

# Mathematical Sciences in the FY 2006 Budget

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## NSF Highlights



2005

- Federal support for the mathematical sciences is slated to grow from an estimated \$390.68 million in FY 2005 to an estimated \$397.58 million in FY 2006, an increase of 1.8 percent. This is the lowest rate of increase for the mathematical sciences in several years.
- The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) would have no increase in FY 2006. The DMS budget for FY 2006 would remain at \$200.38 million.
- The aggregate funding for the mathematical sciences in the Department of Defense agencies (Air Force Office of Scientific Research (AFOSR), Army Research Office (ARO), Defense Advanced Research Projects Agency (DARPA), National Security Agency (NSA), and Office of Naval Research (ONR)) would increase by 4.7 percent. The majority of this increase comes from DARPA, where the mathematical sciences budget would grow by 13.5 percent.
- The Department of Energy (DOE) Applied Mathematics Division would receive a 9.8 percent increase.

## Introduction

The mathematical sciences are funded through the National Science Foundation, the Department of Defense (including the National Security Agency), the Department of Energy, and the National Institutes of Health (NIH). As in the past, the majority of federal support for the mathematical sciences in FY 2006 would come from the NSF, contributing approximately 50.4 percent of the federal total. The DOD accounts for around 23.1 percent of the total, with the NIH supplying 19.2 percent, and the DOE around 7.3 percent. The NSF currently accounts for

over 70.0 percent of the federal support for academic research in the mathematical sciences and is the only agency that supports mathematics research broadly across all fields. The DOD, DOE, and NIH support research in the mathematical sciences that contributes to missions of these agencies.

The DOD has five programs supporting mathematical sciences research and related activities: the Directorate of Mathematics and Space Sciences within the Air Force Office of Scientific Research; the Mathematical Sciences Division within the Army Research Office; the Mathematical, Computer, and Information Sciences Division within the Office of Naval Research; the Applied and Computational Mathematics Program within the Defense Advanced Research Projects Agency; and the Mathematical Sciences Program within the National Security Agency.

The DOE funds mathematics through its Applied Mathematics Program within the DOE Mathematical, Information and Computational Sciences Division. The National Institutes of Health funds mathematical sciences research primarily through the National Institute of General Medical Sciences (NIGMS) and through the National Institute of Biomedical Imaging and Bioengineering (NIBIB).

Several other agencies have small amounts of funding for mathematics research as it relates to agency missions. These agencies include the National Aeronautics and Space Administration (NASA), the Environmental Protection Agency (EPA), and the National Institute of Standards and Technology (NIST).

## Trends in Federal Support for the Mathematical Sciences

The FY 2006 estimated aggregate spending for mathematical sciences research and related activities would be \$397.58 million, a potential increase of 1.8 percent over FY 2005 estimated spending.

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The NSF Division of Mathematical Sciences budget would have no increase in FY 2006, greatly impacting the growth of overall federal support for the mathematical sciences. The increase at DOE for FY 2006 would be 9.8 percent over the FY 2005 level. DARPA surprises with a projected 13.5 percent increase. The remaining DOD agencies would essentially have no growth in FY 2006.

More and more the mathematical sciences are contributing to advances in life science research, a trend that will grow in the future. Realizing that the mathematical sciences can be critical to certain areas of biomedical research, the NIH, over the last several years, has been actively pairing mathematicians and biomedical researchers through funded projects.

The mathematical sciences are making major contributions to the country's intellectual capacity, and the need for the mathematical sciences in scientific discovery and technological innovation is accelerating. Yet many mathematical scientists who are performing excellent research and submitting grant proposals deemed of very high quality are either not funded or are underfunded. According to the *Science and Engineering Indicators*, 2004 Edition, only 30.1 percent of full-time academic doctoral mathematicians receive federal research support. This is much lower than most other fields of science.

### National Science Foundation (NSF)

The Division of Mathematical Sciences is housed in the NSF Directorate of the Mathematical and Physical Sciences (MPS). This directorate also contains the Divisions of Astronomical Sciences, Chemistry, Materials Research, Physics, and Multidisciplinary Activities.

The mathematical sciences would continue to be an NSF-wide priority area in FY 2006. The foundation has budgeted \$88.63 million to carry out the priority area activities in FY 2006, with \$70.23 million of this amount coming from the Division of Mathematical Sciences (DMS) and the remaining \$18.40 million coming from throughout the foundation. The NSF-wide allocation (\$18.40 million) depends on cooperative funding opportunities with other NSF directorates and requires matching funds from the DMS. The mathematical sciences were first designated an NSF priority area in FY 2002, and currently this designation is to last through FY 2007. Tentatively, this priority area will receive \$88.63 million in FY 2007.

The DMS is slated to receive a budget of \$200.38 million in FY 2006. The division has essentially had the same budget since FY 2004. However, from FY 2003 to FY 2006 the DMS budget will have grown by 12.1 percent, while for the same period the MPS budget will have grown by 4.4 percent. All

**Table 1. Federal Funding for the Mathematical Sciences (millions of dollars)<sup>1</sup>**

	FY 04 Actual	FY 05 Estimate	FY 06 Request	Change 2005-06 Amount	Change 2005-06 Percent
National Science Foundation					
DMS	\$200.35	\$200.38	\$200.38	\$0.0	0.0%
Department of Defense					
AFOSR	\$ 30.00	\$ 30.90	\$ 31.00	\$0.1	0.3%
ARO	9.50	10.00	10.00	0.0	0.0
DARPA	16.30	29.70	33.70	4.0	13.5
NSA	3.00	3.50	3.50	0.0	0.0
ONR	13.10	13.60	13.60	0.0	0.0
Total DOD	\$ 71.90	\$ 87.70	\$ 91.80	\$4.1	4.7
Department of Energy					
Applied Mathematics	\$ 22.60	\$ 26.40	\$ 29.00	\$2.6	9.8%
National Institutes of Health					
NIGMS	\$ 35.00*	\$ 38.00*	\$ 38.00*	\$0.0	0.0%
NIBIB	37.10	38.20	38.40	0.2	0.5
Total NIH	\$ 72.10	\$ 76.20	\$ 76.40	\$0.2	0.3
Total All Agencies	\$366.95	\$390.68	\$397.58	\$6.9	1.8%

\*Estimates based on conversation with program officer.

<sup>1</sup>Budget information comes from agency documents and conversations with agency program managers and representatives.

the growth for the DMS occurred from FY 2003 to FY 2004.

The DMS has essentially two modes of support: research and education grants, and institutes. Grants include individual-investigator awards, awards for multidisciplinary groups of researchers, and educational and training awards aimed at increasing the number of U.S. students choosing careers in the mathematical sciences. Approximately 72 percent of the DMS funds are available for new awards and activities. The remaining 28 percent funds awards made in previous years.

For FY 2006 the DMS has the following priorities:

- maintaining a strong program of research grants,
- investing in algorithm development and computational tools for large-scale problems of scientific importance,
- broadening participation in the mathematical sciences,
- maintaining research training activities in the mathematical sciences,
- continuing support for the Mathematical Sciences Priority Area.

#### **Air Force Office of Scientific Research (AFOSR)**

The Directorate of Mathematics and Space Sciences provides funds for research in the mathematical sciences in support of the Air Force mission. Current program emphases include cooperative control, quantum computing, and Maxwell's equations. Beginning perhaps as early as FY 2005, a new initiative in nanoscience is anticipated. The AFOSR mathematics program includes specific portfolios in dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, systems and software, electromagnetics, and signals communication and surveillance. The AFOSR budget would increase slightly, by 0.3 percent, over FY 2005.

#### **Army Research Office (ARO)**

The Mathematical Sciences Division manages the following programs: modeling of complex systems, computational mathematics, discrete mathematics and computer science, probability and statistics and stochastic analysis, and cooperative systems. The Mathematical Sciences Division plays an essential role in the modeling, analysis, and control of complex phenomena and large-scale systems that are of critical interest to the army. The areas of application include wireless communication networks, image analysis, visualization and synthetic environments, pattern recognition, test and evaluation of new systems, sensor networks, and autonomous systems. The division also works closely with the Computer and Information Sciences Division of the ARO to develop mathematical theory for information processing, information assurance, and data fusion. The FY 2006 budget for the Mathematical Sciences Division is the same as for FY 2005.

#### **Defense Advanced Research Projects Agency (DARPA)**

DARPA's Applied and Computational Mathematics program is structured around focused program initiative areas in interdisciplinary and core mathematics. Current program areas include: Integrated Sensing and Processing, Mathematical Time-Reversal Methods, Predicting Real Optimized Materials, Quantum Information Science and Technology, Geospatial Representation and Analysis, Topological Data Analysis, Stochastic and Perturbation Methods in PDE Systems, Geometric Langlands, Discovery and Exploitation of Structure in Algorithms, and Femtosecond Adaptive Spectroscopy Techniques. The FY 2006 budget for the mathematical sciences would increase by approximately 13 percent over FY 2005.

#### **Department of Energy (DOE)**

Mathematics is funded through the Applied Mathematics Program of the Mathematical, Information, and Computational Sciences Division (MICS) of the DOE. Research is conducted on the underlying mathematical understanding of physical, chemical, and biological systems and advanced numerical algorithms that enable effective description, modeling, and simulation of such systems on high-end computing systems. Research in applied mathematics supported by MICS underpins computational science throughout the DOE. The FY 2005 budget for the Applied Mathematics Program continues the Computational Sciences Fellowship program at its current level of \$3.5 million. The FY 2006 budget also includes \$8.5 million for the Atomic to Macroscopic Mathematics (AMM) effort, which provides the research support in applied mathematics needed for understanding complex physical processes that occur on a wide range of interacting length- and time-scales. Current state-of-the-art theory and modeling of complex physical systems require that the physical phenomena being modeled either occur at a single scale or widely separated scales with little or no interaction. The AMM effort supports university researchers, partnerships between universities and national laboratories, and multidisciplinary research teams at national laboratories. The Applied Mathematics Program FY 2006 budget would increase by 9.8 percent over FY 2005.

#### **National Institutes of Health (NIH)**

The NIH funds mathematical sciences research through the National Institute of General Medical Sciences (NIGMS) and the National Institute of Biomedical Imaging and Bioengineering (NIBIB). Mathematical sciences areas of interest are those that support the missions of the NIGMS and the NIBIB. Currently the NIGMS is supporting a biomathematics initiative in cooperation with the National Science Foundation, and the NIBIB is participating in a joint initiative with the NSF and

other NIH institutes: “Collaborative Research in Computational Neuroscience”. The aggregate budget for the mathematical sciences in the NIBIB and the NIGMS would grow only slightly, 0.3 percent, in FY 2006.

#### **National Security Agency (NSA)**

The NSA has a small grants program that supports fundamental research in the mathematical areas of algebra, number theory, discrete mathematics, probability, and statistics. The grants program also accepts proposals for conferences and workshops in these research areas. Additional funding (non-grant) is available to support an in-house faculty sabbatical program. The program administrators are especially interested in funding initiatives that encourage the participation of underrepresented groups in mathematics (such as women, African-Americans, and other minorities). The NSA is the largest employer of mathematicians in the United States. As such, it has a vested interest in maintaining a healthy academic mathematics community in the United States. The grants program’s budget would remain unchanged for FY 2006.

#### **Office of Naval Research (ONR)**

The ONR Mathematical, Computer, and Information Sciences Division’s scientific objective is to establish rigorous mathematical foundations and analytical and computational methods that enhance understanding of complex phenomena and enable prediction and control for naval applications in the future. Basic research in the mathematical sciences is focused on analysis and computation for multi-phase, multimaterial, multiphysics problems; predictability of models for nonlinear dynamics; electromagnetic and acoustic wave propagation; signal and imaging processing; modeling pathological behaviors of large, dynamic complex networks and exploiting hybrid control to achieve reliability and security; optimization; and formal methods for verifiably correct software construction. The Mathematical, Computer, and Information Sciences Division’s budget would remain unchanged in FY 2006.

*Note: Information gathered from agency documents and from agency representatives.*

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