

the highest 10 percent earned more than \$63,480. Median annual earnings in the industries employing the largest numbers of computer support specialists in 2000 were:

Professional and commercial equipment .....	\$42,970
Computer and data processing services .....	37,860
Personnel supply services .....	34,080
Colleges and universities .....	32,830
Miscellaneous business services .....	21,070

Median annual earnings of network and computer systems administrators were \$51,280 in 2000. The middle 50 percent earned between \$40,450 and \$65,140. The lowest 10 percent earned less than \$32,450, and the highest 10 percent earned more than \$81,150. Median annual earnings in the industries employing the largest number of network and computer systems administrators in 2000 were:

Computer and data processing services .....	\$54,400
Telephone communication .....	52,620
Management and public relations .....	51,340
Elementary and secondary schools .....	45,450
Colleges and universities .....	44,010

According to Robert Half International, starting salaries in 2001 ranged from \$30,500 to \$56,000 for help-desk support staff, and from \$48,000 to \$61,000 for more senior technical support specialists. For systems administrators, starting salaries in 2001 ranged from \$50,250 to \$70,750.

### Related Occupations

Other computer-related occupations include computer programmers; computer software engineers; systems analysts, computer scientists, and database administrators; and operations research analysts.

### Sources of Additional Information

For additional information about a career as a computer support specialist, contact:

- ▶ Association of Computer Support Specialists, 218 Huntington Rd., Bridgeport, CT 06608. Internet: <http://www.acss.org>
- ▶ Association of Support Professionals, 66 Mt. Auburn St., Watertown, MA 02472. Internet: <http://www.asponline.com>

For additional information about a career as a systems administrator, contact:

- ▶ System Administrators Guild, 2560 9th St., Suite 215, Berkeley, CA 94710. Internet: <http://www.sage.org>

Further information about computer careers is available from:

- ▶ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: <http://www.nwcet.org>

## Mathematicians

(O\*NET 15-2021.00)

### Significant Points

- A doctoral degree in mathematics usually is the minimum education needed, except in the Federal Government.
- Employment is expected to decline because very few jobs with the title mathematician are available.
- Master's and Ph.D. degree holders with a strong background in mathematics and a related discipline, such as computer science or engineering, should have good employment opportunities in related occupations.

### Nature of the Work

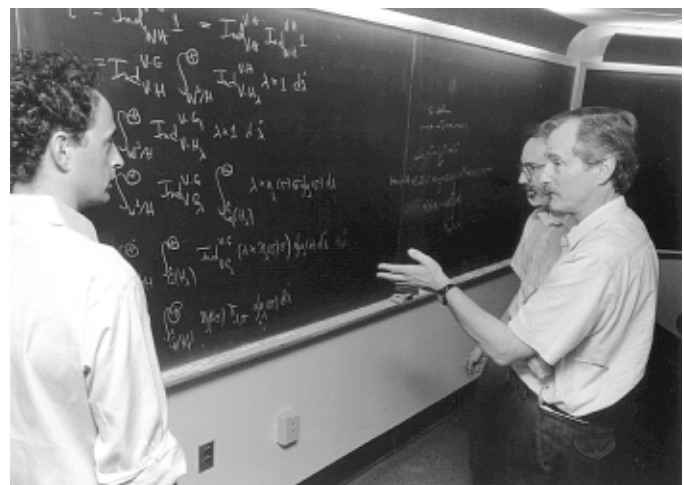
Mathematics is one of the oldest and most fundamental sciences. Mathematicians use mathematical theory, computational techniques, algorithms, and the latest computer technology to solve economic, scientific, engineering, physics, and business problems. The work of mathematicians falls into two broad classes—theoretical (pure) mathematics and applied mathematics. These classes, however, are not sharply defined, and often overlap.

*Theoretical mathematicians* advance mathematical knowledge by developing new principles and recognizing previously unknown relationships between existing principles of mathematics. Although they seek to increase basic knowledge without necessarily considering its practical use, such pure and abstract knowledge has been instrumental in producing or furthering many scientific and engineering achievements. Many theoretical mathematicians are employed as university faculty and divide their time between teaching and conducting research. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

*Applied mathematicians*, on the other hand, use theories and techniques, such as mathematical modeling and computational methods, to formulate and solve practical problems in business, government, engineering, and in the physical, life, and social sciences. For example, they may analyze the most efficient way to schedule airline routes between cities, the effect and safety of new drugs, the aerodynamic characteristics of an experimental automobile, or the cost-effectiveness of alternate manufacturing processes. Applied mathematicians working in industrial research and development may develop or enhance mathematical methods when solving a difficult problem. Some mathematicians, called cryptanalysts, analyze and decipher encryption systems designed to transmit military, political, financial, or law enforcement-related information in code.

Applied mathematicians start with a practical problem, envision the separate elements of the process under consideration, and then reduce the elements into mathematical variables. They often use computers to analyze relationships among the variables and solve complex problems by developing models with alternate solutions.

Much of the work in applied mathematics is done by individuals with titles other than mathematician. In fact, because mathematics is the foundation upon which so many other academic disciplines are built, the number of workers using mathematical techniques is much greater than the number formally designated as mathematicians. For example, engineers, computer scientists, physicists, and economists are among those who use mathematics extensively. Some professionals, including statisticians, actuaries, and operations



Mathematicians use abstract mathematical concepts and theories in real-world applications.

research analysts, actually are specialists in a particular branch of mathematics. Frequently, applied mathematicians are required to collaborate with other workers in their organizations to achieve common solutions to problems. (For more information, see the statements on actuaries, operations research analysts, and statisticians elsewhere in the *Handbook*.)

### Working Conditions

Mathematicians usually work in comfortable offices. They often are part of an interdisciplinary team that may include economists, engineers, computer scientists, physicists, technicians, and others. Deadlines, overtime work, special requests for information or analysis, and prolonged travel to attend seminars or conferences may be part of their jobs. Mathematicians who work in academia usually have a mix of teaching and research responsibilities. These mathematicians often conduct research alone, or are aided by graduate students interested in the topic being researched.

### Employment

Mathematicians held about 3,600 jobs in 2000. In addition, about 20,000 persons held full-time mathematics faculty positions in colleges and universities in 2000, according to the American Mathematical Society. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

Many nonfaculty mathematicians work for Federal or State governments. The U.S. Department of Defense is the primary Federal employer, accounting for about three-fourths of the mathematicians employed by the Federal Government. In the private sector, major employers include research and testing services, educational services, security and commodity exchanges, and management and public relations services. Within manufacturing, the aerospace and drug industries are the key employers. Some mathematicians also work for banks and insurance companies.

### Training, Other Qualifications, and Advancement

A doctoral degree in mathematics usually is the minimum education needed for prospective mathematicians, except in the Federal Government. In the Federal Government, entry-level job candidates usually must have a 4-year degree with a major in mathematics or a 4-year degree with the equivalent of a mathematics major—24 semester hours of mathematics courses.

In private industry, candidates for mathematician jobs typically need a Masters or Ph.D. degree. Most of the positions designated for mathematicians are in research and development laboratories as part of technical teams. Research scientists in such positions engage either in basic research on pure mathematical principles or in applied research on developing or improving specific products or processes. The majority of those with a bachelor's or master's degree in mathematics who work in private industry do so not as mathematicians, but in related fields such as computer science, where they have titles such as computer programmer, systems analyst, or systems engineer.

A bachelor's degree in mathematics is offered by most colleges and universities. Mathematics courses usually required for this degree include calculus, differential equations, and linear and abstract algebra. Additional courses might include probability theory and statistics, mathematical analysis, numerical analysis, topology, discrete mathematics, and mathematical logic. Many colleges and universities urge or require students majoring in mathematics to take courses in a field that is closely related to mathematics, such as computer science, engineering, life science, physical science, or economics. A double major in mathematics and another discipline such as computer science, economics, or another one of the sciences is particularly desirable to many employers. A prospective

college mathematics major should take as many mathematics courses as possible while in high school.

In 2001, about 200 colleges and universities offered a master's degree as the highest degree in either pure or applied mathematics; about 200 offered a Ph.D. degree in pure or applied mathematics. In graduate school, students conduct research and take advanced courses, usually specializing in a subfield of mathematics.

For jobs in applied mathematics, training in the field in which the mathematics will be used is very important. Mathematics is used extensively in physics, actuarial science, statistics, engineering, and operations research. Computer science, business and industrial management, economics, finance, chemistry, geology, life sciences, and behavioral sciences are likewise dependent on applied mathematics. Mathematicians also should have substantial knowledge of computer programming because most complex mathematical computation and much mathematical modeling is done on a computer.

Mathematicians need good reasoning ability and persistence in order to identify, analyze, and apply basic principles to technical problems. Communication skills are important, as mathematicians must be able to interact and discuss proposed solutions with people who may not have an extensive knowledge of mathematics.

### Job Outlook

Employment of mathematicians is expected to decline through 2010, because very few jobs with the title mathematician are available. However, master's and Ph.D. degree holders with a strong background in mathematics and a related discipline, such as engineering or computer science, should have good job opportunities. However, many of these workers have job titles that reflect their occupation, rather than the title mathematician.

Advancements in technology usually lead to expanding applications of mathematics, and more workers with knowledge of mathematics will be required in the future. However, jobs in industry and government often require advanced knowledge of related scientific disciplines in addition to mathematics. The most common fields in which mathematicians study and find work are computer science and software development, physics, engineering, and operations research. More mathematicians also are becoming involved in financial analysis. Mathematicians must compete for jobs, however, with people who have degrees in these other disciplines. The most successful jobseekers will be able to apply mathematical theory to real-world problems, and possess good communication, teamwork, and computer skills.

Private industry jobs require at least a master's degree in mathematics or in one of the related fields. Bachelor's degree holders in mathematics usually are not qualified for most jobs, and many seek advanced degrees in mathematics or a related discipline. However, bachelor's degree holders who meet State certification requirements may become primary or secondary school mathematics teachers. (For additional information, see the statement on teachers—pre-school, kindergarten, elementary, middle, and secondary elsewhere in the *Handbook*.)

Holders of a master's degree in mathematics will face very strong competition for jobs in theoretical research. Because the number of Ph.D. degrees awarded in mathematics continues to exceed the number of university positions available, many of these graduates will need to find employment in industry and government.

### Earnings

Median annual earnings of mathematicians were \$68,640 in 2000. The middle 50 percent earned between \$50,740 and \$85,520. The lowest 10 percent had earnings of less than \$35,390, while the highest 10 percent earned over \$101,900.

According to a 2001 survey by the National Association of Colleges and Employers, starting salary offers averaged \$46,466 a year for mathematics graduates with a bachelor's degree, and \$55,938 for those with a master's degree. Doctoral degree candidates averaged \$53,440.

In early 2001, the average annual salary for mathematicians employed by the Federal Government in supervisory, nonsupervisory, and managerial positions was \$76,460; for mathematical statisticians, it was \$76,530, and for cryptanalysts, \$70,840.

### Related Occupations

Other occupations that require extensive knowledge of mathematics or, in some cases, a degree in mathematics include actuaries; statisticians; computer programmers; systems analysts, computer scientists, and database administrators; computer software engineers; and operations research analysts. A strong background in mathematics also facilitates employment as teachers—postsecondary, engineers, economists and survey and market researchers, financial analysts and personal financial advisors, and physicists and astronomers.

### Sources of Additional Information

For more information about careers and training in mathematics, especially for doctoral-level employment, contact:

► American Mathematical Society, 201 Charles St., Providence, RI 02940. Internet: <http://www.ams.org>

For specific information on careers in applied mathematics, contact:

► Society for Industrial and Applied Mathematics, 3600 University City Science Center, Philadelphia, PA 19104-2688. Internet:

<http://www.siam.org/alterindex.htm>

Information on obtaining a mathematician position with the Federal Government is available from the Office of Personnel Management (OPM) through a telephone-based system. Consult your telephone directory under U.S. Government for a local number or call (912) 757-3000; Federal Relay Service: (800) 877-8339. The first number is not tollfree, and charges may result. Information also is available from the OPM Internet site: <http://www.usajobs.opm.gov>.

## Operations Research Analysts

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### Significant Points

- Individuals with a master's or Ph.D. degree in management science, operations research, or a closely related field should have good job prospects.
- Employment growth is projected to be slower than average because few job openings are expected to have the title *operations research analyst*.

### Nature of the Work

Operations research and management science are terms that are used interchangeably to describe the discipline of applying advanced analytical techniques to help make better decisions and to solve problems. The procedures of operations research gave effective assistance during World War II in missions such as deploying radar, searching for enemy submarines, and getting supplies where they were most needed. Following the war, new analytical methods were developed and numerous peacetime applications emerged, leading to the use of operations research in many industries and occupations.

The prevalence of operations research in the Nation's economy reflects the growing complexity of managing large organizations that require the effective use of money, materials, equipment, and people. Operations research analysts help determine better ways to coordinate these elements by applying analytical methods from mathematics, science, and engineering. They solve problems in different ways and propose alternative solutions to management, which then chooses the course of action that best meets the organization's goals. In general, operations research analysts may be concerned with diverse issues such as top-level strategy, planning, forecasting, resource allocation, performance measurement, scheduling, design of production facilities and systems, supply chain management, pricing, transportation and distribution, and analysis of data in large databases.

The duties of the operations research analyst vary according to the structure and management philosophy of the employer or client. Some firms centralize operations research in one department; others use operations research in each division. Operations research analysts also may work closely with senior managers to identify and solve a variety of problems. Some organizations contract operations research services with a consulting firm. Economists, systems analysts, mathematicians, industrial engineers, and others also may apply operations research techniques to address problems in their respective fields. (These occupations are discussed elsewhere in the *Handbook*.)

Regardless of the type or structure of the client organization, operations research in its classical role entails a similar set of procedures in carrying out analysis to support management's quest for performance improvement. Managers begin the process by describing the symptoms of a problem to the analyst, who then formally defines the problem. For example, an operations research analyst for an auto manufacturer may be asked to determine the best inventory level for each of the parts needed on a production line and to determine the number of windshields to be kept in inventory. Too many windshields would be wasteful and expensive, while too few could result in an unintended halt in production.

Operations research analysts study such problems, then break them into their component parts. Analysts then gather information about each of these parts from a variety of sources. To determine the most efficient amount of inventory to be kept on hand, for example, operations research analysts might talk with engineers about production levels, discuss purchasing arrangements with buyers, and examine data on storage costs provided by the accounting department.

With this information in hand, the analyst is ready to select the most appropriate analytical technique. Analysts could use several techniques—including simulation, linear and nonlinear programming, dynamic programming, queuing and other stochastic-process models, Markov decision processes, econometric methods, data envelopment analysis, neural networks, expert systems, decision analysis, and the analytic hierarchy process. Nearly all of these techniques, however, involve the construction of a mathematical model that attempts to describe the system being studied. The use of models enables the analyst to assign values to the different components, and clarify the relationships between components. These values can be altered to examine what may happen to the system under different circumstances.

In most cases, the computer program developed to solve the model must be modified and run repeatedly to obtain different solutions. A model for airline flight scheduling, for example, might include variables for the cities to be connected, amount of fuel required to fly the routes, projected levels of passenger demand, varying ticket and fuel prices, pilot scheduling, and maintenance costs. By locating the right combination of variable values, the analyst is able to produce the best flight schedule consistent with particular assumptions.