# Mathematical Sciences in the FY 2012 Budget

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## Highlights

- Federal support for the mathematical sciences is estimated to increase by 12.1 percent over fiscal year (FY) 2010[1] to US$593.4 million.
- The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) is estimated to increase by 6.3 percent over FY 2010 to US$260.4 million.
- Department of Defense (DOD) funding for the mathematical sciences is estimated to grow by 29.4 percent over FY 2010 to US$132.0 million.
- The aggregate funding for the mathematical sciences in the Department of Energy (DOE) is estimated to increase by 16.9 percent.

## Introduction

Research in the mathematical sciences is funded primarily 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 previous years, the majority of federal support for the mathematical sciences in FY 2012 would come from the Division of Mathematical Sciences (DMS) of NSF. NSF accounts for 65 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. Most research in the mathematical sciences in the United States is performed by academic researchers. The DOD, DOE, and NIH support research in the mathematical sciences that contributes to the missions of these agencies. DOD supports mathematical sciences research and related activities in several programs: the Directorate of Mathematics, Information, and Life Sciences and the Directorate of Physics and Electronics within the Air Force Office of Scientific Research (AFOSR); the Information Sciences Division within the Army Research Office (ARO); the Mathematics, Computers, and Information Sciences Research Division within the Office of Naval Research (ONR); the Defense Sciences Office and the Microsystems Technology Office within the Defense Advanced Research Projects Agency (DARPA); and the Mathematical Sciences Program within the National Security Agency (NSA). DOE funds mathematics through its Applied Mathematics and Scientific Discovery through Advanced Computing (SciDAC) programs within the office of Advanced Scientific Computing Research. 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).

## Trends in Federal Support for the Mathematical Sciences

The FY 2012 aggregate spending for mathematical sciences research and related activities is estimated to be US$593.4 million, a potential increase of 12.1 percent over FY 2010 funding. Given the current budget-cutting atmosphere, it is unlikely that this estimate can make it through the upcoming appropriations cycle. In particular, NSF will likely not receive the level of funding proposed in the FY 2012 Budget Request. This is unfortunate because in FY 2009, NSF/DMS, with American Recovery and Reinvestment Act (ARRA) money, provided support for deserving investigators who in the past were not supported because of a lack of funds. Many of the grants funded with ARRA money will be ending in FY 2012, and the investigators will, very probably, be reapplying in extremely competitive circumstances.

The mathematical sciences make major contributions to the country's intellectual capacity and provide the tools, insight, and capability needed for innovation and technological progress. Many disciplines depend on research in the mathematical sciences to open up new frontiers and advance discovery. Mathematical sciences research contributes

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[1]*At the time of this writing, the agencies discussed in this article were operating on a continuing resolution for FY 2011, meaning that their FY 2011 budgets were the same as their FY 2010 budgets. Therefore, throughout the article, the FY 2012 budget estimates are compared with the FY 2010 appropriated budgets. The FY 2012 budget estimates are based on the FY 2012 Budget Request.*

to advances in many areas, such as: medicine, cyber security, weather prediction, digital data compression and mining, aeronautics, and computing.

***National Science Foundation (NSF).*** The Division of Mathematical Sciences (DMS) is housed in the NSF Directorate of the Mathematical and Physical Sciences (MPS). DMS has essentially two modes of support: (1) research and education grants and (2) institutes. Grants include individual-investigator awards; awards for groups of researchers, including multidisciplinary; and educational and training awards aimed at increasing the number of U.S. students choosing careers in the mathematical sciences. Each year, typically 59 percent of the DMS budget is available for new research grants, and the remaining 41 percent is used primarily to fund continuing grants made in previous years. The Division supports core research programs in algebra and number theory, analysis, applied mathematics, computational mathematics, geometry and topology, mathematical biology, probability, combinatorics and foundations, and various areas within statistics. Additionally, DMS will participate in the new NSF-wide initiatives, Cyber-Infrastructure Framework for the 21st Century (CIF21) and Advanced Manufacturing, as well as in the new Research at the Interface of Biological, Mathematical, and Physical Sciences (BioMaPS) program.

The Division will continue to invest in the Science, Engineering, and Education for Sustainability Portfolio (SEES) and Science Beyond Moore's Law (SEBML). The DMS FY 2012 budget is estimated to increase by 6.3 percent over FY 2010.

***Air Force Office of Scientific Research (AFOSR).*** Portfolios for the mathematical sciences at AFOSR are found in the Directorate of Mathematics, Information, and Life Sciences and the Directorate of Physics and Electronics. The AFOSR mathematics program includes specific portfolios in dynamics and control, multiscale modeling, computational mathematics, optimization and discrete mathematics, electromagnetics, and sensing, surveillance, and navigation. For additional information on the focus areas within each of these portfolios, refer to the Broad Area Announcement 2010–1 (see the website `http://www.afosr.af.mil`). The AFOSR FY 2012 budget estimate for mathematical sciences reflects an increase of 17.2 percent over FY 2010.

***Army Research Office (ARO).*** The Mathematics Program, housed in the Information Sciences Division, manages the following programs: modeling of complex systems, numerical analysis, probability and statistics, and biomathematics. 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 communication networks, image analysis, pattern recognition, test and

**Table 1. Federal Funding for the Mathematical Sciences (millions of dollars)**

| | FY 2010 Actual | FY 2012 **Budget** | Change Amount | FY 10–12 Percent |
|---|---|---|---|---|
| **National Science Foundation** | | | | |
| Mathematical Sciences | 245 | **260** | 16 | 6.3% |
| **Department of Defense** | 102 | **132** | 30 | 29.4% |
| Air Force Off. of Sci. Res. | 52 | **61** | 9 | 17.2% |
| Army Research Office | 12 | **12** | 0 | 0.0% |
| Def. Adv. Res. Proj. Agency | 12 | **28** | 16 | 129.2% |
| Natl. Security Admin | 7 | **6** | -1 | -7.7% |
| Office of Naval Research | 20 | **26** | 6 | 30.0% |
| **Department of Energy** | 93 | **109** | 16 | 16.9% |
| Applied Mathematics | 44 | **49** | 5 | 12.1% |
| SciDAC[1] | 50 | **60** | 11 | 21.2% |
| **National Institutes of Health** | 89 | **92** | 3 | 3.4% |
| General Medical Sciences | 50 | **52** | 2 | 4.0% |
| Imaging & Bioengineering | 39 | **40** | 1 | 2.6% |
| Total Mathematical Sciences | 529 | **593** | 64 | 12.1% |

*Source: Agency budget justifications and other agency communication.*
*All figures rounded to the nearest million.*
*Changes calculated from unrounded figures.*
[1] *Scientific Discovery through Advanced Computing*

evaluation of new systems, sensor networks, network science, autonomous systems, analysis of very large or very small data sets, and mathematics of biological systems. The division also works closely with the Computing Sciences Division and Network Science Division of ARO to develop mathematical theory for systems control, information processing, information assurance, network design, and data fusion. The Mathematics Program FY 2012 budget is estimated to be unchanged from FY 2010.

***Defense Advanced Research Projects Agency (DARPA).*** The Defense Sciences Office (DSO) and the Microsystems Technology Office (MTO) inside DARPA both have mathematics programs cutting across mathematics and its applications. Current programs include Focus Areas in Theoretical Mathematics, Mathematics of the Brain, Foundational Computer Science, Mathematical Challenges, and Nanostructure in Biology. The aggregate FY 2012 DARPA mathematics budget is estimated to increase by 129.2 percent over 2010.

***National Security Agency (NSA).*** The Mathematical Sciences Program of the NSA administers a Grants Program that supports fundamental research in the areas of algebra, number theory, discrete mathematics, probability, and statistics. The Grants Program accepts proposals for conferences and workshops in these research areas. NSA does not fund grant proposals in cryptography in order to avoid direct conflict of interest with the Agency's mission. In addition to grants, the Mathematical Sciences Program supports 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). As the largest employer of mathematicians in the United States, NSA has a vested interest in maintaining a healthy academic mathematics community in the United States. The NSA mathematics FY 2012 budget is estimated to decrease by 7.7 percent from FY 2010.

***Office of Naval Research (ONR).*** The ONR Mathematics, Computers, and Information Research 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 multiphase, multimaterial, and multiphysics problems; predictability of models for nonlinear dynamics; electromagnetic and acoustic wave propagation; mathematical foundation for quantum information sciences; and signal and image analysis and understanding. Also of interest are modeling pathological behaviors of large, dynamic complex networks and exploiting hybrid control to achieve reliability and security; optimization; formal methods for verifiably correct software construction; and computational foundations for machine reasoning and intelligence to support integrated sensing, computing, communication/networking, and control of cyber-physical systems. The Mathematical, Computer, and Information Sciences Division's FY 2012 budget would increase by 30.0 percent over FY 2010.

***Department of Energy (DOE).*** Mathematics at DOE is funded through the Office of Advanced Scientific Computing Research (ASCR), one of the interdisciplinary research offices within DOE's Office of Science. Research supported by ASCR underpins computational science throughout DOE. ASCR funding for the mathematical sciences is found primarily in the Applied Mathematics program and the Scientific Discovery through Advanced Computing (SciDAC) program. The Applied Mathematics activity supports the research, development, and application of applied mathematical models, methods, and algorithms to understand complex physical, chemical, biological, and engineered systems related to the department's mission. SciDAC investments in FY 2012 will include addressing challenges from emerging hardware to ensure continued progress in computational science in support of the department's missions. Aggregate funding for the mathematical sciences within DOE is estimated to increase by 16.9 percent over FY 2010.

***National Institutes of Health (NIH).*** NIH funds mathematical sciences research through the National Institute of General Medical Sciences (NIGMS; see `http://www.nigms.nih.gov/About/Overview/cbcb.htm`) and the National Institute of Biomedical Imaging and Bioengineering (NIBIB; see `http://www.nibib.nih.gov/Research/ProgramAreas/MathModeling`). Mathematical sciences areas of interest are those that support the missions of NIGMS and NIBIB. The NIGMS Center for Bioinformatics and Computational Biology supports programs in computational biology, such as the generation of mathematical models of biological networks, the development of modeling and simulation tools, the conduct of basic theoretical studies related to network organization and dynamic processes, and the development of methods for the analysis and dissemination of computational models. NIGMS is currently supporting a biomathematics initiative at around US$12 million per year in cooperation with the National Science Foundation. NIBIB supports the mathematical sciences through its Mathematical Modeling, Simulation and Analysis Program Area. The aggregate FY 2012 budget for the mathematical sciences in NIBIB and NIGMS would increase by 3.4 percent over FY 2010.