATH 472.
573 Boundary Value Problems (3) Fourier Series and integrals, heat and wave equations in one dimension, Laplace equation in two dimensions, problems in higher dimensions, and numerical methods of solving boundary value problems.  
Prerequisite: MATH 374.  
Not open to students who have credit in MATH 473.

575 Topics in Partial Differential Equations (3) Classical solution techniques for linear PDEs. Topics include first- and second-order equations, method of characteristics, special functions, orthogonal polynomials, transforms, Green’s functions, and fundamental solutions. A computer algebra system is utilized.  
Prerequisite: MATH 374 or permission of the department chairperson.  
Prerequisite recommended: MATH 267.  
Not open to students who have credit in MATH 475.

599 Special Studies in Mathematics (1-8) Individual work under the direction of a staff member of the department will involve assigned reading and reports and may involve class attendance in related courses.  
Prerequisite: permission of the department chairperson.  
A total of 8 credits may be earned.

601 Workshop in Mathematics Education (1-12) A one- or two-week workshop addressing specific topics in mathematics education.  
A total of 12 credits may be earned.

619 Special Studies in Geometry, Algebra, or Topology (1-8) Individual work under the direction of a faculty member of the department will involve assigned reading and reports and may involve class attendance in related courses.  
Prerequisite: permission of the department chairperson.  
A total of 8 credits may be earned. MATH 619, 669, and 679, singly or in combination, may be taken for a total of no more than 8 credits.

620 Probability and Random Variables (4) Probability set functions, random variables, density and distribution functions, mathematical expectations, marginal and conditional distributions, sampling distributions, and limiting distributions. The mathematical rigor requires a strong background in calculus.  
Prerequisite recommended: MATH 166 and 215.

621 Theory of Statistics (4) Topics from sampling and statistics, estimation theory and tests of hypothesis. Special emphasis on order statistics, quantiles and their applications, classical and Bayesian estimation, sufficiency, completeness, uniqueness, likelihood-based approaches, hypothesis testing based on Neyman-Pearson approach, goodness-of-fit, nonparametric tests, correlation and regression, and bootstrapping.  
Prerequisite: MATH 620 or permission of the department chairperson.

623 Data Analysis and Probability for Teachers (3) Students will select and use appropriate statistical methods to analyze data, develop, and evaluate inferences and predictions that are based on data, and understand and apply the basic concepts of probability.  
Prerequisite: at least one year of teaching experience or permission of the department chairperson.

624 Introduction to Statistical Learning (3) Supervised learning: classification, linear discriminant analysis, quadratic discriminant analysis, multiple discriminant analysis, model selection regularization, bootstrap methods. Unsupervised learning: principal component analysis, canonical correlation, clustering methods.  
Prerequisite: MATH 620 or permission of the department chairperson.

626 Stochastic Processes (3) Stochastic processes, discrete and continuous time Markov processes, queuing theory, renewal theory.  
Prerequisite: MATH 620 or permission of the department chairperson.

627 Generalized Linear Models with Applications (3) Methods needed to analyze non-normal data. Topics include exponential family of distributions, an overview of generalized linear models. Models for continuous, discrete, and count data.  
Prerequisite: MATH 621 or permission of the department chairperson.

628 Computational Methods in Statistics (3) Random variable generation, Monte Carlo methods and numerical integration, Bayesian inference and Markov chain Monte Carlo, Metropolis-Hastings and Gibbs Sampling, basics of numerical optimization such as Newton’s method, constrained optimization, Expectation-Maximization algorithms.  
Prerequisite: MATH 620 or permission of the department chairperson.

631 Technology for Mathematics Teachers (3) Modeling, computational, and communication tools used in teaching mathematics.  
Prerequisite: at least one year of teaching experience or permission of the department chairperson.

632 Assessment in Mathematics Education (3) Issues related to assessment in mathematics education and the relationship of assessment to curriculum and instruction. Examination of various types of assessments administered in mathematics classrooms, as well as large-scale local, national, and international assessments.  
Prerequisite: at least one year of teaching experience or permission of the department chairperson.

641 Topics in Geometry (3) A survey of topics in contemporary geometry from various perspectives, including conjecture and exploration, formal analysis, and application beyond geometry.  
Prerequisite: at least one year of teaching experience or permission of the department chairperson.
645 Topology 1 (3) Introduction to point-set topology. Topics include set-theoretic preliminaries, topological spaces, continuous functions, metric spaces, product and quotient spaces, connectedness, compactness, countability and separation axioms, Urysohn’s Metrization Theorem, Tietze’s Extension Theorem, and Tychonoff’s Theorem.

Prerequisite: MATH 470 or 471 or 570 or 571.


Prerequisite: MATH 645.

655 Topics in Actuarial Science (1-4) Focuses on advanced studies in actuarial science. Actuarial science uses knowledge from many areas including mathematics, statistics, and finance. It also continually expands its scope to include latest developments from multiple areas. The instructor will have flexibility to determine course content.

Prerequisite: permission of the department chairperson.
A total of 4 credits may be earned.

Prerequisite: MATH 552.

659 Research Seminar in Actuarial Science (3) Research study in actuarial subjects of current interest in life, property/casualty, health, pension, and/or financial risk management. Literature searches on selected topics. Articles from research journals may be read and discussed. Will use actuarial skills from several courses. A paper will be required. Case studies and special projects will be completed and results presented on a team basis.

Prerequisite: MATH 557.
Prerequisite or parallel: MATH 553.

660 Topics in the History of Mathematics (3) In-depth study of selected topics in the history of mathematics.
Prerequisite: MATH 460 or 560.
Prerequisite recommended: MATH 162 or 165.

669 Special Studies in Applied Mathematics (1-8) Individual work under the direction of a faculty member of the department; will involve assigned reading and reports and may involve class attendance in related courses.
Prerequisite: permission of the department chairperson.
A total of 8 credits may be earned. MATH 619, 669, and 679, singly or in combination, may be taken for a total of no more than 8 credits.

675 Measure Theory and Integration 1 (3) The concept of measurability, simple functions, properties of measures, integration of positive as well as complex functions, sets of measure zero, Riesz representation theorem, Borel and Lebesgue measures, LP-spaces, approximation by continuous functions, elementary Hilbert space theory.

Prerequisite: MATH 472 or 572.

676 Measure Theory and Integration 2 (3) Banach spaces, Baire’s theorem, Hahn-Banach theorem, complex measures, total variation, absolute continuity, Radon-Nikodym theorem, bounded linear functionals on LP, the Riesz representation theorem, differentiation of measures, the fundamental theorem of calculus, integration on product spaces, the Fubini theorem, completion of product measures, convolutions, distribution functions.

Prerequisite: MATH 675.

677 Complex Variables 1 (3) Complex number systems, differentiation and integration, functions (analytic, entire, meromorphic) of one complex variable, singularities, complex integration, Cauchy’s theorem, Cauchy’s integral formula, power series, Laurent series, calculus of residues.

Prerequisite: MATH 470 or 471 or 570 or 571.

678 Complex Variables 2 (3) Analytic continuation, Riemann surfaces, theorems of Weierstrass and Mittag-Leffler, solution of two-dimensional potential problem, conformal mapping, Schwartz-Christoffel transformations and their applications.

Prerequisite: MATH 677.

679 Special Studies in Analysis (1-8) Individual work under the direction of a faculty member of the department; will involve assigned reading and reports and may involve class attendance in related courses.
Prerequisite: permission of the department chairperson.
A total of 8 credits may be earned. MATH 619, 669, and 679, singly or in combination, may be taken for a total of no more than 8 credits.

680 Special Studies in the Teaching of Mathematics (1-6) The student will work under the direction of a staff member in the Department of Mathematical Sciences. Assigned reading and reports; possible class attendance in related courses.
Prerequisite: permission of the department chairperson.
A total of 6 credits may be earned.

689 Research Methods in Mathematics and Statistics (3) The scientific method in mathematical research. Location of relevant journal articles, reference books, and reviews. Development of research and problem-solving techniques. Each student will write a mathematical paper. The instructor will assist students whose work is of exceptional quality in submitting their results for publication.

690 Curriculum and Instruction in Mathematics Education (3) Focuses on the mathematics curriculum, with emphasis on current issues and trends, on teaching strategies, and standards-based teaching. Looking at mathematics curriculum from a K-12 perspective, students will work on understanding these recommendations in light of previous mathematics curriculum experiences.
692 Actuarial Science Exit Survey (0) This 0-credit course consists of an exit survey that should be completed by all students who attain an MA in Actuarial Science from Ball State University. The survey will ask students about professional actuarial exams completed prior to graduation, actuarial internships held during their time in the program, and their employment or education plans after graduation. Offered credit/no credit only.

Prerequisite: students will either have completed all course requirements for an MA in Actuarial Science or will complete all requirements by the end of the current semester.

693 Teaching Mathematics through Problem Solving (3)
Knowledge and skills for teaching and learning mathematics through problem solving using multiple representations and orchestrating mathematical discourse to promote mathematical reasoning in student-centered mathematics classrooms. Design, select/adapt, and solve worthwhile mathematical tasks to support teaching through problem solving.

Prerequisite: at least one year of teaching experience or permission of the department chairperson.

694 Research Methods in Mathematics Education (3)
Research analysis and methodology in mathematics education.

Prerequisite: at least one year of teaching experience, and 18 graduate credits in mathematics or mathematics education, including MATH 690, or permission of the department chairperson.

695 Mathematics Learners and Learning (3) In-depth look at mathematics learners and learning as related to learning trajectories, cultural differences, and social learning contexts while building upon learners’ existing knowledge/skills.

Prerequisite: at least one year of teaching experience or permission of the department chairperson.

696 Action Research in Mathematics Education (3)
Teachers conduct an action research project in a mathematics classroom and present their findings in a written report.

Prerequisite: MATH 694 or permission of the department chairperson.

697 Mathematics Teacher Leadership 1 (3) An introduction to the development of strategies and skills for teacher leadership in mathematics education, with a focus on models for professional development of mathematics teachers.

Prerequisite: MATH 690.

698 Mathematics Teacher Leadership 2 (3) An expansion of the development of strategies and skills for teacher leadership in mathematics education, with a focus on research and collaboration with colleagues and professional communication with stakeholders.

Prerequisite: MATH 694, 697.

699 Seminar in Mathematics (1-6) For students who wish to pursue some particular problem or group of problems in mathematics. Assigned readings and conferences.

A total of 6 credits may be earned.

ANATOMY (ANAT)


Prerequisite: admission to the medical education program.

606 Medical Neuroanatomy (4) Normal structural and functional organization of the human central nervous system as a background for the interpretation of its dysfunction. Assumes prior knowledge of human peripheral nervous system and effector mechanisms. Two-and-one-half hour lecture plus four hours of laboratory weekly.

Prerequisite: ANAT 601.

631 Medical Histology-Embryology (5) Normal and abnormal developmental processes related to the differentiation of tissues and organs; microscopic study of organs and tissues as background for physiological and pathological consideration.

Prerequisite: admission to the medical education program.

BIOLOGY (BIO)

642 Medical Microbiology (8) Microbiology for medical students with consideration of bacteria, fungi, viruses, and parasites as agents in human disease and the immunological and serological aspects of the host-parasite relationship.

Open only to medical students or by permission of the department chairperson.