Millikin University
Student Learning in the Mathematics Major
By Daniel Miller
July 1, 2015

Executive Summary

The Department of Mathematics supports Millikin's Mission in that the Department works:

1. To prepare students for professional success.
   a. Applied mathematics – we provide core mathematical experiences and a range of application areas to prepare students for work or graduate study.
   b. Mathematics education – we prepare students for the Illinois State Certification Exam, give them experience in teaching, and keep them current on the use of technology in mathematics education.

2. To prepare students for democratic citizenship in a diverse and dynamic global environment.
   a. Applied mathematics- we provide fundamental tools to analyze dynamic events that will inform public policy.
   b. Mathematics education- in a world where political leaders are becoming increasingly numbers driven, we provide the teachers the skills to empower children by enhancing their ability to reason quantitatively.

3. To prepare students for a personal life of meaning and value we help our students develop the intellectual framework, and instill in them the mindset, that will enable them to remain life-long learners. Our students are taught to think rigorously and rationally, and to revel in the sheer pleasure of thinking.

Additionally, the department has specific goals for two of its majors Applied Mathematics, and Mathematics Education. These goals clarify and document the department's desire to produce highly qualified and successful majors. The University completed the paperwork for the Actuarial Science program to receive VEE credit for applied statistical methods, time series, corporate finance, and economics. In 2013 we stated that "A complete assessment of this program including its long-term viability is being developed by Dr. Beck with consolation from the School of Business." This assessment still has not been completed. The Tabor School of Business was in the middle of redesigning their curriculum and postponed decision on finance / actuarial programs. The mathematics department expects the only assessment criteria beyond those of mathematics major will be to track actuarial exam scores for student who choose this option.

The assessment results for data collected from July 2014- July 2015 constitute the department's ongoing systemic attempt to quantify student achievement within the department. The results suggest that for students in both Mathematics and Mathematics Education program goals are being met. Additionally, Mathematics Education maintains NCATE special program accreditation from NCTM. There should be no additional assessment data necessary for the mathematics education major beyond what is collected for the yearly NCATE report completed by Dr. Paula R. Stickles.

Report

Goals

The Department of Mathematics supports the mission of the university in preparing students for professional success, democratic citizenship in a global community, and a personal life of meaning and value. The mission of the department is to produce graduates who achieve the following learning outcome goals:

1. Applied Mathematics

An applied mathematics major will

a. be able to integrate and differentiate functions,
b. be able to express and interpret mathematical relationships from numerical, graphical and symbolic points of view,
c. be able to read and construct mathematical proofs in analysis and algebra, and
d. be able to apply mathematics to at least two areas taken from biology, physics, chemistry, economics or computer science.

2. Mathematics Education

A mathematics education major will

a. be able to pass the Illinois high school mathematics certification exam,
b. know in broad terms the history of calculus, algebra, and probability,
c. have prepared at least 2 lesson plans in mathematics, and
d. have served as an teaching intern for a member of the mathematics faculty

These goals also reflect a connection to Millikin's Mission in that the Department works:

1. To prepare students for professional success.
    a. Applied mathematics – we provide core mathematical experiences and a range of application areas to prepare students for work or graduate study.
    b. Mathematics education – we prepare students for the Illinois State Certification Exam, give them experience in teaching, and keep them current on the use of technology in mathematics education.
    c. Computer science – we train students in fundamental programming techniques and theory so that they can learn new technologies in this rapidly changing field.

2. To prepare students for democratic citizenship in a diverse and dynamic global environment.
    d. Applied mathematics- we provide fundamental tools to analyze dynamic events that will inform public policy.

   e. Mathematics education- in a world where political leaders are becoming increasingly numbers driven, we provide the teachers the skills to empower children by enhancing their ability to reason quantitatively.
   f. Computer science- we provide the skills necessary for students to succeed in an increasingly technological world

3. To prepare students for a personal life of meaning and value we help our students develop the intellectual framework, and instill in them the mindset, that will enable them to remain life-long learners. Our students are taught to think rigorously and rationally, and to revel in the sheer pleasure of thinking.

<u>Snapshot</u>

The Department of Mathematics guides students in the completion of three different majors: mathematics education (12 students), applied mathematics (9 students) and actuarial science (8 students). Currently, 29 students are following one of our major programs of study. This is an enrollment increase of 7 (or 32%) from last year.

General Description. The Department of Mathematics includes the disciplines of mathematics and statistics. The department offers mathematic majors with options in Applied Mathematics, Mathematics- Secondary Teaching, and Actuarial Science. Additionally, a minor in Applied Mathematics is offered. Elementary Education majors may take a concentration in mathematics. The curriculum is structured to meet the overlapping needs of students who fall in one or more of the following categories:

- those who plan to become high school mathematics teachers;
- those who intend to pursue graduate work in applied mathematics, computer science, or other related fields; and
- those who will apply mathematics and/or computer science in the natural sciences, social sciences, business or other areas of quantitative studies such as actuarial science.

Additional Comments.

- The three majors offered in the Department share courses and faculty. The applied mathematics and mathematics secondary education majors are particularly entwined with students taking common courses and interacting with the same faculty members. In many respects these two majors cannot be disentangled for analysis.
- Students can earn either the Bachelor of Arts or Bachelor of Science. The choice of B.A. or B.S. depends entirely on the student's interest in studying a foreign language. There is no distinction in Departmental coursework between the B.A. and B.S. degrees. Therefore, this report will not separate the B.A. from the B.S.
- All fulltime tenure-track members of the Department have doctorate degrees and are tenured. (See Table 1.) The adjunct load has remained constant at 2 FTE for years

with PACE contributing 1 FTE. For fall 2015 this number remained constant by increasing developmental **class sizes to 30** in the traditional program.

Description Applied Mathematics**.** The applied mathematics major is for students interested in immediate employment or further study in applied mathematics or in actuarial sciences. Applied mathematics majors take a minimum of 33 credit hours in mathematics. The core courses and required advanced courses are those specified in *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004* by the Committee on the Undergraduate Program in Mathematics of The Mathematical Association of America.

Description Mathematics Education. The Mathematics-Secondary Teaching major is a rigorous course of study in mathematics and education. The major has 38 required credit hours in mathematics. Unique among institutions of comparable size we require a mathematics teaching internship experience as part of our program. During this experience the student is paired with a member of the faculty in teaching an undergraduate mathematics course.

Description Actuarial Science Concentration. This option is a rigorous treatment of the mathematics and business skills necessary for a major to enter the workforce as an entry-level actuary. Students who completed this option and all highly recommended courses in business will be prepared to take the first two Actuarial Examinations (1/P and 2/FM) of the Casualty Actuarial Society and the Society of Actuaries. The department is currently working with Tabor School of Business to offer additional course to our majors to prepare them for additional exams. Currently through this corporation, Millikin students can obtain Verification of Educational Experiences (VEE) credit from the Society of Actuaries (SOA) in Applied Statistical Methods, Corporate Finance, and Economics (see table in appendix).

<u>The Learning Story</u>

Applied mathematics and mathematics education majors follow nearly the same curriculum within the Department. The Department believes that to be a good mathematics teacher one needs to know mathematics. Therefore, the education majors are expected to successfully compete with the applied majors in most of their mathematics courses. The program assumes entering students can start with calculus the fall of their freshmen year. Additionally, education majors are advised to have completed the core of their mathematics courses by the spring of their junior year so that they are prepared for the state certification examination that must be passed prior to being placed for student teaching.

The applied mathematics curriculum focuses on the integration of mathematical theory and mathematical practice. Our majors learn concepts and techniques appropriate for actuarial science, ecological modeling, engineering, numerical analysis, and statistical inference. We assume that most of our applied mathematics major will seek employment in commerce or industry, but the curriculum also prepares them for post-graduate work in mathematics.

The current curriculum maps are included as Appendix 1-2.

Assessment Methods

All students are required to pass the Millikin mathematics placement exam or MA 098 prior to receiving credit for a QR course or receive an equivalent math ACT sub-score (22). In the past, the Department expected our majors to score an ACT math sub-score of 28 or higher or a placement score of 5 (the suggested score for placement into Calculus I). The Department now tests all students wanting to take Calculus with the Millikin Calculus readiness exam and students are placed by the score obtained on the exam. Students are assessed within our programs in numerous ways: course exams, problem sets, and written and oral demonstrations. Additionally, the Department requires every student in Mathematics Education to complete an internship. Written evaluations from these experiences including evaluation by the students' supervisors are kept. Mathematics Education majors take and pass the state certification examination and submit to a portfolio review. Mathematics majors lead a graduate school like seminar their last semester or an individualized project.

Assessing the Mathematics Major Goals

A mathematics major will

1. be able to integrate and differentiate functions,

   All Mathematics majors are required to take and pass both Calculus I and Calculus II to graduate with a Mathematics degree. It is the consensus of the department that it would not be possible to pass these two courses without the ability to integrate and differentiate functions. Therefore, verifying the completion of these two courses by all Mathematics majors will assess fulfillment of this goal. Additionally, the department chair will collect copies of all Calculus I and Calculus II final exams each semester to verify the assertion that integration and differentiation of functions was necessary to pass the exams.

   a. In the spring of 2014 the department chair collected copies of all Calculus I and II final exams. The instructors for each course were asked to verify that no student could pass the exam without having knowledge how to integrate and differentiate functions. The department chair then independently verified this conclusion. The collected data in being maintained by the departmental chair and is included at the end of this document.

2. be able to express and interpret mathematical relationships from numerical, graphical and symbolic points of view,

   All Mathematics majors are required to take and pass Discrete Mathematics, Differential Equations, and Numerical Analysis. It is the consensus of the department that it would not be possible to pass these three courses without the ability to express and interpret mathematical relationships from numerical, graphical and symbolic points of view. Therefore verifying the completion of these courses by all Mathematics majors will assess fulfillment of this goal. Additionally, the department chair will collect copies of all Discrete Mathematics, Differential Equations, and Numerical Analysis final exams each semester to verify the assertion that expressing and interpreting mathematical relationships from numerical, graphical and symbolic points of view was necessary to pass the exams.

a. See attached final exams and reviews of these finals by the individual faculty members.

3. be able to read and construct mathematical proofs in analysis and algebra, and

All Mathematics majors are required to take and pass Discrete Mathematics, Calculus III and Linear Algebra. It is the consensus of the department that it would not be possible to pass these three courses without the ability to read and construct mathematical proofs in analysis and algebra. Therefore verifying the completion of these two courses by all Applied Mathematics majors will assess fulfillment of this goal. Additionally, the department chair will collect copies of all Discrete Mathematics, Calculus III and Linear Algebra final exams each semester to verify the assertion that reading and constructing mathematical proofs in analysis and algebra was necessary to pass the exams.

a. Discrete Mathematics, Calculus III and Linear Algebra were all offered this year. A copy of the final exams from Calculus III and Linear Algebra are attached. A review of these exams support the contention that it would not be possible to pass these three courses without the ability to read and construct mathematical proofs in analysis and algebra. See attached final exams and reviews of these finals by the individual faculty members.

4. be able to apply mathematics to at least two areas taken from biology, physics, chemistry, economics or computer science.

All Mathematics majors are required to take Calculus I and II and Discrete Mathematics. The final exams from all sections of these courses will be review by the department chair to ensure that these routinely contain problems from biology, physics, chemistry, economics or computer science. Specifically, physics will be covered in Calculus I; biology, chemistry, and economics in Calculus II, and computer science applications in Discrete Mathematics.

a. This review was completed and verified that the exam contained appropriate problems involving biology, physics, chemistry, economics or computer science. All final exams for these courses are attached. Again, see attached final exams and reviews of these finals by the individual faculty members.

Assessing the Mathematics Education Major Goals

A mathematics education major will

1. be able to pass the Illinois high school mathematics certification exam,

The department chair will verify that each Mathematics Education major has passed the state certification exam prior to student teaching. Additionally, the chair will note and analyze the subject area sub scores on an ongoing basis to determine the need for curricular change.

a. All students passed the state exam!
b. The program is nationally accredited!!

2. know in broad terms the history of calculus, algebra, and probability,

   All Mathematics Education majors are required to take and pass Mathematics History to graduate with an Mathematics Education degree. It is the consensus of the department that it would not be possible to pass this course without knowing in broad terms the history of calculus, algebra, and probability. Therefore verifying the completion of this course by all Mathematics Education majors will assess fulfillment of this goal. Additionally, the department chair will audit the Mathematics History syllabus each semester to verify the assertion that the assignments cover the history of calculus, algebra, and probability. Samples of student work will also be collected by the instructor for chair evaluation.

3. have prepared at least 2 lesson plans in mathematics, and

   All Mathematics Education majors will be required to submit 2 graded lesson plans to the department teaching supervisor prior to student teaching. These lesson plans may come from a variety of courses; MA 425 Teaching Secondary and Middle School Mathematics, MA 471 Mathematics Internship, or any other education course that required the completion of a mathematics lesson plan.

   a. Lesson plans for MA 425 and MA471 were collected and reviewed by the department. Dr. Paula R. Stickles has taken over this assessment.

4. have served as a teaching intern for a member of the mathematics faculty

   In support of this goal, all Mathematics Education majors are required to take and pass the departmental teaching internship MA 471 to graduate with a Mathematics Education degree. The departmental chair will collect and analyze the end of course reflection required for this internship to determine the effectiveness of the experience.

   a. All secondary mathematics majors taking MA 471 were required to complete an end of course reflection. These reflections were reviewed by Dr. Paula R. Stickles and she has taken over this assessment.

Assessing the Actuarial Science Major Goals.

An assessment program for the new actuarial science track has been delayed. Currently there are 8 students in the program. We are waiting to review the new Tabor School requirements before proceeding.

Analysis of Assessment Results

The assessment data collected for 2014-2015 constitutes the department's second systemic attempt to quantify student achievement within the department. The results suggest that for students in both Mathematics and Mathematics Education program goals are being met. Assessment of the Actuarial Science program will be delayed until enrollment increases.

Review of 2014-2015 Improvement Plans

- Analyze data from all developmental mathematics classes to determine if raising the limit to 25 from 20 has negatively impacted student performance.
    - This reduces the department's FTE need by ½ position (18 developmental classes, or an increase of 90 seats).
        - The increase class size did not affect passing rates; it did result in students indicating that they felt they received little individualized attention (SRI data).
        - In many cases the class size approached 30 and in 4 cases exceeded 30.

Improvement Plans 2015-2016

- Hold the developmental courses to 20 students and access students concerns for individualized attention.
- Hire a replacement for the Director of the Mathematics Center.
- Develop a plan for the retirement of Dr. Beck and possibility Dr. Miller.
- Support Dr. J. Stickles as he becomes Chair of the Department.
- Reevaluate the developmental sequence to determine both scope and sequence and content delivery.

Student Publications and Presentations
Department of Mathematics
2010-2014

Peck, H. Accepted to the Research Experience for Undergraduates in combinatorics at the University of Minnesota, Minneapolis, MN. One of twelve participants in a summer program completing a research project in combinatorics (June-August 2014)

Spaw, J. Accepted to the Pacific Undergraduate Research Experience in Mathematics at the University of Hawaii, Hilo, HI. One of twelve participants in a summer program completing a research project in factorization theory (June-July 2014)

Peck, H. Conference Presentation. *On the Center of Zero-Divisor and Ideal-Divisor Graphs of Finite Commutative Rings*, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN (April 2014)

Bloome, L. and **Peck, H.** On the Center of Zero-Divisor and Ideal-Divisor Graphs of Finite Commutative Rings, *Journal of Algebra and Its Applications,* **13** (2014), no. 5, 1-12.

Peck, H. Conference Presentation. *Irreducible Divisor Graphs with Respect to Tau-Relations,* Western Kentucky University Mathematics Symposium, Bowling Green, KY (November 2013)

Axtell, M., Stickles, J. **Bloome, L.**, Donovan, R., Milner, P., **Peck, H.**, Richard, A., Williams, T. An exploration of ideal-divisor graphs, *Involve: A Journal of Mathematics,* to appear (July 2013)

Peck, H. Accepted to the Summer Mathematics Institute at Cornell University, Ithaca, NY. One of twelve participants in a summer program learning algebra and completing a research project (June-July 2013)

Peck, H. Summer Undergraduate Research Fellowship, Millikin University. One of five recipients. (Summer 2012)

Bloome, L. Accepted to the Summer Mathematics Institute at Cornell University, Ithica, NY. One of twelve participants in a summer program learning analysis and completing a research project (June-July 2012)

Bloome, L. Conference Presentation. *Connections between Central Sets and Cut Sets in Zero-Divisor Graphs of Commutative Rings*, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN, twenty minutes. Recognized as one of the five best talks of the conference. (April 2012)

Buhrmann, J. Conference Presentation. *The U.S. Life Insurance Industry: Time Series Analysis*, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN, twenty minutes. Recognized as one of the five best talks of the conference. (April 2012)

Perkins, M. Conference Presentation. *The Predicted Success Rate in Lower 10 Percent of Accepted Students*, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN, twenty minutes. Recognized as one of the five best talks of the conference. (April 2012)

Woods, M. Conference Presentation. *Good or Bad: Lowering Entrance Standards*, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN, twenty minutes. Recognized as one of the five best talks of the conference. (April 2012)

Lee, E., Lee, S., Elliot, D., Mathy, K., and **Walker, D.** Interval Estimation for Extreme Value Parameter with Censored Data, *ISRN Applied Mathematics* (2011), Article ID 687343, 1-12.

Weber, D. Zero-Divisor Graphs and Lattices of Finite Commutative Rings, *Rose-Hulman Undergraduate Math Journal*, **12** (2011), no. 1.

Coté, B., Ewing, C., Huhn, M. and Plaut, C., **Weber, D.** Cut-sets in Zero-Divisor Graphs of Finite Commutative Rings, *Communications in Algebra*, **39** (2011), no. 8, 2849-2864

Bloome, L. Conference Presentation. *Compressed Zero-Divisor Graphs of Finite Commutative Rings*, University of Dayton Undergraduate Mathematics Day, Dayton, OH, fifteen minutes (November 2011)

Morin, M. Conference Presentation. *Formalizing Course Materials for a Quantitative Reasoning Course*, University of Dayton Undergraduate Mathematics Day, Dayton, OH, fifteen minutes (November 2011)

Stickles, P. and **Morin, M.** Conference Presentation. *Undergraduate Fellows Program AKA Getting an Undergraduate to Do Your Work and Enjoy it!* Annual Meeting of the Illinois Council of Teachers of Mathematics. Springfield, IL, sixty minutes (October 2011)

Stickles, J., **Helding, C.**, and **Morin, M.** Conference Presentation. *Undergraduate Teaching Internship Program at Millikin University*, Annual Meeting of the Illinois Council of Teachers of Mathematics. Springfield, IL, sixty minutes (October 2011)

Lee, E., Lee, S., Elliot, D., Mathy, K., and **Walker, D.** Interval Estimation for Extreme Value Parameter with Censored Data, ISRN Applied Mathematics (2011), Article ID 687343, 1-12.

Weber, D. Zero-Divisor Graphs and Lattices of Finite Commutative Rings, Rose-Hulman Undergraduate Math Journal, 12 (2011), no. 1, 58-70.

Coté, B., Ewing, C., Huhn, M. and Plaut, C., **Weber, D.** Cut-sets in Zero-Divisor Graphs of Finite Commutative Rings, Communications in Algebra, 39 (2011), no. 8, 2849-2864

Weber, D. James Millikin Scholar Project. Zero-Divisor Graphs and Zero-Divisor Lattices of Finite Commutative Rings. Received Outstanding JMS Project Award. (May 2011)

Stickles, P., **Helding, C., and Smith, B.** Conference Presentation. Authentic Teaching Experiences in Secondary Mathematics Methods Courses. Annual Meeting of the National Council of Teachers of Mathematics. Indianapolis, IN, sixty minutes (April 2011)

Bloome, L. Conference Presentation. Compressed Zero-divisor Graphs of Finite Commutative Rings, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN, twenty minutes (March 2011)

Luciano, G. Conference Presentation. Using Data Mining to Determine Academic Success in College, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN, twenty minutes (March 2011)

Weber, D., Conference Presentation. A Preliminary Look at Compressed Zero-Divisor Graphs and Zero-Divisor Lattices, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN, twenty minutes (March 2011)

Bloome, L. and Weber, D. Poster Presentation. Compressed Zero-Divisor Graphs and Zero-Divisor Lattices of Finite Commutative Rings, Joint Mathematics Meetings, New Orleans, LA. (One of twenty $100 prize winners out of over 250 posters. (January 2011)

Coté, B., Ewing, C., Huhn, M. and Plaut, C., **Weber, D.** Cut-sets in Cut-Vertices in the Zero-Divisor Graph of , Rose-Hulman Undergraduate Math Journal, 11 (2010), no. 1, 1-8.

Bloome, L. Conference Presentation. Compressed Zero-divisor Graphs of Finite Commutative Rings, Millikin Undergraduate Mathematics Research Conference, Decatur, IL, twenty minutes (November 2010)

Luciano, G. Conference Presentation. Using Data Mining to Analyze Admissions Data, Millikin Undergraduate Mathematics Research Conference, Decatur, IL, twenty minutes (November 2010)

Weber, D., Conference Presentation. Zero-Divisor Lattices on Commutative Rings, Millikin Undergraduate Mathematics Research Conference, Decatur, IL, twenty minutes (November 2010)

Weber, D., Conference Presentation. Cut-Vertices and Cut-Sets on Zero-Divisor Graphs, Special Session in Commutative Rings, AMS Sectional Meeting, St. Paul, MN, twenty minutes (April 2010)

Weber, D., Conference Presentation. Cut-Sets in Zero-Divisor Graphs of Finite Commutative Rings, Rose-Hulman Undergraduate Mathematics Conference, Terre Haute, IN, twenty minutes (March 2010)

Arn, R. and Miller, D., Conference Presentation. Combatting Noise in Imaging Systems, Rose-Hulman Institute of Technology Undergraduate Mathematics Research Conference, Terre Haute, IN, twenty minutes (March 2010)

Weber, D., Poster Presentation. Cut-Sets and Cut-Vertices on Zero-Divisor Graphs, Joint Mathematics Meeting, San Francisco, CA (January 2010)

Table 1. Full time faculty: Mathematics

Faculty	Highest Degree	Rank	Tenure Status	Year Hired	Specialty Field	Courses taught
James Rauff	Ph.D.	Professor	Tenured	1988	Formal Languages, Computational Linguistics, Ethnomathematics.	Discrete Math, Computing Theory, History of Math, Linear Algebra, Calculus, Remedial Algebra.
Randal Beck	Ph.D.	Associate Professor	Tenured	1979	Partial Differential Equations, Statistics.	Calculus, Statistics, Differential Equations.
Daniel Miller	Ph.D.	Professor	Tenured	1997	Mathematics Education, Geometry, Educational Technology.	Teaching Methods, Precalculus, Geometry, Remedial Algebra
Joe Stickles	Ph.D.	Professor	Tenured	2006	Ring Theory.	Calculus, Liberal Arts Mathematics, Abstract Algebra.
Eun-Joo Lee	Ph.D.	Assistant Professor	Tenured	2006	Mathematical Statistics.	Statistics, Calculus.
Paula Stickles	Ph.D.	Associate Professor	Tenured	2006	Problem Solving/Posing, Mathematical Modeling	Secondary Methods, Calculus, Mathematics Content for Elementary Teachers

Curriculum Matrix
Mathematics

	MA 140	MA 208	MA 240	MA 303	MA 304	MA 305	MA 313	MA 340	MA 403	MA 440	MA 499		MA 308	MA 314	MA 320	MA 420	MA 472	MA 491
Goal 1																		
Goal 2																		
Goal 3																		
Goal 4																		
				Required Course									Elective Courses (Two-required)					

An mathematics major will

Goal 1: be able to integrate and differentiate functions.

Goal 2: be able to express and interpret mathematical relationships from numerical, graphical and symbolic points of view.

Goal 3: be able to read and construct mathematical proofs in analysis and algebra.

Goal 4: be able to apply mathematics to at least two areas taken from biology, physics, chemistry, economics or computer science.

Appendix 2

Curriculum Matrix
Mathematics Education

	MA 140	MA 240	MA 208	MA 301	MA 303	MA 304	MA 320	MA 425	MA 471		MA 340	MA 403	MA 305	MA 313	MA 314	MA 420	MA 440
Goal 1																	
Goal 2																	
Goal 3																	
Goal 4																	
		Required Course									Elective Courses (Two-required)						

Goal 1: A mathematics education major will be able to pass the Illinois high school mathematics certification exam.

Goal 2: A mathematics education major will know in broad terms the history of calculus, algebra, and probability.

Goal 3: A mathematics education major will have prepared at least 4 lesson plans.

Goal 4: A mathematics education major will have served as a teaching intern for a member of the mathematics faculty.

Assessment of MA 140 Final Exam for Spring 2015

Goal: An applied mathematics major will be able to integrate and differentiate functions.

Assessment of goal:

Differentiation: Of the 17 problems on this final exam, problems , 3 – 7, 5, 6, 7, 11, 13, 14, and 15 either explicitly or implicitly required the students to take a derivative of some function in order to be able to solve the problem. Problem 1 required the students to understand the definition of the derivative. Problem 7 required the students to connect the first derivative of a function with the function increasing or decreasing and to connect the second derivative with the concavity of the function. Problem 11 required the students to apply differentiation techniques without having an explicitly stated function. Problem 13 required students to connect the derivative to optimizing a quantity given certain restrictions. Problem 14 required students to connect the derivative to a change in quantities with respect to time (related rates).

Integration: Of the 17 problems on this final exam, problems 2, 8, and 9 either explicitly or implicitly required students to integrate some function in order to be able to solve the problem. Problem 2 on the non-calculator part required the students to understand the definition of the definite integral to obtain the exact value of the definite integral. The remaining problems either explicitly or implicitly required students to integrate some function in order to be able to solve the problem.

As nearly every problem on this final exam involved either differentiation or integration (or both), it would be impossible for a student to pass this exam without knowing how to differentiate or integrate functions.

Goal: An applied mathematics major will be able to apply mathematics to at least two areas taken from biology, physics, chemistry, economics, or computer science.

Assessment of Goal: Problem 16 dealt with estimating integrals from a table of values; in particular. Since science students will be making inferences using experimental data, the ability to estimate derivatives and integrals from a table of values will be extremely useful. Problem 13 required students to determine the minimum value of some physical quantity. Though this particular problem did not explicitly bring in physics or chemistry per se, the technique required to solve this problem *does* occur in solving problems in physics and chemistry, and therefore, students who successfully completed this problem have learned a technique they can use to solve application problems in physics and chemistry. Also, problem 14 involved differentiation to determine the rate of change of a physical quantity with respect to another physical quantity, which is a topic from physics.

Assessment of MA 303 Final Exam for Spring 2015

Goal: An applied mathematics major will be able to read and construct mathematical proofs in
analysis and algebra.

A mathematics education major will be able to pass the Illinois high school mathematics
certification exam.

Assessment of goal:

This course addresses the following Illinois State Board of Education and NCTM Content Standards.
Standards for Teachers of Mathematics: 8B4, 8F6, and 9F3.
NCTM Indicators: 2.1-2.4, 3.1-3.3, 4.1-4.3, 6.1, 9.7-9.9, 10.2, 10.5, and 11.5.

Further, this course addresses Subarea III of the Illinois Certification Testing System Mathematics (115) exam. (http://www.icts.nesinc.com/PDFs/IL_field115_SG.pdf) An examination of the final exam will show that these indicators and standards have been addressed.

Problems 4, 5, 9 –11 require students to construct proofs, while the rest of the exam requires students to understand the concepts presented in proofs in order to complete the problems. Therefore, students must be successful in reading and constructing mathematical proofs in algebra in order to pass this exam.

MA208 Final Exam: Spring 2015

Sign in please: ____________________________________

Part I: Logic (40 points)

1. Use a truth table to establish whether the statement form $\left(\left(p\wedge \sim q\right)\to r\right)\leftrightarrow\left(q\vee r\right)$ is a tautology, a contradiction, or neither.

2. Determine whether or not the following argument is valid. Assume that all predicates are over the domain X and $a,c\in X$. Explain your answer.

   1. $\forall x,\forall y\left(P(x,y)\vee Q(x,y)\right)$
   2. $\forall y\left(Q(y,c)\to W(a,y)\right)$
   3. $\sim P(a,c)$

   Therefore, $W(a,a)$

3. Write the following argument symbolically and then determine whether it is valid or invalid. Explain your answer.

   For a simplex to be malleable is necessary that it be continuous. Every differentiable simplex is continuous. The Beeblebrox simplex is malleable. Therefore, the Beeblebrox simplex is differentiable.

4. Let $a, b,$ and c be propositions such that a is true, b is true, and c is false. Let P and Q be predicates on the domain $\{a,b,c\}$ such that $P(a), P(b),$ and $P(c)$ are true and $Q(a), Q(b),$ and $Q(c)$ are false. Determine the truth value of each of the following.

   a. $(a\to c)\vee\sim b$

   b. $\sim\left(Q(a)\wedge P(b)\right)\to\left(Q(c)\to P(a)\right)$

   c. $\forall x, Q(x)\to Q(y)$

d. $\forall x \exists y \left(P(x) \to \left(P(y) \wedge Q(y) \right) \right)$

Part II: Numbers (40 points)

5. Prove: If $n \bmod 7 = 3$ then $5n \bmod 7 = 1$.

6. Prove by mathematical induction: $\sum_{i=0}^{n} (2i+1) = (n+1)^2$ for all integers $n \ge 1$.

7. Prove: For all integers *n*, $n^3 + n$ is even.

8. Use the Euclidean algorithm to find $\gcd(13585, 4862)$.

Part III. Sets (20 points)

9. Let the universal set $U = \{0,1,2,3,4,5,6,7,8,9\}$. Let $A = \{0,2,4,6,8\}$, $B = \{1,3,5,7,9\}$, $D = \{0,3,6,9\}$ and $E = \{0,1,2,3\}$. Find the elements of each set.

   a. $B^C \cup D$ =

   b. $(A \cap E) \times (E \cap B)$ =

10. Prove: For all sets *A*, *B*, and *D*, $(A \cup B) \cap D = \left(\left(A^C \cap B^C \right) \cup D^C \right)^C$.

Part IV. Functions and Relations (40 points)

11. Let $F : \mathscr{P}(\square) = \square^{nonneg}$ be defined by $F(A) = n(A)$ if *A* is finite and $F(A) = 0$ if *A* is infinite. For example, $F(\{-2,3,19\}) = 3$ and $F(\{0,2,4,6,8,\ldots\}) = 0$.

a. Is F a one-to-one function? Explain.

b. Is F an onto function? Explain.

12. Let $G : \mathbb{Z}^{nonneg} \to \mathbb{Z}_3$ be defined by $G(n) = [n]$.

a. Find $G^{-1}([2])$.

b. Find $G \circ F(\{1,2,3,4,5,6,7\})$ where F is the function defined in question #11.

13. Let R be the relation on $\mathbb{Z} \times \mathbb{Z}$ defined by $(a,b)R(c,d)$ iff $a+d=b+c$.

a. Prove that R is transitive.

b. Given that R is an equivalence relation list five elements of $[(2,-1)]$.

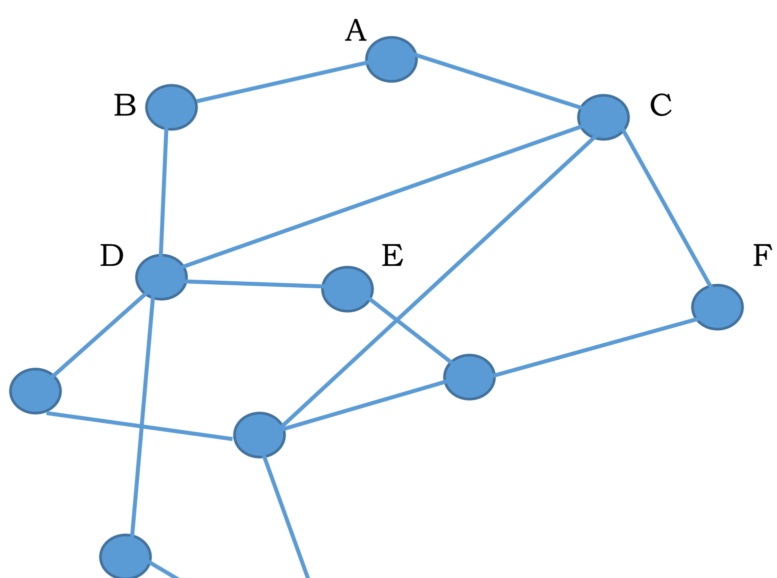
14. Suppose that Q is an equivalence relation on $\mathbb{Z}$. Answer true or false.

a. If $2Q5$, then $[5] \subseteq [2]$.

b. If $\sim(5Q42)$ then $[5] \cap [42] = [5]$.

Part V. Graphs (20 points)

15. Let G be the graph shown below.



G H I

J

K

a. Give the vertex sequence of an Euler circuit for *G* or explain why no Euler circuit exists in *G*.

b. Give the vertex sequence of Hamiltonian circuit for *G* or explain why no Hamiltonian circuit exists in *G*.

c. Find a subgraph of *G* that is isomorphic to $K_{2,2}$. Draw the subgraph with labeled vertices.

d. Find a subgraph of *G* that is a rooted tree with 2 levels (the leaves are a distance 2 from the root) that includes all of the vertices of *G*.. Draw the tree with labeled vertices and clearly indicate which vertex is the root.

Part VI. Probability and Counting (40 points)

16. A spring bouquet contains 5 red roses, 3 yellow roses, 4 yellow tulips, and 2 pink carnations. A single flower will be selected at random from the bouquet. What is the probability that

a. the selected flower will not be yellow?

b. the selected flower will be yellow or a rose?

17. A spring bouquet contains 5 red roses, 3 yellow roses, 4 yellow tulips, and 2 pink carnations. Four flowers will be taken at random from the bouquet without regard to order. What is the probability that two tulips and two roses will be taken?

18. A spring bouquet contains 5 red roses, 3 yellow roses, 4 yellow tulips, and 2 pink carnations. Four flowers will be taken at random in succession from the bouquet. What is the probability that the first and last flower taken are carnations?

19. Prove: $\binom{n+1}{k} = \frac{n+1}{n-k+1}\binom{n}{k}$

20. Suppose that A and B are events in a sample space S. Prove:
$P\left(A \cap B^C\right) = P(A) - P(B) + P(A^C \cup B)$

THE END

Assessment of MA240 Final Exam for Fall 2014

Goal: An applied mathematics major will be able to integrate and differentiate functions.

Assessment of goal: Problems 1-6, and 8-12 of the final exam required the students (directly or indirectly) to integrate or differentiate a function. Therefore, it is necessary for students to be able to integrate and differentiate functions in order to pass the final exam.

Goal: An applied mathematics major will be able to apply mathematics to at least two areas taken from biology, physics, chemistry, economics or computer science.

Assessment of goal: Problem 12 required students to apply calculus to solve an application problem. That problem is closely related to chemistry. However, the techniques used can be applied to a number of fields. Therefore, students who successfully complete this problem will be able to apply mathematics to at least two areas taken from biology, physics, chemistry, economics or computer science.

Assessment of MA340 Final Exam for Fall 2013

Goal: An applied mathematics major will be able to integrate and differentiate functions.

Assessment of goal: All problems on the final exam required the students (directly or indirectly) to integrate or differentiate a function. Therefore, it is necessary for students to be able to integrate and differentiate functions in order to pass the final exam.

Goal: An applied mathematics major will be able to apply mathematics to at least two areas taken from biology, physics, chemistry, economics or computer science.

Assessment of goal: While not explicitly application problems, problems 6-9 required using theorems that have many applications to physics.

MA340 - Final Exam - Fall 2013

Let me be your ruler. You can call me ______________________________.

Directions: Answer the following questions. Show ALL work. An answer with no work receives NO credit.

1. Consider the vector field

$$\mathbf{F}(x,y,z) = (2xe^z \sin y - \ln z)\,\mathbf{i} + \left(x^2e^z \cos y + \frac{z}{1+y^2}\right)\mathbf{j} + \left(x^2e^z \sin y + \tan^{-1} y - \frac{x}{z} + \sec z \tan z\right)\mathbf{k}$$

   (a) (8 points) Show that $\mathbf{F}$ is conservative.

   (b) (10 points) Find a function f such that $\mathbf{F} = \nabla f$.

Assessment of MA440 Final Exam for Fall 2013

Goal: An applied mathematics major will be to read and construct mathematical proofs in analysis and algebra.

Assessment of goal: Advanced calculus is the first course mathematics majors see in the more abstract area of mathematics known as analysis. A quick perusal of the final for this course will demonstrate to the reader that the entire course was devoted to reading and constructing mathematical proofs in analysis.

MA440 - Final Exam - Fall 2013

1. (10 points) TRUE or FALSE?

   (a) It is possible to find two functions f and g such that f is integrable with respect to g over $[a, b]$, but g is not integrable with respect to f over $[a, b]$.

   (b) Suppose f is Riemann integrable on $[a, b]$, and let $F(x) = \int_a^x f(t)\, dt$ for $x \in [a, b]$. It is possible that there exists $c \in (a, b)$ such that $F'(c)$ does not exist.

   (c) A function with a finite number of discontinuites over $[a, b]$ is Riemann integrable over $[a, b]$.

   (d) Let $f : [0, 1] \longrightarrow \mathbb{R}$ be bounded, and define $a_n = \frac{1}{n} \sum_{k=1}^{n} f\left(\frac{k}{n}\right)$ for all $n \in \mathbb{N}$. If $\{a_n\}$ converges, then $f \in R(x)$ on $[0, 1]$.

   (e) If f^2 is Riemann integrable over $[a, b]$, then f is Riemann integrable over $[a, b]$.

   (f) A function with infinitely many discontinuities cannot be Riemann integrable.

   (g) If f is Riemann integrable on $[a, b]$ and if $\varepsilon > 0$, then provided the mesh of the partition is small enough, we can use whatever marking of the partition we wish to approximate the value of $\int_a^b f\, dx$ to within ε of its true value.

   (h) If P and Q are partitions of $[a, b]$ with $P \subseteq Q$, then $L(Q, f) \leq U(P, f)$.

   (i) If g' exists and if f is integrable with respect to g, then $\int_a^b f\, dg = \int_a^b f g'\, dx$

   (j) Every song's like gold teeth, grey goose, trippin' in the bathroom.

2. (10 points) Let $f(x) = \begin{cases} a, & 0 \leq x < 2 \\ b, & x = 2 \end{cases}$. Compute $\overline{\int_0^1} f\, dx$ and $\underline{\int_0^1} f\, dx$. Is f integrable on $[0, 1]$? Why or why not?

3. (15 points) Answer the following.

   (a) Let $f : [a, b] \longrightarrow \mathbb{R}$ be bounded. Then $f \in R(x)$ on $[a, b]$ if and only if for each $\varepsilon > 0$ there is a partition P such that $U(P, f) - L(P, f) < \varepsilon$.

   (b) Let $f \in R(x)$ on $[a, b]$ where $f(x) \geq c > 0$ for all $x \in [a, b]$. Prove $\sqrt{f} \in R(x)$ on $[a, b]$.

4. (15 points) Answer the following.

   (a) Prove the Differentiation Theorem for Riemann-Stieltjes integrals: Suppose that f is continuous on $[a, b]$ and that g is increasing on $[a, b]$. If $g'(c)$ exists, where $c \in [a, b]$, then $F'(c) = f(c)\, g'(c)$, where $F(x) = \int_a^x f\, dg$.

   (b) Suppose f and g are continuous on $[a, b]$ with $\int_a^b f\, dx = \int_a^b g\, dx$. Prove there exists $c \in (a, b)$ such that $f(c) = g(c)$.

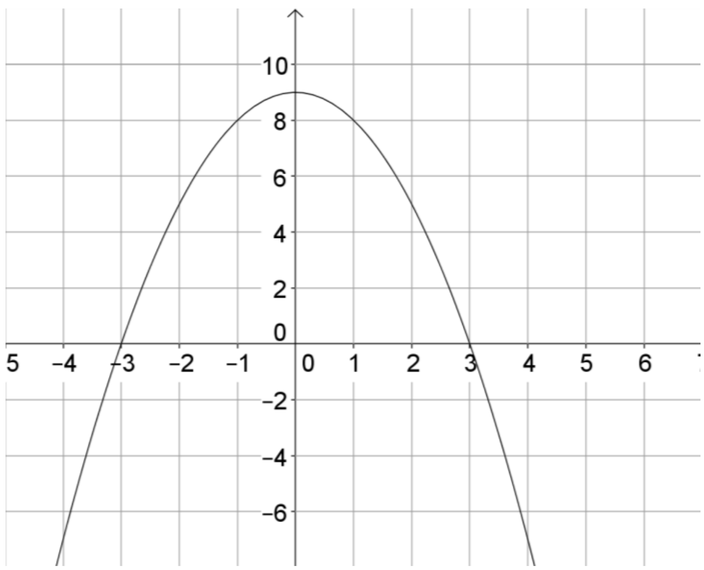
(OVER)

MA240 Final Exam

Sign in please: ____

All of the definite integrals on this exam may be worked on your calculator.

1. Write and evaluate the integral(s) that will compute the volume of the solid obtained when the shaded region is revolved about the line $y = 2$. (The parabola shown is $y = 9 - x^2$)



2. Let $f(x, y, z) = 2x^2ye^z - zx\tan z$. Find f_{zx}.

3. Find the maximum rate of change of the function $f(x, y) = 2xy - 3x^2y^2$ at the point $(2, -1)$ and the direction in which it occurs.

4. Find the equation of the tangent plane to the graph of $f(x, y) = e^x\cos(x + y)$ at the point $(0, \pi)$.

5. Find and classify the critical points. $f(x, y) = x^3 + 9xy - y^3$.

6. Evaluate the iterated integral. $\int_0^1 \int_x^1 \cos(y^2)\,dy\,dx$

7. Evaluate the double integral over the region R in the xy-plane.
$\iint_R x^2 y\,dA,\ R = \{(r,\theta) \mid 0 \le r \le 2,\ 0 \le \theta \le \pi\}$

8. Find the solution to the IVP: $x^2 y' = y(x^2+1),\ y(1) = e^2$

9. Find the solution to the IVP: $x^4 y' + x^3 y = x^3 sinx,\ y(\pi/2) = 2$

10. Evaluate $\int \frac{2x+3}{x^2+4x}\,dx$.

11. The waiting times at the corn dog stand have an exponential probability density function. The mean waiting time for a corn dog is 3 minutes. The waiting times at the beer tent have an exponential probability density function. The mean waiting time for a beer is 8 minutes. The waiting times at the corn dog stand and the beer tent are independent. What is the probability that a person who buys a corn dog and a beer will wait less than a total of 11 minutes?

12. Evaluate $\int_1^2 \frac{1}{(x-2)^3}\,dx$

13. Evaluate $\int_0^\infty 3xe^{-x^2}\,dx$

14. Suppose that x measures the time (in hours) it takes a beaver to cut down an aspen. Assume that every beaver can cut down an aspen within 3 hours and the probability density function for x is given by

$$f(x) = \begin{cases} \frac{x^3}{20} & \text{if } 0 < x < 3 \\ 0 & \text{otherwise} \end{cases}$$

a. What is the mean time for beavers to cut down aspens?

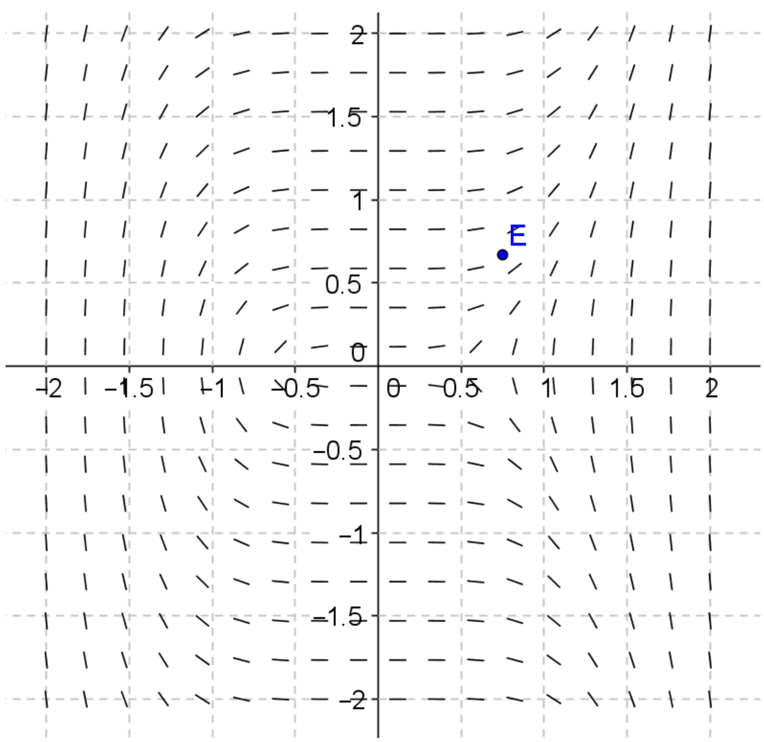
b. What is the probability that a beaver will cut down an aspen in less than 1 hour?

15. The rate of change of the population of India is proportional to the population. The population of India in the year 2000 was 1.042 billion people. In the year 2013 the population of India was 1.252 billion people. If the growth rate doesn't change, estimate the population of India in the year 2020.

16.

a. Which of the four ODEs given below has the slope field depicted?

a. $\frac{dy}{dx} = \frac{x}{y^2}$ b. $\frac{dy}{dx} = \frac{y}{x}$ c. $\frac{dy}{dx} = \frac{x^4}{y}$ d. $\frac{dy}{dx} = \frac{y^3}{x}$



b. Draw the solution to this differential equation through point E.

17. An MRI scan indicates that the cross-sectional areas of adjacent slices of tumor are given by the values in the table.

x (cm)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
A(x) (cm^2)	0.1	0.5	0.4	0.3	0.2	0.2	0.3	0.4	0.5	0.6	0.7

Estimate the volume of the tumor.

18. Find the directional derivative of $f(x,y) = 5xy - x^2y$ at the point (1,2) in the direction of $\langle 5, -12 \rangle$

19. Evaluate $\int_0^2 \int_0^3 xe^{xy} \, dx \, dy$

20. If $\Gamma(a+1)=\int_0^\infty t^a e^{-t}\,dt$, show that $\Gamma(a+1)=a\Gamma(a)$.

SOCIETY OF ACTUARIES

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Millikin University
Millikin University - Actuarial Science

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