Foreward

"Hence we must believe that all the sciences are so interconnected, that it is much easier to study them all together than to isolate one from all the others. If, therefore, anyone wishes to search out the truth of things in serious earnest, he ought not select one special science, for all the sciences are cojoined with each other and interdependent."
-- Descartes

This volume focuses on how mathematicians, engineers, and physical scientists view the role of undergraduate core mathematics (the first two years of instruction) over the next five to ten years. The major perspectives considered in this analysis of the courses (primarily calculus) include the goals and contents of the courses, the anticipated advances in technology, the development of a more interdisciplinary academic culture, and the instructional techniques associated with these teaching core courses. The genesis of this volume was a workshop held at the United States Military Academy, sponsored by the National Science Foundation (through Project INTERMATH, as part of the Mathematics Across the Curriculum (MATC) initiative) and the Mathematical Association of America (through the Committee on the Undergraduate Program in Mathematics (CUPM) and its subcommittees Calculus Reform and the First Two Years (CRAFTY) and Mathematics Across Disciplines (MAD)). The proceedings editors were the organizers and coordinators of the workshop. They wish to thank the participants and several administrative assistants: Nelson Emmons, Connie Arndt, Loren Eggen, and Andrew Weate. Special thanks is also given to Dr. William Wulf, President of the National Academy of Engineering, for providing an inspiring keynote address on the "Urgency of Engineering Education Reform."

In this volume, disciplinary experts in mathematics, physics, and engineering attending the workshop identify issues, make findings and recommendations, suggest example assessments, and produce action plans for future implementations. Some of the questions analyzed and discussed in the volume include:

<u>Goals and Content</u>.

- What are the important and difficult content choices?
- How should we balance theoretical understanding with computational skills?
- How should we match goals to the intended audience?
- How do modeling and applications fit into the curriculum?
- What are “high standards” and how can they be achieved?
- When should calculus be taught and what other courses are needed?

<u>Technology</u>.

- How should technology affect what and how we teach?
- What are the strengths/drawbacks of different technology choices?
- How should we match technology choices to the intended audience?
- What are the possible effects of future technology?

<u>Interdisciplinary Culture</u>.

- What is the impact of mathematics reform on the partner disciplines?
- How should science education reforms affect mathematics instruction? (and vise versa)
- How is mathematics effectively integrated into the undergraduate curriculum?
- When should calculus be taught and what other courses are needed?
- How is on-going involvement of the partner disciplines maintained?

Instructional Techniques.

What are the strengths/drawbacks of different instructional methods?
How should we choose and integrate various instructional methods?
What methods best increase success of underrepresented groups?
How does the learning media affect reading, writing, and problem solving?
How should we build theoretical understanding?
How should we align the “achieved curriculum” and the “intended curriculum”?
What guiding principles arise from educational research?
Should Calculus be a laboratory (discovery) course?
How should we assimilate the skills-proficient high school students?

Some of the general recommendations considered by the working groups and individual participants include:

1. In 2005, we should teach the following course/topics in core mathematics:
2. In 2005, we plan to use the following technologies/methodologies in teaching mathematics:
3. In 2005, we plan on having established the following interdisciplinary culture:
4. In 2005, we expect the partner disciplines in physics and engineering will provide the following support (technology, pedagogy) for the core mathematics program:
5. By 2010, we hope the mathematics reform has produced the following improvements in physics and engineering programs:
6. Examples of the important types of problems students should be able to solve after 2 years of core math:
7. Action Plan: What do we need to do to accomplish/implement the recommendations we made?
8. Follow up: Do you plan to change anything as a result of this workshop? --or-- What will you do to accomplish/implement the ideas of the workshop?

These proceedings are part of the CUPM's study of the undergraduate mathematics curriculum, specifically launching CRAFTY's analysis of the first two years of the college mathematics program. This volume contains foundational materials that are based on the MAD committee's study of the interdisciplinary needs of our students and provides a basis for the construction of the core mathematics curriculum for the first two years of college. These foundational materials include

- expectations on the skills to be attained (outcomes)
- problems that ought to be solvable after two years of study (outcomes)
- the nature of assessment tools that should be employed
- the “learning environments” that students should be exposed to (process)
- examples of how these expectations can be met in the form of possible topics, courses, and course sequences.

This volume contains 25 articles written by workshop participants and summaries of the workshop's findings and recommendations written by the editors. The sections of the volume are: interdisciplinary culture, technology, goals and content, instructional techniques, and assessment and curriculum proposals. The participants (by discipline) were as follows:

Engineers:

Jim Dally	Maryland (emeritus)
Jeff Froyd	Rose-Hulman
Mary Goodwin	Iowa State Univ.
Jack Grubbs	Tulane
Mike McGinnis	USMA
Richard Plumb	SUNY Binghamton
Steve Ressler	USMA
Andre Sayles	USMA
John Scharf	Carroll College
Bob Soutas-Little	Michigan State
Bill Vanbuskirk	New Jersey Institute of Technology
Bill Wulf	President, National Academy of Engineering

Physicists:

Bob Fuller	Nebraska (visiting USMA)
Heidi Mauk	USAFA
Tom Lainis	USMA
Jim Stith	American Institute of Physics

Mathematicians:

Don Albers	Mathematical Association of America
Chris Arney	USMA
Bill Barker	Bowdoin College (CRAFTY)
Lida Barrett	USMA-emeritus
Tom Berger	Colby College (CUPM)
Lisette dePillis	Harvey Mudd College
Ray Cannon	Baylor (visiting USMA)
John Dossey	Illinois State University
Penny Dunham	Muhlenberg
Laurette Foster	Prairie View A&M
Frank Giordano	COMAP (MAD)
Bill Haver	Virginia Commonwealth
Gary Krahn	USMA
James Lightborne	National Science Foundation
Dave Lomen	University of Arizona
Joe Myers	USMA
Shirley Pomerans	University of Tulsa
Fred Rickey	USMA
Don Small	USMA
Kathi Snook	USMA
Elizabeth Teles	National Science Foundation
Frank Wattenberg	Texas Instruments
Brian Winkel	USMA
Lee Zia	National Science Foundation
Paul Zorn	St. Olaf College

Workshop Agenda

Thursday, 4 Nov

7:30-8:45 PM Organization (Description of the workshop, Introduction of participants)

Friday, 5 Nov

8:30-9:30 AM Keynote and Interdisciplinary Address (Bill Wulf)
9:30-10:30 AM Panel discussion on Interdisciplinary Culture
10:45-noon Group meetings to discuss assigned topics and issues
1:30-2:15 PM Major address on Technology (Charlie Patton)
2:15-3:15 PM Panel discussion on Technology
3:30-4:30 PM Group meetings to discuss assigned topic and issues
4:30-5:00 PM USMA Math-Physics briefing
7:15-8:00 PM History of calculus reform and status of calculus reform

Saturday, 6 Nov

8:30-9:00 AM Major address on Goals & Content (Don Small)
9:00-10:00 AM Panel discussion on Goals & Content
10:30-11:00 AM Major address on Instructional Techniques (Kathi Snook)
11:00-noon Panel discussion on Instructional Techniques
1:00-2:45 PM Group meetings to discuss assigned topic and issues
2:45-5:00 PM Group presentations & discussions (issues, recommendations)
7:15-8:00 PM Status of interdisciplinary activities

Sunday, 7 Nov:

9:00-10:30 AM Develop examples & produce action plans

Workshop Participants

1. Don Albers	MAA
2. Bill Barker	Bowdoin College
3. Lida Barrett	USMA-retired
4. Tom Berger	Colby College
5. Jim Dally	Maryland-emertius
6. Lisette dePillis	Harvey Mudd College
7. John Dossey	Illinois State University
8. Penny Dunham	Muhlenberg
9. Mary Goodwin	Iowa State Univ.
10. Laurette Foster	Prairie View A&M
11. Jeff Froyd	Rose-Hulman
12. Frank Giordano	COMAP
13. Jack Grubbs	Tulane
14. Heidi Mauk	USAFA
15. Bill Haver	VA Commonwealth
16. Jim Lightbourne	NSF
17. Dave Lomen	University of Arizona
18. Charlie Patton	Sci Math Tech serv
19. Richard Plumb	SUNY Binghamton
20. Shirley Pomeranz	University of Tulsa
21. John Scharf	Carroll College
22. Bob Soutas-Little	Michigan State
23. Jim Stith	AIP
24. Liz Teles	NSF
25. Bill Vanbuskirk	NJ Inst of Tech
26. Frank Wattenberg	Texas Instruments
27. Bill Wulf	NAE
28. Lee Zia	NSF
29. Paul Zorn	St. Olaf College

<u>West Point Group</u>

1. COL Chris Arney (Math)
2. Professor Ray Cannon (Math, visiting from Baylor)
3. LTC Pat Driscoll (Math)
4. Professor Bob Fuller (Physics, visiting from Nebraska)
5. LTC Gary Krahn (Math)
6. COL Tom Lainis (Physics)
7. LTC Mike McGinnis (Engineering)
8. LTC Joe Myers (Math)
9. LTC Steve Ressler (Engineering)
10. Professor Fred Rickey (Math)
11. COL Andre Sayles (Engineering)
12. Professor Don Small (Math)
13. LTC Kathi Snook (Math)
14. MAJ Bill Wilhelm (Math)
15. Professor Brian Winkel (Math)

Group Assignments and Speakers

Groups		Additional Members
Interdisciplinary	**Bill Wulf (Presenter)**	
Panelists	(M) Brian Winkel - Moderator	(M) Tom Berger
	1 (P) Jim Stith	(E) Bill VanBuskirk
	2 (P) Bob Fuller	(E) Mary Goodwin
	3 (M) Gary Krahn	(E) Jim Dally
	4 (E) Jack Grubbs (facilitator)	(M) Don Albers
Technology	**Charlie Patton (Presenter)**	
Panelists	(M) Lisette dePillis (Moderator)	(M) Joe Myers (facilitator)
	1 (M) Frank Wattenberg	(M) Penny Dunham
	2 (E) Bob Soutas-Little	(E) Andre Sayles
	3 (P) Heidi Mauk	(M) P.J. Driscoll
	4 (E) John Scharf	(M) Lee Zia
Goals & Contents	**Don Small (Presenter)**	
Panelists	(M) John Dossey - Moderator	(M) David Lomen
	1 (M) Jim Lightborne	(M) Frank Giordano (facilitator)
	2 (M) Bill Wilhelm	(M) Fred Rickey
	3 (M) Paul Zorn	(M) Laurette Foster
	4 (E) Jeff Froyd	
Instructional	**Kathi Snook - (Presenter)**	
Panelists	(M) Lida Barrett - Moderator	(M) Chris Arney (facilitator)
	1 (M) Bill Haver	(M) Bill Barker
	2 (P) Tom Lainis	(M) Shirley Pomeranz
	3 (E) Steve Ressler	(M) Ray Cannon
	4 (M) Liz Tellis	(E) Richard Plumb
	5 (E) Mike McGinnis	

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