

Millikin University  
Student Learning in the Mathematics and Computer Science Major

By Daniel Miller  
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### **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.
  - 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.
  - 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.
  - c. 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.

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. In 2009 the department eliminated the Computer Science option. Dr. Beck completed the paperwork for the Actuarial Science program to receive VEE credit for applied statistical methods (through 2011), time series (through 2013), corporate finance (through 2010), and economics (through 2010). A complete assessment of this program will be completed by Dr. Beck with consolation from the School of Business. We expect 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 2009- July 2010 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. It will take at least another year to develop the goals for the Actuarial Science option and determine if they are being met. Additionally, Mathematics Education received 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.

## 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:

4. 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.
5. 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.
  - c. 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.

### Snapshot

The Department of Mathematics guides students in the completion of three different majors: mathematics education, applied mathematics and actuarial science. Currently, 34 students are following one of our major programs of study. The Department also serves elementary education students with mathematics concentrations, currently 6.

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. (See Table 1.) The department continues to **rely heavily** on adjunct faculty for most of our developmental offerings (12 of 22).

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 (through 2011), Corporate Finance (through 2010), and Economics (through 2010).

### The Learning Story

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 prior to taking a QR course or receive an equivalent math ACT score. The Department expects 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). 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 Computer Science and 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. Applied Mathematics majors lead a graduate school like seminar their last semester.

### Assessing the Applied Mathematics Major Goals

An applied mathematics major will

1. be able to integrate and differentiate functions,

All Applied Mathematics majors are required to take and pass both Calculus I and Calculus II to graduate with an Applied 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 Applied 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 2009 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 Applied 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 Applied 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. In 2008-2009, Numerical Analysis and Differential Equations were not offered. Discrete Mathematics and Linear Algebra were offered in the spring of 2009. However, the Discrete Mathematics final is not attached as the professor who taught this course has left the university. A review of the final exams from these courses support the propositions that it would not be possible to pass these exams without the ability to express and interpret mathematical relationships from numerical, graphical and symbolic points of view. 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 Applied 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. With the exception of Discrete Mathematics, 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.

- a. Math History syllabus was collected and reviewed along with student work (see attached)

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 chair prior to student teaching. These lesson plan 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. MA425 was not offered during the 2008-2009 academic year. Lesson plans for MA471 were collected and review by the department chairperson.

4. have served as an 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 an 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. The chair has reviewed these reflections.

#### Assessing the Actuarial Science Major Goals.

An assessment program for the new actuarial science is also under development. I expect it to be in place for the fall of 2009.

#### Analysis of Assessment Results

The assessment data collected for 2008-2009 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. We will conduct our first formal assessment of the Actuarial Science program at the end of the 2009-2010 academic year.

#### Improvement Plan

Upon analysis of applied mathematics majors at other institutions, the department decided to add a new course to the applied mathematics curriculum – Advanced Calculus. This course will be offered for the first time in Spring 2011. Also, we are not certain of the necessity for Mathematics Education students to take both MA 304 and MA 220. We will revisit this issue in Fall 2009. Additionally, we will be formalizing the Actuarial Science learning goals and assessment methods, including finalizing all CoC paperwork pertaining to this major option. Finally, the department will submit CoC paperwork to end all Computer Science options within the department.

The department is engaged in opening a mathematics tutoring center and will hire a director for this center at some point in the 2009-2010 academic year. With the hiring of Dr. Paula Stickles and the hiring of the new mathematics center director, the department has an immediate and ongoing desperate need for at least one addition full-time mathematics faculty member at the instructor level. We anticipate having at least TEN uncovered classes for the Fall 2010 semester. With the retirement of Carol Sudduth, it is very difficult to find within the community enough adjuncts to cover ten courses.

Table 1. Full time faculty: Mathematics and Computer Science

| 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.          | Associate Professor | Tenured       | 1997       | Mathematics Education, Geometry, Educational Technology.       | Teaching Methods, Precalculus, Geometry, Remedial Algebra                                     |
| Joe Stickles       | Ph.D.          | Associate Professor | Tenure-track  | 2006       | Ring Theory.   | Calculus, Liberal Arts Mathematics, Abstract Algebra.   |
| Eun-Joo Lee        | Ph.D.          | Assistant Professor | Tenure-track  | 2006       | Mathematical Statistics.                                       | Statistics, Calculus.   |
| Christine Harshman | M.A.           | Instructor          | One-Year      | 2009       | Mathematics Education  | Remedial Algebra, Liberal Arts  |

Curriculum Matrix  
Applied Mathematics

|        | MA<br>1<br>4<br>0 | MA<br>2<br>4<br>0 | MA<br>2<br>0<br>8 | MA<br>3<br>0<br>1 | MA<br>3<br>0<br>3 | MA<br>3<br>0<br>4 | MA<br>3<br>2<br>0 | MA<br>4<br>7<br>1 |   | MA<br>2<br>5<br>0                  | MA<br>3<br>0<br>2 | MA<br>3<br>0<br>5 | MA<br>3<br>1<br>3 | MA<br>3<br>1<br>4 |
|--------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|---|------------------------------------|-------------------|-------------------|-------------------|-------------------|
| Goal 1 | ■                 |                   |                   |                   |                   |                   |                   |                   | ■ | ■                                  |                   |                   |                   |                   |
| Goal 2 | ■                 | ■                 | ■                 | ■                 | ■                 | ■                 | ■                 | ■                 | ■ | ■                                  | ■                 | ■                 | ■                 | ■                 |
| Goal 3 |                   |                   |                   |                   |                   |                   |                   | ■                 | ■ |                                    |                   |                   |                   |                   |
| Goal 4 |                   |                   |                   |                   |                   |                   |                   | ■                 |   |                                    |                   |                   |                   |                   |
|        | Required Course   |                   |                   |                   |                   |                   |                   |                   |   | Elective Courses<br>(Two-required) |                   |                   |                   |                   |

An applied 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.

Curriculum Matrix  
Mathematics Education

|        |                   |                   |                   |                   |                   |                   |                   |                   |   |                                    |                   |                   |                   |                   |
|--------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|---|------------------------------------|-------------------|-------------------|-------------------|-------------------|
|        | MA<br>1<br>4<br>0 | MA<br>2<br>4<br>0 | MA<br>2<br>0<br>8 | MA<br>3<br>0<br>1 | MA<br>3<br>0<br>3 | MA<br>3<br>0<br>4 | MA<br>3<br>2<br>0 | MA<br>4<br>7<br>1 |   | MA<br>2<br>5<br>0                  | MA<br>3<br>0<br>2 | MA<br>3<br>0<br>5 | MA<br>3<br>1<br>3 | MA<br>3<br>1<br>4 |
| Goal 1 | █                 |                   |                   |                   |                   |                   |                   |                   | █ | █                                  |                   |                   |                   |                   |
| Goal 2 | █                 | █                 | █                 | █                 | █                 | █                 | █                 | █                 | █ | █                                  | █                 | █                 | █                 | █                 |
| Goal 3 |                   |                   |                   |                   |                   |                   |                   | █                 | █ |                                    |                   |                   |                   |                   |
| Goal 4 |                   |                   |                   |                   |                   |                   |                   | █                 |   |                                    |                   |                   |                   |                   |
|        | Required Course   |                   |                   |                   |                   |                   |                   |                   |   | Elective Courses<br>(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.

Detailed Assessment of Selected Courses and Final Exams

## Assessment of MA 140-01 Final Exam for Fall 2009

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

*Assessment of goal:*

Differentiation: Of the 12 problems on this final exam, problems 2, 3, 4, and 5 on the calculator part, and problems 1a and 5 on the non-calculator part 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(a) on the non-calculator part required the students to understand the definition of the derivative. Problem 5 on the non-calculator part 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 2 on the calculator part required the students to apply differentiation techniques without having an explicitly stated function. Problem 3 on the calculator part required students to connect the derivative to a change in quantities with respect to time (related rates). Problem 4 on the calculator part required students to connect the derivative to optimizing a quantity given certain restrictions. Problem 5 on the calculator part required the student to connect the first derivative of a function with the function increasing or decreasing and to connect the second derivative with concavity of the function.

Integration: Of the 12 problems on this final exam, problems 1(b), 3, 4, and 6 on the non-calculator part, and problems 6(a), 6(b), and 6(c) on the calculator part either explicitly or implicitly required students to integrate some function in order to be able to solve the problem. Problem 1(b) 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. Problems 3, 4 and 6 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 6 on the calculator part 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 3 on the calculator part involved differentiation to determine the rate of change of a physical quantity with respect to another physical quantity, which is a topic from physics. Also, problem 4 on the calculator part 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.

## Assessment of MA 140-01 Final Exam for Spring 2010

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

*Assessment of goal:*

Differentiation: Of the 12 problems on this final exam, problems 2, 3, 4, and 5 on the calculator part, and problems 1a, 4, and 5 on the non-calculator part 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(a) on the non-calculator part required the students to understand the definition of the derivative. Problem 5 on the non-calculator part 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 2 on the calculator part required the students to apply differentiation techniques without having an explicitly stated function. Problem 3 on the calculator part required students to connect the derivative to optimizing a quantity given certain restrictions. Problem 5 on the calculator part required the student to connect the first derivative of a function with the function increasing or decreasing and to connect the second derivative with concavity of the function. Problem 4 on the calculator part required students to connect the derivative to a change in quantities with respect to time (related rates).

Integration: Of the 12 problems on this final exam, problems 1(b), 3, and 6 on the non-calculator part, and problems 6(a), 6(b), and 6(c) on the calculator part either explicitly or implicitly required students to integrate some function in order to be able to solve the problem. Problem 1(b) 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. Problems 3 and 6 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 6 on the calculator part 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 3 on the calculator part 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 4 on the calculator part 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 MA208 for Spring 2010

The stated goals of MA208 are:

*Applied Mathematics Goal 2:* The applied mathematics major will be able to express and interpret mathematical relationships from numerical, graphical and symbolic points of view.

*Applied Mathematics Goal 3:* The applied mathematics major will be able to read and construct mathematical proofs in analysis and algebra.

*Mathematics- Secondary Teaching Goal 1:* A mathematics education major will be able to pass the Illinois high school mathematics certification exam. This course addresses topics in number theory and combinatorics.

*Assessment of goal:*

The final exam is attached. Questions that assess Applied Mathematics Goal 2 are marked in green, those that address Applied Mathematics Goal 3 are marked in pink, and those that address Mathematics-Secondary Teaching Goal 1 are marked in yellow. Some questions address multiple goals. It would not have been possible to pass the exam without passing the questions addressing each goal.

## Assessment of MA240 Final Exam for Spring 2009

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

Questions 1-6,9,13,18 and 20 require integration. Questions 16,17,19 require differentiation. A student could not pass the exam without being able integrate and differentiate.

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

Question #7, 8 & 19 apply calculus to physics, #10 to chemistry and #11 to biology.

Note: White space has been removed for inclusion in this document.

MA240 Final Exam Spring 2009

Sign in please: \_\_\_\_\_

1. Evaluate  $\int x^2 \cos(x^3) dx$  by making the substitution  $u = x^3$ .
2. Evaluate  $\int x \ln x dx$  using integration by parts.
3. Evaluate  $\int_1^{\infty} \frac{2}{\sqrt{2x-1}} dx$ .
4. Evaluate  $\int_1^2 \frac{1}{(x-2)^3} dx$
5. Revolve the region bounded by the curve  $y = \ln(x)$ , the  $x$ -axis, and the line  $x = 2$  about the  $y$ -axis. Write an integral that represents the volume of the resulting solid and then evaluate the integral.
6. Revolve the region bounded by the curves  $y = -x^3 + 2x^2 + 5x + 2$  and  $y = 2x + 2$  in the first quadrant about the  $x$ -axis. Write an integral that represents the volume of this solid and then evaluate the integral.
7. An archer shoots an arrow from a point 5 meters above the ground at a 45 degree angle of inclination and with an initial velocity of 20 meters/second. Ignoring air resistance, find the maximum height of the arrow.

8. The acceleration due to gravity on the planet Re'em is  $20 \text{ m/sec}^2$ . A rocket is launched vertically from a platform 10 meters above the surface of Re'em with an initial velocity of 200 meters per second. Find the height and velocity of the rocket 8 seconds after launch.
9. Solve the differential equation.  $y' = \frac{xy}{2}$ ,  $y(0) = Q$
10. A pot of chili is moved from the stove top to a counter top. The temperature of the room is a constant  $66^\circ F$ . The initial temperature of the chili was  $190^\circ F$ . After sitting on the counter for 10 minutes the temperature of the soup cooled to  $150^\circ F$ . In how many more minutes will the temperature of the chili be  $100^\circ F$ ? Show your work.
11. Find the equilibrium points for the model

$$x' = 0.3x - 0.2x^2 - 0.1xy$$

$$y' = -0.2y + 0.3xy$$

12. Use Euler's method with  $h = 0.1$  to approximate  $y(1.2)$  where  $y' = \frac{xy - 4}{x + 3y}$ ,  $y(1) = 2$ .

Fill in the table with your answers.

|          |          |            |            |
|----------|----------|------------|------------|
| <b>x</b> | <b>1</b> | <b>1.1</b> | <b>1.2</b> |
| <b>y</b> | <b>2</b> |            |            |

13. Use the integral test to decide whether the series  $\sum_{k=0}^{\infty} ke^{-k^2}$  converges or diverges.

14. Use the ratio test to decide whether  $\sum_{k=1}^{\infty} \frac{(-1)^k 2^k k^2}{k!}$  the series converges or diverges.

15. Find the interval of convergence for the power series  $\sum_{k=0}^{\infty} \frac{(x-1)^k}{3^k}$

16. Find the Taylor series about  $c = -1$  for the function  $f(x) = e^{x+1}$  and determine its interval of convergence.

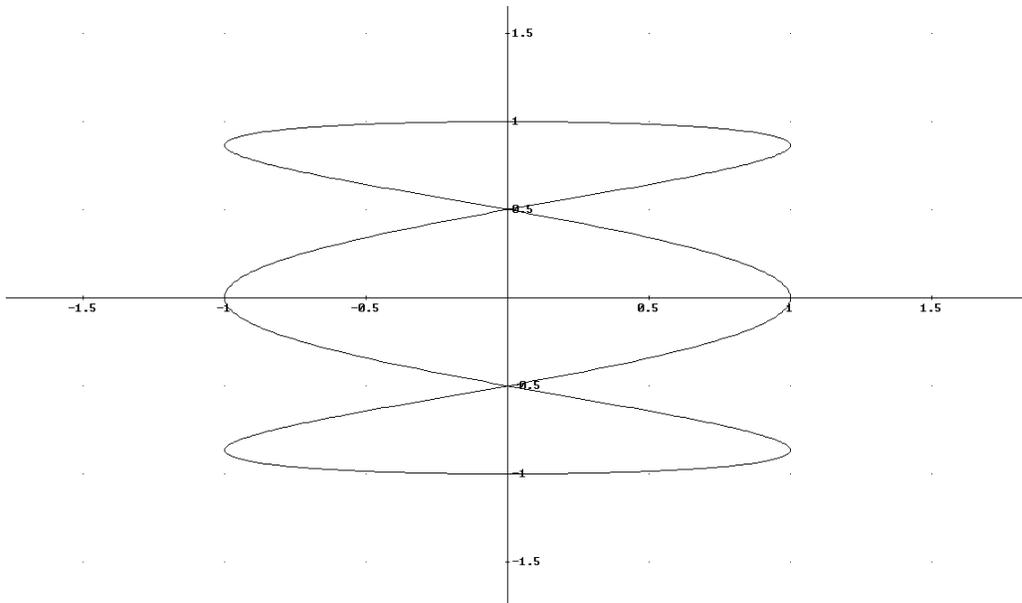
17. Find the equation of the line (in parametric form) tangent to the parametric curve

$$x = t^2 - 2t$$

$$y = t^3 + t$$

at the point (0,10).

18. Find the area of the top loop of the graph of the parametric curve  $x = \cos(3t)$  . The graph is shown below.  
 $y = \sin(t)$



19. The parametric equations for the position of an object are given. Find the object's speed at the given time and describe its motion.

$$x = 20t$$

$$y = 30 - 2t - 16t^2$$

at  $t = 2$ .

20. Consider the curve defined parametrically by

$$x = \pi t$$

$$y = 2\sqrt{t}$$

Find the length of the curve from  $t = 1$  to  $t = 2$ .

Name \_\_\_\_\_  
(20 points)

1. (20 points) Let  $\mathbf{u} = \langle -1, 2, 4 \rangle$ ,  $\mathbf{v} = \langle 0, \sqrt{2}, \sqrt{2} \rangle$ , and  $\mathbf{w} = \langle 5, 4, 3 \rangle$ . Let  $\mathbf{n}$  be the vector with its tail at  $(1,0,1)$  and head at  $(0,1,0)$ . Compute the following.

a)  $\mathbf{u} - \mathbf{w}$

b)  $\mathbf{v} \cdot \mathbf{n}$

c)  $\mathbf{u} \times \mathbf{w}$

d)  $\|\mathbf{v}\|$

2. (10 points) Determine if the following pair of lines are the same line, parallel lines, skewed lines, or intersecting lines. If the lines intersect, then find the point of intersection.

a)

| $l_1$         | $l_2$           |
|---------------|-----------------|
| $x = 2 + 4t$  | $x = 30 - 20s$  |
| $y = -4 + 2t$ | $y = 10 - 10s$  |
| $z = 36 - 8t$ | $z = -20 + 40s$ |

b)

| $m_1$         | $m_2$         |
|---------------|---------------|
| $x = 1 - 3t$  | $x = -3 + s$  |
| $y = -2 + 3t$ | $y = -2 - 3s$ |
| $z = 3 - t$   | $z = 7 + 3s$  |

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3. (10 points) Find the angle between the planes  $x + 2y + 3z = 10$  and  $x - 2y + 4z = -19$ .
4. (10 points) Find the equation of the line tangent to the graph of  $\mathbf{r}(t) = \langle 1 + t^2, \sin(\pi t), \ln(t) \rangle$  at  $t = 1$ .
5. (10 points) Find the curvature of  $\mathbf{r}(t) = \langle 2, \sin(\pi t), \ln(t) \rangle$  at  $t = 1$ .

Final Examination

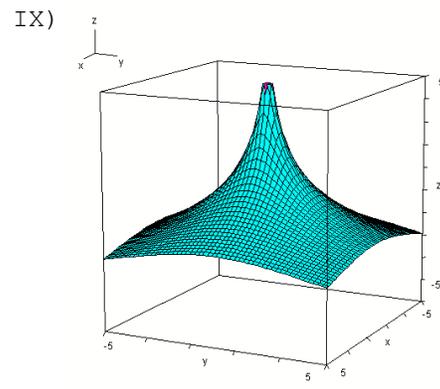
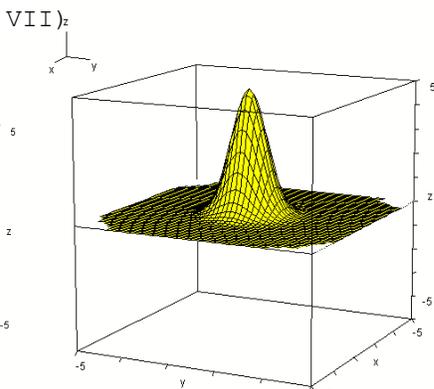
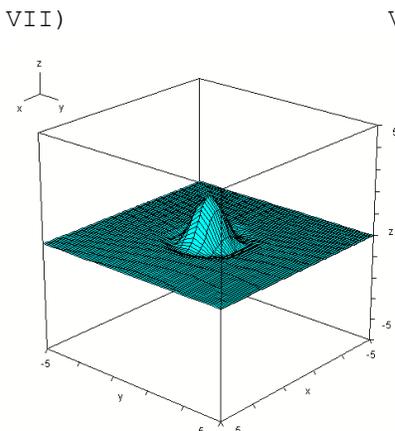
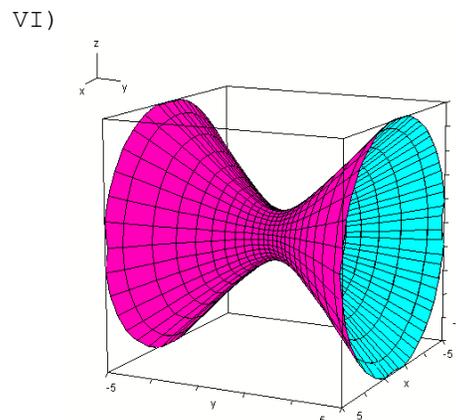
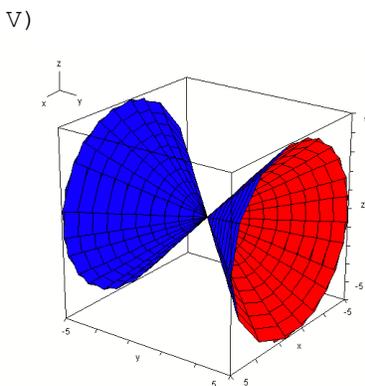
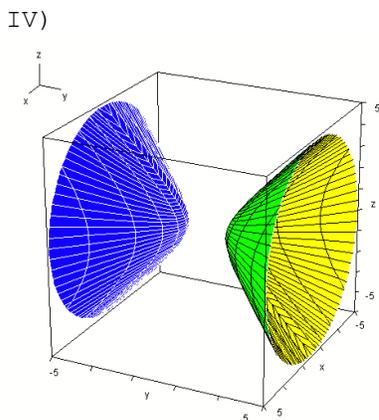
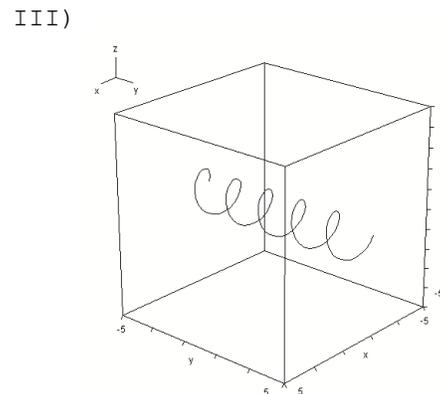
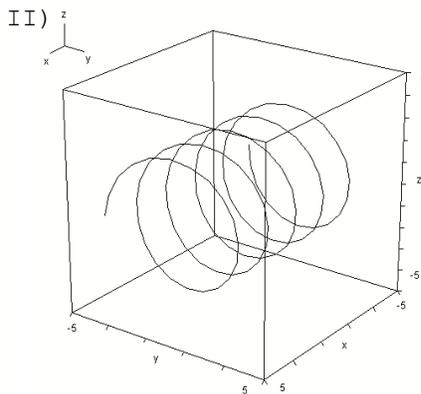
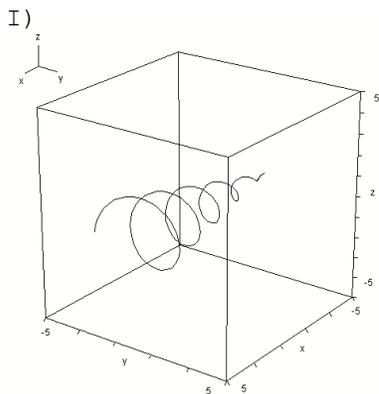
6. (16 points) Match each function or equation with its graph.

a)  $x^2 - y^2 + z^2 = 0$

c)  $f(r, \theta) = e^{-r} \cos(\theta)$

b)  $r(t) = \langle \cos(-t), t, \sin(-t) \rangle$

d)  $-x^2 + y^2 - z^2 = 1$



Bonus(5 points): Select 1 graph that was not an answer for #6 and find function  
or equation for the graph.

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**Final Examination**

7. (15 points) Let  $f(x,y,z) = xyz - 2xz^2$ . Find all first and second order partial derivatives.

8. (10 points) Find and evaluate all critical points of  $f(x,y) = (x^3 - 3x)(y^2 + 2)$ .

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9. (20 points) Compute.

a) 
$$\int_1^4 \int_0^2 6xy^2 \, dy \, dx$$

b) 
$$\int_0^1 \int_{\sqrt{y}}^1 3e^{x^3} \, dx \, dy$$

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**Final Examination**

10. (10 points) Find the absolute maximum and minimum and the points where they occur for the function  $f(x,y) = xy$  subject to  $x^2 + y^2 \leq 4$ .

**Assessment of MA 303 01 Final Exam for Spring 2009**

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

*Assessment of goal:*

Problems 5(b), 6, 7, 8, 9, 10 on the take-home portion of the final and problems 2 and 5 on the in-class portion of the final require students to construct algebraic proofs. Since these problems comprise almost half of the final exam, it is necessary for students to be able to read and construct mathematical proofs in algebra in order to pass the final exam.

**Assessment of MA305- Differential Equations**

**This Course was not offered during this academic year.**

**Assessment of MA 313- Numerical Analysis**

**This Course was not offered during this academic year.**

**Assessment of MA320 for Spring 2010**

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

*Assessment of goal:*

The final exam is attached. Questions directly addressing the goal are marked in pink. Students would have been unable to pass the final exam or the course without a knowledge, in broad terms, of algebra, calculus and probability.

**See Departmental copy for exam.**