

# Modeling Forum

## Results of the 2003 Mathematical Contest in Modeling

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### Introduction

A total of 492 teams of undergraduates, from 230 institutions in 9 countries—and from varying departments, including an Art Education Center—spent the second weekend in February working on applied mathematics problems in the 18th Mathematical Contest in Modeling (MCM).

The 2003 MCM began at 8:00 P.M. EST on Thursday, Feb. 6 and ended at 8:00 P.M. EST on Monday, Feb. 10. During that time, teams of up to three undergraduates were to research and submit an optimal solution for one of two open-ended modeling problems. Students registered, obtained contest materials, downloaded the problems at the appropriate time, and entered completion data through COMAP'S MCM Website.

Each team had to choose one of the two contest problems. After a weekend of hard work, solution papers were sent to COMAP on Monday. Eleven of the top papers appear in this issue of *The UMAP Journal*.

Results and winning papers from the first sixteen contests were published in special issues of *Mathematical Modeling* (1985–1987) and *The UMAP Journal* (1985–2002). The 1994 volume of *Tools for Teaching*, commemorating the tenth anniversary of the contest, contains all of the 20 problems used in the first ten years of the contest and a winning paper for each. Limited quantities of that volume and of the special MCM issues of the *Journal* for the last few years are available from COMAP.

This year's Problem A teams were asked to determine the size, location, and number of cardboard boxes needed to cushion a stunt person's fall using

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different combined weights (stunt person and motorcycle) and different jump heights.

Problem B dealt with the use of a gamma knife in the treatment of tumor cells in brain tissue. Teams were asked to design a model to provide the fewest and most direct doses in order to treat the tumor without going outside the target tumor itself.

In addition to the MCM, COMAP also sponsors the Interdisciplinary Contest in Modeling (ICM) and the High School Mathematical Contest in Modeling (HiMCM). The ICM, which runs concurrently with MCM, offers a modeling problem involving concepts in operations research, information science, and interdisciplinary issues in security and safety. Results of this year's ICM are on the COMAP Website at <http://www.comap.com/undergraduate/contests>; results and Outstanding papers appeared in Vol. 24 (2003), No. 2. The HiMCM offers high school students a modeling opportunity similar to the MCM. Further details about the HiMCM are at <http://www.comap.com/highschool/contests>.

## Problem A: The Stunt Person

An exciting action scene in a movie is going to be filmed, and you are the stunt coordinator! A stunt person on a motorcycle will jump over an elephant and land in a pile of cardboard boxes to cushion their fall. You need to protect the stunt person, and also use relatively few cardboard boxes (lower cost, not seen by camera, etc.).

Your job is to:

- determine what size boxes to use,
- determine how many boxes to use,
- determine how the boxes will be stacked,
- determine if any modifications to the boxes would help, and
- generalize to different combined weights (stunt person and motorcycle) and different jump heights.

Note that in the 1997 film "Tomorrow Never Dies," the James Bond character, on a motorcycle, jumps over a helicopter.

## Problem B: Gamma Knife Treatment Planning

Stereotactic radiosurgery delivers a single high dose of ionizing radiation to a radiographically well-defined, small intracranial 3D brain tumor without

delivering any significant fraction of the prescribed dose to the surrounding brain tissue. Three modalities are commonly used in this area; they are the gamma knife unit, heavy charged particle beams, and external high-energy photon beams from linear accelerators.

The gamma knife unit delivers a single high dose of ionizing radiation emanating from 201 cobalt-60 unit sources through a heavy helmet. All 201 beams simultaneously intersect at the isocenter, resulting in a spherical (approximately) dose distribution at the effective dose levels. Irradiating the isocenter to deliver dose is termed a “shot.” Shots can be represented as different spheres. Four interchangeable outer collimator helmets with beam-channel diameters of 4, 8, 14, and 18 mm are available for irradiating different size volumes. For a target volume larger than one shot, multiple shots can be used to cover the entire target. In practice, most target volumes are treated with 1 to 15 shots. The target volume is a bounded, three-dimensional digital image that usually consists of millions of points.

The goal of radiosurgery is to deplete tumor cells while preserving normal structures. Since there are physical limitations and biological uncertainties involved in this therapy process, a treatment plan needs to account for all those limitations and uncertainties. In general, an optimal treatment plan is designed to meet the following requirements.

1. Minimize the dose gradient across the target volume.
2. Match specified isodose contours to the target volumes.
3. Match specified dose-volume constraints of the target and critical organ.
4. Minimize the integral dose to the entire volume of normal tissues or organs.
5. Constrain dose to specified normal tissue points below tolerance doses.
6. Minimize the maximum dose to critical volumes.

In gamma unit treatment planning, we have the following constraints:

1. Prohibit shots from protruding outside the target.
2. Prohibit shots from overlapping (to avoid hot spots).
3. Cover the target volume with effective dosage as much as possible. But at least 90% of the target volume must be covered by shots.
4. Use as few shots as possible.

Your tasks are to formulate the optimal treatment planning for a gamma knife unit as a sphere-packing problem, and propose an algorithm to find a solution. While designing your algorithm, you must keep in mind that your algorithm must be reasonably efficient.

## The Results

The solution papers were coded at COMAP headquarters so that names and affiliations of the authors would be unknown to the judges. Each paper was then read preliminarily by two “triage” judges at either Appalachian State University (Problem A) or at the National Security Agency (Problem B). At the triage stage, the summary and overall organization are the basis for judging a paper. If the judges’ scores diverged for a paper, the judges conferred; if they still did not agree on a score, a third judge evaluated the paper.

This year, an additional Regional Judging site was created at the U.S. Military Academy to support the growing number of contest submissions.

Final judging took place at Harvey Mudd College, Claremont, California. The judges classified the papers as follows:

	Outstanding	Meritorious	Honorable Mention	Successful Participation	Total
Stunt Person	6	36	97	128	267
Gamma Knife Treatment	<u>5</u>	<u>34</u>	<u>56</u>	<u>130</u>	<u>225</u>
	11	70	153	258	492

The 11 papers that the judges designated as Outstanding appear in this special issue of *The UMAP Journal*, together with commentaries. We list those teams and the Meritorious teams (and advisors) below; the list of all participating schools, advisors, and results is in the **Appendix**.

### Outstanding Teams

#### Institution and Advisor

#### Team Members

#### Stunt Person Papers

##### “Safe Landings”

California Institute of Technology  
Pasadena, CA  
Darryl H. Yong

Chad T. Kishimoto  
Justin C. Kao  
Jeffrey A. Edlund

##### “A Time-Independent Model of Box Safety for Stunt Motorcyclists”

Harvard University  
Cambridge, MA  
Clifford H. Taubes

Ivan Corwin  
Sheel Ganatra  
Nikita Rozenblyum

“Thinking Outside the Box  
and Over the Elephant”

Harvey Mudd College  
Claremont, CA  
Jon Jacobsen

Melissa J. Banister  
Matthew Macauley  
Micah J. Smukler

“You Too Can Be James Bond”

Southeast University  
Nanjing, China  
Chen Enshui

Deng Xiaowei  
Xu Wei  
Zhang Zhenyu

“Cardboard Comfortable When It Comes  
to Crashing”

University of Washington  
Seattle, WA  
James Allen Morrow

Jeffrey Giansiracusa  
Ernie Esser  
Simon Pai

“Fly With Confidence”

Zhejiang University  
Hangzhou, China  
Tan Zhiyi

Hu Yuxiao  
Hua Zheng  
Zhou Enlu

### **Gamma Knife Treatment Papers**

“The Genetic Algorithm-Based Optimization  
Approach for Gamma Unit Treatment”

Donghua University  
Shanghai, China  
Ding Yongsheng

Sun Fei  
Yang Lin  
Wang Hong

“A Sphere-Packing Model for the  
Optimal Treatment Plan”

Peking University  
Beijing, China  
Liu Xufeng

Long Yun  
Ye Yungqing  
Wei Zhen

“The Gamma Knife Problem”

University of Colorado  
Boulder, CO  
Anne M. Dougherty

Darin W. Gillis  
David R. Lindstone  
Aaron T. Windfield

“Shelling Tumors with Caution and Wiggles”

University of Washington

Seattle, WA

James Allen Morrow

Luke Winstrom

Sam Coskey

Mark Blunk

“Fly With Confidence”

Youngstown State University

Youngstown, OH

Angela Spalsbury

Sarah Grove

Chris Jones

Joel Lepak

## Meritorious Teams

### Stunt Person Papers (36 teams)

Asbury College, Wilmore, KY (Ken Rietz)

California Polytechnic State University, San Luis Obispo, CA (Jonathan E. Shapiro)

Central Washington University, Ellensburg, WA (Stuart F. Boersma)

City Univ. of Hong Kong, China (Jonathan J. Wylie)

Duke University, Durham, NC (David Kraines)

Earlham College, Richmond, IN (Charlie Peck) (two teams)

Harvey Mudd College, Claremont, CA (Ran Libeskind-Hadas) (two teams)

James Madison University, Harrisonburg, VA (Joseph W. Rudmin)

Kansas State University, Manhattan, KS (Dave Auckly, Mikil Foss, and Marianne Korten)

Luther College, Decorah, IA (Reginald D. Laursen)

Maggie Walker Governor’s School, Richmond, VA (John, A. Barnes)

Massachusetts Institute of Technology, Cambridge, MA (Martin Z. Bazant)

Mesa State College, Grand Junction, Colorado (Edward K. Bonan-Hamada)

Messiah College, Grantham, PA (Lamarr C. Widmer)

N.C. School of Science and Mathematics, Durham, NC (Dot Doyle)

National University of Defence Technology, China (Ziyang Mao)

Rose-Hulman Institute of Technology, Terre Haute, IN (David J. Rader)

Southeastern Oklahoma State University, Durant, OK (Brett M. Elliott)

Southern Oregon University, Ashland, OR (Kemble R. Yates)

State University of West Georgia, Carrollton, Georgia (Scott Gordon)

Tri-State University, Angola, IN (Steven A. Schonefeld)

Truman State University, Kirksville, MO (Steve J. Smith)

United States Air Force Academy, USAF Academy, CO (James S. Rolf)

United States Military Academy, West Point, NY (Frank A. Wattenberg)

University College Cork, Ireland (James Gleeson)

University College Cork, Ireland (Donal J. Hurley)

University of Alaska Fairbanks, Fairbanks, AK (Chris M. Hartman)

University of New South Wales, Sydney, Australia (James W. Franklin)

University of Puget Sound, Tacoma, WA (Michael S. Casey)

University of San Diego, San Diego, CA (Jeffrey H. Wright)

University of Science and Technology of China, China (Li Yu)

Worcester Polytechnic Institute, Worcester, MA (Suzanne L. Weekes)  
Xidian University, China (Zhou Shui-Sheng)  
York University, Toronto, Ontario, Canada (Huaxiong Huang)

**Gamma Knife Treatment Papers** (34 teams)

Bethel College, St. Paul, MN (William, M. Kinney) (two teams)  
Boston University, Boston, MA (Glen, R. Hall)  
California Polytechnic State University, San Luis Obispo, CA (Jonathan E. Shapiro)  
Dalhousie University, Canada (Dorothea A. Pronk)  
Hangzhou University of Commerce, China (Ding Zhengzhong)  
Harvey Mudd College, Claremont, CA (Jon Jacobsen)  
Hong Kong Baptist University, China (Chong-Sze Tong)  
Kenyon College, Gambier, OH (Keith E. Howard)  
Lawrence Technological University, Southfield, MI (Ruth G. Favro)  
Northwestern Polytechnical University, China (Peng Guohua)  
Rensselaer Polytechnic Institute, Troy, NY (Peter R. Kramer)  
Rowan University, Glassboro, NJ (Hieu D. Nguyen)  
Saint Louis University, St. Louis, MO (James E. Dowdy)  
Science Institution of Northeastern University, China (Sun Ping)  
Shanghai Jiaotong University, China (Baorui Song)  
Shanghai Jiaotong University, China (Jianguo Huang)  
Simpson College, Indianola, Iowa (Werner Kolln)  
South China University of Technology, China (Jianliang Lin)  
Southeast Missouri State University, Cape Girardeau, MO (Robert W. Sheets)  
Tianjin University, China (Zeyi Liu)  
Trinity University, San Antonio, TX (Robert W. Laird)  
Tsinghua University, China (Jun Ye)  
University College Dublin (Maria G. Meehan)  
University of Arizona, Tucson, AZ (Bruce J. Bayly)  
University of Colorado at Boulder, Boulder, CO (Anne M. Dougherty)  
University of Delaware, Newark, DE (Louis F. Rossi)  
University of Richmond, Richmond, VA (Kathy W. Hoke)  
University of Saskatchewan, Canada (Rainer Dick)  
University of Saskatchewan, Canada (James A. Brooke)  
Washington University, St. Louis, MO (Hiro Mukai)  
Westminster College, New Wilmington, PA (Barbara T. Faires)  
Wuhan University of Technology, China (Peng Sijun)  
Xidian University, China (Zhang Zhuo-kui)

## Awards and Contributions

Each participating MCM advisor and team member received a certificate signed by the Contest Director and the appropriate Head Judge.

INFORMS, the Institute for Operations Research and the Management Sciences, recognized the teams from Zhejiang University (Stunt Person Problem)

and University of Washington (Gamma Knife Treatment Problem) as INFORMS Outstanding teams and provided the following recognition:

- a letter of congratulations from the current president of INFORMS to each team member and to the faculty advisor;
- a check in the amount of \$300 to each team member;
- a bronze plaque for display at the team's institution, commemorating their achievement;
- individual certificates for team members and faculty advisor as a personal commemoration of this achievement;
- a one-year student membership in INFORMS for each team member, which includes their choice of a professional journal plus the *OR/MS Today* periodical and the INFORMS society newsletter.
- a one-year subscription access to the COMAP modeling materials Website for the faculty advisor.

The Society for Industrial and Applied Mathematics (SIAM) designated one Outstanding team from each problem as a SIAM Winner. The teams were from California Institute of Technology (Stunt Person Problem) and University of Colorado (Gamma Knife Treatment Problem). Each of the team members was awarded a \$300 cash prize and the teams received partial expenses to present their results in a special Minisymposium at the SIAM Annual Meeting in Montreal, Canada in June. Their schools were given a framed, hand-lettered certificate in gold leaf.

The Mathematical Association of America (MAA) designated one Outstanding team from each problem as an MAA Winner. The teams were from University of Washington (Stunt Person Problem) and Youngstown State University (Gamma Knife Treatment Problem). With partial travel support from the MAA, both teams presented their solutions at a special session of the MAA Mathfest in Boulder, CO in August. Each team member was presented a certificate by Richard S. Neal, Co-Chair of the MAA Committee on Undergraduate Student Activities and Chapters.

## Judging

### *Director*

Frank R. Giordano, Naval Postgraduate School, Monterey, CA

### *Associate Directors*

Robert L. Borrelli, Mathematics Dept., Harvey Mudd College, Claremont, CA  
 Patrick Driscoll, Dept. of Mathematical Sciences, U.S. Military Academy,  
 West Point, NY



*Contest Coordinator*

Kevin Darcy, COMAP Inc., Lexington, MA

**Stunt Person Problem**

*Head Judge*

Marvin S. Keener, Executive Vice-President, Oklahoma State University,  
Stillwater, OK (MAA)

*Associate Judges*

William C. Bauldry, Chair, Dept. of Mathematical Sciences,  
Appalachian State University, Boone, NC (Triage)

Kelly Black, Mathematics Dept., University of New Hampshire,  
Durham, NH (SIAM)

Courtney Coleman, Mathematics Dept., Harvey Mudd College,  
Claremont, CA

Lisette De Pillis, Mathematics Dept., Harvey Mudd College, Claremont, CA

Ben Fusaro, Mathematics Dept., Florida State University,  
Tallahassee, FL (SIAM)

Mario Juncosa, RAND Corporation, Santa Monica, CA

Michael Moody, Mathematics Dept., Harvey Mudd College, Claremont, CA

John L. Scharf, Mathematics Dept., Carroll College, Helena, MT  
(COMAP HiMCM)

Dan Solow, Mathematics Dept., Case Western Reserve University,  
Cleveland, OH (INFORMS)

Michael Tortorella, Lucent Technologies, Holmdel, NJ

Daniel Zwillinger, Newton, MA (author)

**Gamma Knife Treatment Problem**

*Head Judge*

Maynard Thompson, Mathematics Dept., University of Indiana,  
Bloomington, IN

*Associate Judges*

Peter Anspach, National Security Agency, Ft. Meade, MD (Triage)

Karen D. Bolinger, Mathematics Dept., Ohio State University, Columbus, OH

James Case, Baltimore, MD (SIAM)

J. Douglas Faires, Youngstown State University, Youngstown, OH (MAA)

William P. Fox, Mathematics Dept., Francis Marion University, Florence, SC  
(MAA)

Jerry Griggs, Mathematics Dept., University of South Carolina, Columbia, SC  
(author rep)

John Kobza, Mathematics Dept., Texas Tech University, Lubbock, TX  
(INFORMS)

Veena Mendiratta, Lucent Technologies, Naperville, IL

Don Miller, Mathematics Dept., St. Mary's College, Notre Dame, IN (SIAM)

Kathleen Shannon, Mathematics Dept., Salisbury State University,  
Salisbury, MD

Marie Vanisko, Dept. of Mathematics, Engineering, Physics, and  
Computer Science, Carroll College, Helena, MT (MAA)

### **Regional Judging Session**

#### *Head Judge*

Patrick Driscoll, Dept. of Mathematical Sciences

#### *Associate Judges*

Edward Pohl, Dept. of Systems Engineering

Michael Jaye, Dept. of Mathematical Sciences

Darrall Henderson, Dept. of Mathematical Sciences

Steven Horton, Dept. of Mathematical Sciences

—all of the U.S. Military Academy, West Point, NY

### **Triage Sessions:**

#### **Stunt Person Problem**

##### *Head Triage Judge*

William C. Bauldry, Chair, Dept. of Mathematical Sciences,  
Appalachian State University, Boone, NC

##### *Associate Judges*

Terry Anderson, Dept. of Mathematical Sciences

Anthony Calamai, Physics Dept.

Mark Ginn, Dept. of Mathematical Sciences

Andrew Graham, Physics Dept.

Rick Klima, Dept. of Mathematical Sciences

—all from Appalachian State University, Boone, NC

Dan Warner, Dept. of Mathematical Sciences, Clemson University,  
Clemson, SC

Richard West, Mathematics Dept., Francis Marion University, Florence, SC

#### **Gamma Knife Treatment Problem**

##### *Head Triage Judge*

Peter Anspach, National Security Agency (NSA), Ft. Meade, MD

##### *Associate Judges*

James Case, Baltimore, Maryland

Antonia Bluher, Stuart Gott, Blair Kelly, Dean McCullough (retired), Craig Orr,

Brian Pilz, and other members of NSA.

## Sources of the Problems

The Stunt Person Problem was contributed by Dan Zwillinger, Newton, MA. The Gamma Knife Treatment Problem was contributed by Jie Wang.

## Acknowledgments

Major funding for the MCM is provided by the National Security Agency and by COMAP. We thank Dr. Gene Berg of NSA for his coordinating efforts. Additional support is provided by the Institute for Operations Research and the Management Sciences (INFORMS), the Society for Industrial and Applied Mathematics (SIAM), and the Mathematical Association of America (MAA). We are indebted to these organizations for providing judges and prizes.

We thank the MCM judges and MCM Board members for their valuable and unflagging efforts. Harvey Mudd College, its Mathematics Dept. staff, and Prof. Borrelli were gracious hosts to the judges.

## Cautions

*To the reader of research journals:*

Usually a published paper has been presented to an audience, shown to colleagues, rewritten, checked by referees, revised, and edited by a journal editor. Each of the student papers here is the result of undergraduates working on a problem over a weekend; allowing substantial revision by the authors could give a false impression of accomplishment. So these papers are essentially *au naturel*. Editing (and sometimes substantial cutting) has taken place: Minor errors have been corrected, wording has been altered for clarity or economy, and style has been adjusted to that of *The UMAP Journal*. Please peruse these student efforts in that context.

*To the potential MCM Advisor:*

It might be overpowering to encounter such output from a weekend of work by a small team of undergraduates, but these solution papers are highly atypical. A team that prepares and participates will have an enriching learning experience, independent of what any other team does.

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COMAP's Mathematical Contest in Modeling and Interdisciplinary Contest in Modeling are the only international modeling contests in which students work in teams. Centering its educational philosophy on mathematical modeling, COMAP uses mathematical tools to explore real-world problems. It serves the educational community as well as the world of work by preparing students to become better-informed and better-prepared citizens.

## Appendix: Successful Participants

KEY:

P = Successful Participation

A = Stunt Person Problem

H = Honorable Mention

B = Gamma Knife Treatment Problem

M = Meritorious

O = Outstanding (published in this special issue)

INSTITUTION	CITY	ADVISOR	A	B
<b>ALASKA</b>				
University of Alaska	Fairbanks	Chris M. Hartman	M	
<b>ARKANSAS</b>				
Arkansas Schl for Math. & Sci.	Hot Springs	Bruce E. Turkal	H,P	
Hendrix College	Conway	Duff Gordon Campbell		P
<b>CALIFORNIA</b>				
California Institute of Tech.	Pasadena	Darryl H. Yong	O	
California Polytech. State Univ.	San Luis Obispo	Jonathan E. Shapiro	M	M
Calif. State Univ., Monterey Bay	Seaside	Hongde Hu	H	
Calif. State Univ., Bakersfield	Bakersfield	David Gove	H	
Calif. State Univ., Northridge	Northridge	Gholam Ali Zakeri	H,P	
Calif. State Univ., Stanislaus	Turlock	Brian Jue	P	
Harvey Mudd College	Claremont	Jon Jacobsen	O	M
		Ran Libeskind-Hadas	M,M	
Monta Vista High School	Cupertino	I-Heng McComb	H,P	
Pomona College	Claremont	Ami E. Radunskaya		P
Sonoma State University	Rohnert Park	Elaine T. McDonald	P	
University of San Diego	San Diego	Jeffrey H. Wright	M,P	
<b>COLORADO</b>				
Colorado College	Colorado Springs	Peter L. Staab	H	P
Colorado State University	Fort Collins	Michael J. Kirby		P
	Pueblo	Bruce N. Lundberg	P	
U.S. Air Force Academy	USAF Academy	James S. Rolf	M	
University of Colorado	Boulder	Anne M. Dougherty		O,M
Mesa State College	Grand Junction	Edward K. Bonan-Hamada	M	
<b>CONNECTICUT</b>				
Sacred Heart University	Fairfield	Peter Loth	H	
Western Conn. State Univ.	Danbury	Charles F. Rocca jr	P	
<b>DELAWARE</b>				
University of Delaware	Newark	Louis F. Rossi	H	M
<b>DISTRICT OF COLUMBIA</b>				
Georgetown University	Washington	Andrew Vogt	P	
<b>FLORIDA</b>				
Embry-Riddle Aeronaut. Univ.	Daytona Beach	Greg Scott Spradlin	H	
Florida Gulf Coast University	Fort Myers	Charles Lindsey		H
Jacksonville University	Jacksonville	Paul R. Simony	H,P	
		Robert J. H. ...	H	P

INSTITUTION	CITY	ADVISOR	A	B
ILLINOIS				
Greenville College	Greenville	Galen R. Peters	H	P
		Hugh E. Siefken	P	
Monmouth College	Monmouth	Christopher G. Fasano	P	
Wheaton College	Wheaton	Paul Isihara		P
INDIANA				
Earlham College	Richmond	Timothy J. McLarnan		P
		Charlie Peck	M,M	
		Jennifer Joy Ziebarth		H
Goshen College	Goshen	David Housman	H	
Rose-Hulman Inst. of Tech.	Terre Haute	David J. Rader	M	P
		Cary Laxer		P
Saint Mary's College	Notre Dame	Joanne R. Snow	H	P
Tri-State University	Angola	Steven Schonefeld	M	
IOWA				
Grand View College	Des Moines	Sergio Loch	P,P	
Grinnell College	Grinnell	Alan R. Wolf	P,P	
		Mark Montgomery		H,P
Luther College	Decorah	Reginald D. Laursen	M,H	
Simpson College	Indianola	Bruce F. Sloan	H	P
		Werner Kolln		M
Wartburg College	Waverly	Mariah Birgen	H	
KANSAS				
Kansas State University	Manhattan	Dave Auckly, Mikil Foss, and Marianne Korten	M	P
KENTUCKY				
Asbury College	Wilmore	Ken Rietz	M	P
Bellarmino University	Louisville,	William J. Hardin	H	
Northern Kentucky Univ.	Highland Heights	Gail S. Mackin		H
MAINE				
Colby College	Waterville	Jan Holly	H,P	
MARYLAND				
Goucher College	Baltimore	Robert E. Lewand	H,P	
Hood College	Frederick	Betty Mayfield		P
Loyola College	Baltimore	Christos Xenophontos	H,H	
Mount St. Mary's College	Emmitsburg	Fred J. Portier	H,P	
Salisbury University	Salisbury	Steven M. Hetzler	H	
Towson University	Towson	Mike P. O'Leary	H,P	
Washington College	Chestertown	Eugene P. Hamilton	P,P	
MASSACHUSETTS				
Boston University	Boston	Glen R. Hall	H	M
Harvard University	Cambridge	Clifford H. Taubes	O	
Massachusetts Inst. of Tech.	Cambridge	Martin Z. Bazant	M	
Olin College of Engineering	Needham	Burt S. Tilley		P

INSTITUTION	CITY	ADVISOR	A	B
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## MICHIGAN

Calvin College	Grand Rapids	Gary W. Talsma	P	
Eastern Michigan University	Ypsilanti	Christopher E. Hee	P	P
Hillsdale College	Hillsdale	John P. Boardman	H	
Hope College	Holland	Aaron C. Cinzori	P	
Lawrence Tech. Univ.	Southfield	Ruth G. Favro	H	M
		Valentina Tobos	P	
Siena Heights University	Adrian	Toni Carroll	H,P	
		Timothy H. Husband	P	
University of Michigan	Dearborn	David James		P

## MINNESOTA

Augsburg College	Minneapolis	Nicholas Coult		P
Bemidji State University	Bemidji	Colleen G. Livingston	P	H
Bethel College	St. Paul	William M. Kinney		M,M
College of St. Benedict and St. John's University	Collegeville	Robert J. Hesse	H,P	
Gustavus Adolphus College	St. Peter	Thomas P. LoFaro	H	
Macalester College	St. Paul	Daniel T. Kaplan	H	P
		Elizabeth G. Shoop		P

## MISSOURI

NW Missouri State Univ.	Maryville	Russell N. Euler	P,P	
Saint Louis University	St. Louis	David Jackson	P	
		Stephen Blythe	H	
		James E. Dowdy		M
SE Missouri State Univ.	Cape Girardeau	Robert W. Sheets		M
Truman State University	Kirksville	Steve J. Smith	M,H	
Washington University	St. Louis	Hiro Mukai		M,H

## MONTANA

Carroll College	Helena	Holly S. Zullo	H	
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## NEBRASKA

Hastings College	Hastings	David Cooke	H,H	
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## NEVADA

Sierra Nevada College	Incline Village	Charles Levitan	P	
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## NEW JERSEY

Rowan University	Glassboro	Hieu D. Nguyen		M
William Paterson Univ.	Wayne	Donna J. Cedio-Fengya	P	

## NEW MEXICO

New Mexico State Univ.	Las Cruces	Caroline P. Sweezy		P
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## NEW YORK

Cornell University	Ithaca	Alexander Vladimirovsky	H	
Hobart & William Smith Coll.	Geneva	Scotty L. Orr	H,P	
Manhattan College	Riverdale	Kathryn W. Weld		P
Marist College	Poughkeepsie	Tracey McGrail	P	
Nazareth College	Rochester	Nelson G. Rich	H	
Rensselaer Polytechnic Inst	Troy	Peter R. Kramer		M,H

INSTITUTION	CITY	ADVISOR	A	B
<b>NORTH CAROLINA</b>				
Appalachian State University	Boone	Eric S. Marland		P
Brevard College	Brevard	C. Clarke Wellborn	P	
Davidson College	Davidson	Laurie J. Heyer	H	H
Duke University	Durham	David Kraines	M	
Elon University	Elon	Todd Lee		H
Meredith College	Raleigh	Cammey E. Cole	P	
N.C. School of Sci. and Math.	Durham	Dot Doyle	M	
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