Department of Mathematics

Assessment Program

November 2008
Original Assessment Plan
ASSESSMENT PLAN FOR THE MATHEMATICS MAJOR

The Department of Mathematics offers degree programs leading to the BA and BS degrees in mathematics. A departmental committee was formed to devise a plan to provide ongoing assessment of the mathematics major. The committee solicited the input of the entire department, and the proposal was approved by the faculty.

1. Goals of the Program

Recipients of an undergraduate degree in mathematics are expected to understand and apply:

- basic real analysis of one variable;
- calculus of several variables and vector analysis;
- basic linear algebra and theory of vector spaces;
- concerted study of at least one advanced topic of mathematics, chosen from: advanced calculus, abstract algebra, set theory and logic, probability and statistics, partial differential equations, and numerical analysis.

In addition, they are expected to acquire the ability and skills to:

- give direct proofs, proofs by contradiction, and proofs by induction;
- formulate definitions and give examples and counterexamples;
- read mathematics without supervision;
- follow and explain algorithms; and
- apply mathematics to other fields.

Degree Requirements. For the BA degree in mathematics, students must complete 21 credit hours in mathematics courses numbered above 300, including

- Math 321 (an introduction to understanding and writing formal proofs),
- 3 credit hours in a writing-intensive mathematics course,
- 6 credit hours in a sustained two-course sequence approved by the department.

For the BS degree in mathematics, students must complete 24 credit hours in mathematics courses numbered above 300, and 15 credit hours in additional upper division mathematics courses or appropriate non-introductory courses in the natural or information sciences, including

- Math 321,
- 6 credit hours in writing-intensive mathematics courses,
- 6 credit hours in a sustained two-course sequence approved by the department.
In addition, students in the BS program must demonstrate ability to program scientific problems on a computer by passing one of an approved list of courses.

The Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America established national guidelines for the mathematics major in its 1991 report [1]. The CUPM Report lists seven components which form the structure of the mathematical sciences major:

- **A. Calculus (with differential equations),**
- **B. Linear algebra,**
- **C. Probability and statistics,**
- **D. Proof-based courses,**
- **E. An in-depth experience in mathematics,**
- **F. Applications and connections,**
- **G. Track courses, departmental requirements and electives.**

All of our mathematics majors take linear algebra. Most mathematics majors at UH Manoa take probability and statistics; it has been suggested that this be added as a requirement for the major. Our requirements fit the national guidelines well. The degree requirements also correspond well to the departmental “Goals of the Program” given above.

Other MAA guidelines for the mathematics major, taken from [3], include that the department should provide:

- quality faculty advising,
- undergraduate seminars,
- special meeting rooms for majors,
- undergraduate research opportunities.

Math majors are encouraged to see their adviser at least once per semester (and are required to do so once per year). We have weekly undergraduate seminars and a lounge for math majors.

## 2. Assessment Plans

Assessment practices in mathematics departments at American colleges and universities are described in the MAA book *Assessment Practices in Undergraduate Mathematics* [2]. The departments described therein use a variety of techniques for assessing the major program:

1. capstone seminars,
2. senior projects or presentations,
3. standardized exams,
4. departmental exams for assessment,
5. comprehensive exams,
6. alumni questionnaires,
7. portfolios,
8. focus groups.
Most departments use more than one method. We use a capstone seminar, which includes a senior paper and presentation and a departmentally devised assessment exam, while continuing our use of alumni questionnaires. In addition, we keep track of what courses our graduating seniors actually took; i.e., we assess how they are actually meeting the major requirements.

**Capstone Seminar.** The Mathematics Department has a one-credit capstone seminar, Math 480, required of senior mathematics majors.

Each student in the seminar is required to write a short paper on a mathematical topic, and to present it to the seminar. This provides our majors with a research experience not available in most courses. It provides faculty representatives with an opportunity to evaluate the graduating seniors as a group. The faculty member responsible for the seminar provides a report to the department indicating the strengths and weaknesses of that group of students. This is part of the assessment.

To receive credit, a student has to present an acceptable paper and take the assessment examination. The assessment exam does not affect the student’s grade for the course. It serves as one of the department’s objective assessment tools.

The articles on Saint Mary’s College, Kutztown University and Wabash College in [2] provide detailed accounts of those institutions’ experience with capstone courses.

**Assessment Examination.** The design of the examination is crucial to the effectiveness of the department’s evaluation. It is divided into three parts. The first part tests the student’s retention of basic calculus and linear algebra. The second part tests the student’s ability to produce and write elementary proofs and examples, that is, to think mathematically. The third part contains questions from each of the six specializations available in our program, and the student is asked to answer only questions relevant to the courses he or she has taken (and to indicate on the exam which these are). The exams are graded, summarized, and the summary results distributed to the faculty.

The articles on Franklin College, Ball State University and Wabash College in [2] provide detailed accounts of those institutions’ experience with a variety of assessment and comprehensive examinations.

**Alumni Questionnaires.** The Mathematics Department sends questionnaires to all mathematics majors after graduation. The response rate has varied, but averages close to 50%. Most respondents write favorably of their experience as math majors at UHM. The results are summarized and reported regularly to the faculty.

The model program in this area is that of the Department of Statistics at Iowa State University, described in detail in [2].
REFERENCES


Goals of the Program

Recipients of an undergraduate degree in mathematics are expected to learn, understand, and be able to apply:

- calculus in one and several variables,
- linear algebra and the theory of vector spaces,
- several mathematical topics at the junior and senior level,
- in depth at least one advanced topic of mathematics, an approved two-course sequence.

In addition, students are expected to acquire the ability and skills to:

- develop and write direct proofs, proofs by contradiction, and proofs by induction,
- formulate definitions and give examples and counterexamples,
- read mathematics without supervision,
- follow and explain algorithms,
- apply mathematics to other fields.

Finally, recipients of an undergraduate degree in mathematics are expected to have learned about research in mathematics.
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<td>Course Number</td>
<td>Math or Service</td>
<td>PG1 Goal: Learn, understand, and be able to apply calculus in one and several variables</td>
<td>PG2 Goal: Learn, understand, and be able to apply linear algebra and the theory of vector spaces</td>
<td>PG3 Goal: Study and learn several mathematics topic at junior and senior level</td>
<td>PG4 Goal Study and learn in-depth advanced topic (sequence)</td>
<td>Sk1 Skill: Develop and write direct proofs, proofs by contradiction, and proofs by induction.</td>
<td>Sk2 Skill: Formulate definitions and give examples and counter examples.</td>
<td>Sk3 Skill: Read mathematics without supervision.</td>
<td>Sk4 Skill: Follow and explain algorithms.</td>
<td>Sk5 Apply mathematics to other fields.</td>
<td>R Learn about research.</td>
<td>I Introduced</td>
<td>C Continued</td>
<td>E Emphasized</td>
<td>A Assessed</td>
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Assessment Exam

Instructions and Problems for one Course
Mathematics Department Assessment Exam

Due: May 16th, 2008 at 10:00 am

You should not need or use a calculator or computer for this exam. This is a take home exam. You may use books and notes, but you should work alone on this exam. It is reasonable to spend 30 to 60 minutes on each 400 level course for which you decide to attempt the problems. Some courses change from year to year, and you may come across questions that you are not prepared to answer. Please tell us how much time you spend on each part. We hope you enjoy working on these problems. Good Luck!

Circle the mathematics courses you’ve taken.


Part III Problems from Senior Courses

3.1 Math 412–413

Problem 1. Find (up to isomorphism) all groups with at most eight elements.

Problem 2. Let $G = \langle G, +, -, 0 \rangle$ be an abelian group such that $77x = 0$ for all $x \in G$. Prove that $G = H \oplus K$ where $H$ and $K$ are subgroups of $G$ satisfying $7x = 0$ and $11x = 0$, respectively.

Problem 3. Let $R$ be a commutative ring, and fix an element $a \in R$. Show that $J = \{ r \in R : ra = 0 \}$ is an ideal of $R$.

Problem 4. Let $G$ be a finitely generated group.

1. Prove that every proper subgroup $H < G$ is contained in a maximal proper subgroup.

2. Show that the intersection of all the maximal proper subgroups of $G$ is a normal subgroup.
Sample Syllabus with Program Goals
Math 321 – Introduction to Advanced Mathematics (3)

Formal introduction to the concepts of logic, finite and infinite sets, functions, methods of proof and axiomatic systems. Learning mathematical expressions in writing is an integral part of the course.

Pre: 243 or 253A (or concurrent) or consent

This course is primarily a methods course. It should focus on teaching students to understand, devise and communicate mathematical arguments. This includes both proofs and examples/counterexamples. Topics should include:

- logic,
- proof by induction,
- set theory,
- simple axiomatic systems.

The systems considered could be from calculus, group theory, ring theory, field theory, point set topology, metric spaces, incidence geometry, or any other subject that does not require an extensive background.

Math 321 is taught only in a writing-intensive format. The course is normally run as a seminar, with few lectures. Students are often required to give presentations in class. It is useful to have students critique each other’s presentations.

Clear, concise writing that captures the essence of an idea characterizes good mathematical writing. Towards that end, the student learns to read and understand mathematical definitions, and to read, understand, and write mathematical proofs.

With a few exceptions (e.g., truth tables), the class assignments will involve the writing of proofs, or the explanation of examples or counterexamples. (This includes both homework and exams.) These assignments are of course collected and graded. The instructor should insist that assignments be written legibly using proper grammatical English, with an effort towards clarity and conciseness. Most students will have had little prior experience in writing mathematics, so instructor feedback is essential in obtaining this goal. Poorly written assignments should be returned (with comments) to the student, who must then rewrite and resubmit the work for grading. Help for the student should come in the form of frequent and detailed grading of homework, solutions of problems in class exemplifying good exposition, and individual work with students in the office.

For writing intensive courses, the instructor should insure that the writing assignment, when properly written at an elementary level, would occupy at least 16 typewritten pages. More typical would be assignments totalling 4–6 handwritten pages per week.
If written work (including homework and take–home exams, but not in–class exams) does not make up at least 40% of a student’s course grade, the class syllabus must include the following statement: “Students must adequately complete all writing assignments to pass the course with a D grade or better. Students who do not complete all writing assignments will fail the course”.

Recommended Text: A Transition to Advanced Mathematics by Smith, Eggen, St. Andre. (There are a number of other excellent texts available for this course, including Chapter Zero, Fundamental Notions of Abstract Mathematics by C. Schumacher and How to Read and Do Proofs by D. Solow.)

Course Objectives and Student Learning Outcomes. Upon successful completion of Math 321, the student will be able to

- Develop and write direct proofs, proofs by contradiction, and proofs by induction (emphasized)
- Formulate definitions and give examples and counterexamples

Program Objectives. In this junior level course students are introduced to basic methods of proof that are common to many areas of mathematics. Students will learn to write mathematical proofs (W) and may be required to do some reading without supervision.
Current Efforts

• Annual assessment cycle: Offer our Capstone Senior Seminar (Math 480). As part of it we give the assessment exam (participation is required to receive credit for the course, low stakes). The Assessment Committee revises the exam annually, with the help of those faculty members who teach senior level classes. The Assessment Committee grades the exam and writes a report on the findings. This report together with a report of the instructor of the Math 480 constitutes the Assessment Report, which is presented and discussed during the first fall faculty meeting.

• Based on the findings the Assessment Committee may make suggestions that are then discussed in the Curriculum Committee and presented during a faculty meeting for possible action.

• Because the exam was low stakes and take-home, some students did not try their best on the exam. For this reason we have been experimenting with the format of the exam. We have broken the exam up, so that later parts of the exam do not suffer because the students grew tired of it. This spring we will give the first two parts in class (during to separate class meetings). For this length of time we expect that the students will work seriously on the test. We also experimented with a high stakes component. For two courses we took a couple of problems from the fall semester final, the Assessment Committee graded them independently of the instructor, and drew conclusions for the Assessment Report.
We experimented with the technical set-up of running an assessment exercise in a large, low-level class (how well are we able to implement FS Hallmarks in Math 100, a class with sections of 350 students). Technically we can do it, statistically we can evaluate the results, and the outcome was encouraging.
Lessons Learned

- The *Department Assessment Exam* provides a detailed insight into how much students have learned in individual classes. This is sometimes less than what we expected, and we have learned to be more realistic about the quality of our students, and what we are able to teach them.

- The effort of assessing our program has raised the awareness among the faculty. More professors feel accountable for their success, or lack thereof.

- Through the work of our curriculum committee we have always assessed our program on a continuous basis and made changes to the program. Having an official assessment program legitimizes the process. It may not improve it.

- Real assessment cannot content itself with easily measured, superficial criteria of success. Such a process cannot give justice to a four or five year course of study that is supposed to lay the foundations to a successful lifelong career.

- Assessment is a wasted effort if there are no resources to implement indicated changes.

- Typical assessment as designed and imposed from above leads to an emphasis on formal aspects of the program, and misdirects the attention.
Assessment can be deceiving.