Illustrative Resources for *CUPM Guide 2004*

online at `www.maa.org/cupm/`

This online document describes a variety of experiences and resources associated with the *CUPM Guide2004*, following the organization in Parts I and II. As a major part of the development of this document, CUPM made a broad request for reports on experiences from individuals who had in recent years implemented various ideas discussed in earlier drafts of the *CUPM Guide 2004*, including specific requests to departments with large numbers of majors and/or recent NSF or FIPSE awards for curricular projects. (See Appendix 1 for additional details on the gathering of information.) There was a large response to the CUPM request, and thanks are due to the many mathematics faculty who gave generously of their time and wisdom. The contributed examples, experiences and resources were instrumental in developing this document, and they provided evidence that the CUPM recommendations are indeed feasible. References to many of these contributions are made in the Illustrative Resources

> The experiences described or referred to in the Illustrative Resources for *CUPM Guide 2004* are far from exhaustive. They were not endorsed by CUPM, nor is there an implication that they represent better practice than other implementations not included there. Rather they are offered as experiences and ideas that appear interesting and may serve as a starting point for those considering enhancement of components of their department's programs.
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> CUPM invites all members of the mathematical sciences community to report on additional resources they have successfully used or developed to work toward the recommendations in *CUPM Guide 2004*. They should be submitted to `cupm@maa.org`. The Illustrative Resources will be updated and expanded periodically.

Most entries in the Illustrative Resources include a link to a web address that describes a site containing further material or provides a means of contacting a person or department for additional information. An annotated bibliography with additional reference information is at the end of the Illustrative Resources.

The following pages give an indication of what the Illustrative Resources contains.

CONTENTS OF ILLUSTRATIVE RESOURCES (September 2003)

Part I. Recommendations for Departments, Programs, and all Courses in the Mathematical Sciences

1. Understand the student population and evaluate courses and programs

Understanding Entering Students via Placement Exams
Understanding Entering Students via Mathematical Autobiography
Advising Students—Understanding their Goals
Understanding and Supporting Strong Students
Efforts to Assess Undergraduate Mathematics Programs
Supporting Faculty and Department Efforts in Assessment of Undergraduate Mathematics
Assessment Tools in the Classroom
Gathering Information about Students and Alumni to Improve Programs

2. Develop mathematical thinking and communications skills

Inquiry-Based Learning
Research on Student Difficulties with Reasoning and Problem Solving
Reasoning and Logically Working to Conclusions
Problem-Based Learning and Unstructured Problems
Strategies for Problem Solving
Problem Posing
Efforts to Improve Student Reading
Developing Students' Ability to Read Mathematical Writing
Student Classroom Discussions
Getting Started—Writing and Expressing Mathematics
Evaluating and Assessing Students' Skills in Communicating Mathematics
Rubric for Grading Mathematical Writing Assignments
Additional Resources

3. Communicate the breadth and interconnections

Key Ideas and Concepts
Multiple Approaches/Perspectives
Examples and Applications
Contemporary Topics
Enhance Perception of Vitality and Importance of Mathematics
Additional Resources

4. Promote Interdisciplinary Cooperation

Connecting with other Disciplines within a Mathematics Course
Developing Interdisciplinary Courses
Curriculum of Interdisciplinary Projects
Developing Interdisciplinary Programs
Additional Resources

5. Use computer technology to support problem solving and understanding

Demonstrations for Understanding and Visualization
Exploration, Conjecture and Proof
Using Computer Language
Integrating Technology Tools
Introductory Mathematics with Technology
Additional Resources

6. Provide faculty support for curricular and instructional improvement

Teaching and Learning
Faculty and Professional Development Programs
Successful Practices at Specific Institutions
Additional Resources

Part II. Additional Recommendations Concerning Specific Student Audiences

A. Students taking general education or introductory collegiate courses in the mathematical sciences

A.1. Offer suitable courses
Offering Engaging Courses
Engaging Students in Project Work
Quantitative Literacy
Developing Mathematical and Quantitative Literacy Across the Curriculum
Offering Choices to Satisfy a General Mathematics Requirement
Examples of Introductory Course Syllabi
Support for Faculty Teaching Developmental Mathematics

A.2. Examine the Effectiveness of College Algebra
Refocusing College Algebra
College Algebra — New Approaches

A.3. Ensure the effectiveness of introductory courses
Pre-Calculus—New Approaches
Integrating Pre-Calculus and Calculus

B. Students majoring in partner disciplines & prospective teachers

B.1. Promote interdisciplinary collaboration
Strengthening Mathematics Courses to Support Future STEM Study
Course Pairings
(See C.5 for Interdisciplinary Majors)

B.2. Develop mathematical thinking and communication
Improving Students' Abilities to Think about and Do Mathematics
Research on Teaching and Learning
Programs to Promote Mathematical Insight into All Disciplines
Writing in Introductory and Service Courses

B.3. Critically Examine Course Prerequisites
Prerequisites
Including three-dimensional topics in the first year.

B.4. Pre-service elementary (K–4) and middle-school (5–8) teachers
Guidance to Colleges and Universities
Programs for Elementary Teachers
Programs for Middle School Teachers
Research to Practice—Elementary and Middle School Teachers
Programs for Mathematicians Teaching Future Teachers

C. Students majoring in the mathematical sciences

Examples of Effective Majors
Examples of Programs at Schools with a Large Number of Mathematics Majors
Additional Resources

C.1. Develop mathematical thinking and communication skills
Reasoning and Problem-Solving
Workshops for Mathematics Majors
Inquiry-Guided Learning
Learning through Proof
Developing Ideas of Formal Proof
Writing, Reading and Exploring Proofs
Gain Experience in Careful Analysis of Data
For Mathematics Majors—Reading, Writing and Expressing Mathematics
Evaluating and Assessing Majors' Skills in Communicating Mathematics
Draft Outline of Assessment Plan for Sample Learning Outcome

C.2. Develop skill with a variety of technological tools
Technology and Interactive Learning
Visualization
Linear Algebra—Computer/Technology-Based Texts and Courses
Calculus and Differential Equations—Computer/Technology-Based Texts and Courses
Web/Computer-Based Courses

C.3. Provide a broad view of the mathematical sciences
Discrete Mathematics and Data Analysis
Geometry and Geometric Thinking
Statistics and Probability and Data Analysis
Linkages—Algebra and Discrete Mathematics
Linkages—Algebra and Geometry
Linkages—Number Theory and Geometry
Linkages—Complex Variables and Geometry
Linkages—Probability and Matrix Algebra, Probability and Analysis
Powerful Applications and Contemporary Questions
Breadth of Mathematics and Connections to other Disciplines
Broader and More Flexible Major

C.4. Require study in depth

Pairs of Courses
Capstone Courses and Projects

C.5. Create interdisciplinary majors

Joint Majors

C.6. Encourage and nurture mathematical sciences majors

Prioritizing Introductory Courses
Encouraging Prospective Majors from Under-represented Groups
Providing Career Information
Mentoring and Advising Mathematics Majors
Co-Curricular Activities for Mathematics Majors
Student Assistants and Mentors

D. Mathematical sciences majors with specific career goals

D.1. Majors preparing to be secondary (9–12) school teachers

Connecting Students' Learning to their Future Teaching
Geometry
Capstone Courses for Secondary Teachers
Programs for Mathematicians Teaching Future Teachers
Collaboration with Local School Districts

D.2. Majors preparing for the non-academic workforce

Skills Needed for Industry
Advising and Mentoring for the Nonacademic Workforce
Internships and Summer Research
Professional Master's Degree
Additional Resources

D.3. Majors preparing for post-baccalaureate study in the mathematical sciences and allied disciplines

Internships and Summer Research
Special Programs for Graduate School Preparation
Mentoring and Supporting Underrepresented Students
Advising Mathematics Students
Program Examples

Annotated Bibliography