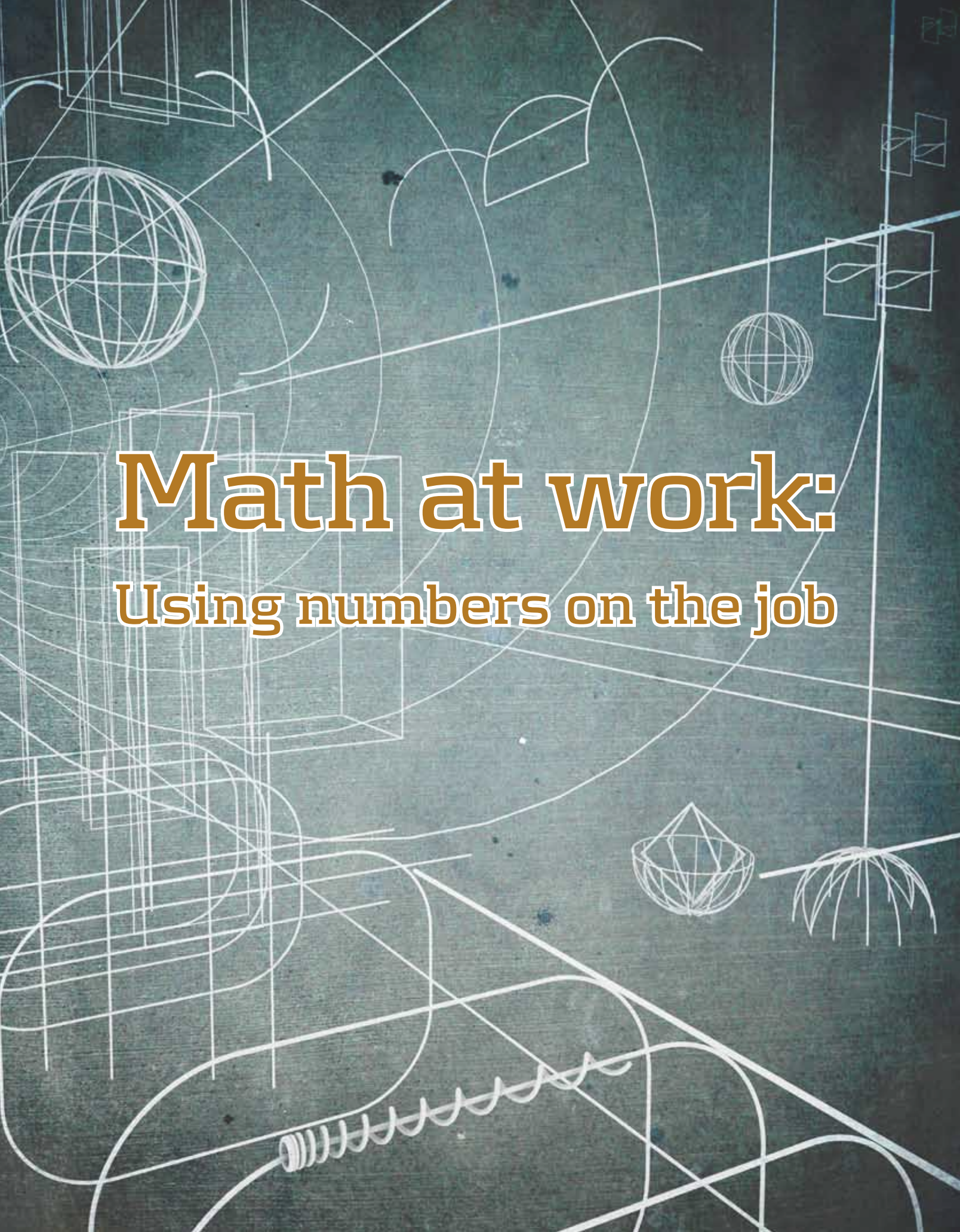


Math at work:

Using numbers on the job

Lois Coles teaches algebra to eighth graders in Brentwood, Tennessee. Each year she has her students talk to workers in careers that interest them, asking for examples of how they use math in their jobs.

"It's unbelievable," says Coles. "The students ask everyone—from figure skaters to real estate agents, nurses, and airline pilots—and they all give us math problems."

Math is used in many occupations. And, experts say, workers with a strong background in mathematics are increasingly in demand. "Employers are looking for math majors a lot more than they used to," says Mike Breen of the American Mathematical Society. That equals prime opportunity for career-minded math enthusiasts.

This article describes how math factors into careers. The first section talks about some of the ways workers use math in the workplace. The second section focuses on three occupations that use math: cryptologists, health data analysts, and math teachers. A third section highlights reasons why workers enjoy their math-related careers and discusses some of their challenges. And a final section suggests sources for more information.

Math: A formula for career success

Mastering mathematics is helpful in almost any career. Learning math helps workers analyze and solve problems—abilities that most employers value. And math teaches other important practices, including how to approach tasks methodically, pay attention to detail, and think abstractly.

Some number-focused occupations, such as accountants and cost estimators, are obvious. However, workers in other occupations combine mathematical know-how with knowledge specific to their field. Science, technology, and engineering disciplines, for example, rely heavily on mathematics. And other disciplines, such as economics, also use math.

"Mathematics is so prevalent across all kinds of fields," says Michael Pearson, executive director of the Mathematical Association of America. Math-intensive occupations include computational biologists, who use statistics to analyze molecular datasets; graphics programmers, who use vector mathematics to create movies and video games; and patent lawyers, who use mathematical concepts to better understand some inventions.

The level of math needed in occupations ranges from basic calculations to complex mathematical theories. Carpenters, electricians, and other skilled trade workers may use basic geometry and algebra to calculate the cost and amount of materials they need. Financial quantitative analysts, in contrast, often use graduate-level statistical, quantitative, or econometric techniques to create mathematical models for analyzing investments.

Even in occupations that don't require it, math knowledge can open the door to lots of careers, says Pearson: "A mathematical background gives you the chance to move in all kinds of directions."

Elka Torpey

Elka Torpey is an economist in the Office of Occupational Statistics and Employment Projections, BLS. She is available at torpey.elka@bls.gov.

Math on the job: A look at three occupations

We know that lots of workers use math on the job. But in what way do they use it?

In the three occupations described here—cryptologist, health data analyst, and math teacher—workers use math in different ways. Details about their math-related job tasks follow, along with the occupations' outlook, wages, and required preparation.

A box on page 9 covers four math occupations profiled in the *Occupational Outlook Handbook*: actuaries, mathematicians, operations research analysts, and statisticians.

Cryptologist

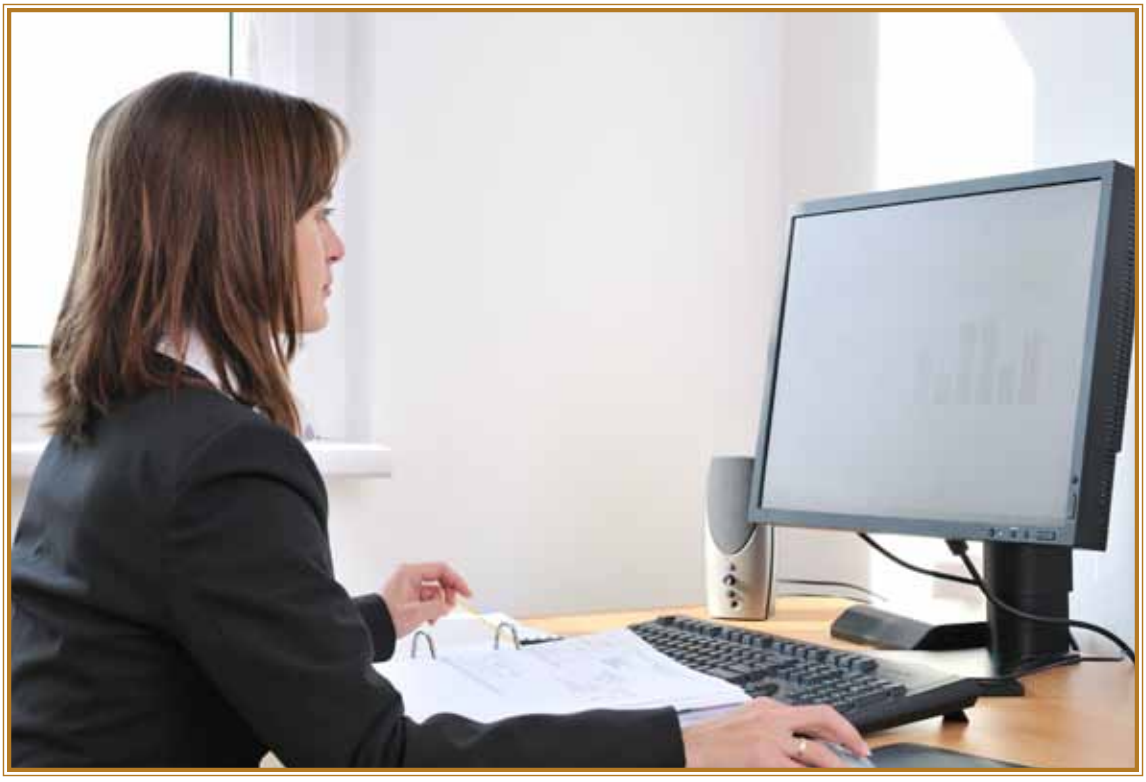
Private information—from government secrets to personal financial records—is usually intended to be kept private. This type of information is usually kept secret by a computerized encryption scheme. Cryptologists use their knowledge of math to create, to improve—and, sometimes, to break these encryptions.

Today, many encryptions are created with algorithms, sets of mathematical instructions that computers use to make information unreadable for people who don't have the key. Depending on their project, cryptologists rely on various types of math: abstract algebra, number theory, probability, statistics, and other specialties. Other job titles for cryptologists include cryptanalyst and cryptographer.

Cryptologists often write computer programs for the algorithms they are creating, refining, or trying to break. Most encryption algorithms are one of two types: symmetric key or asymmetric (public) key. In symmetric-key encryption, the person encrypting the information and the person receiving that information use the same key for decryption. Asymmetric-key encryption uses two different keys.

The need for two keys in public-key encryption increases its complexity. "The algorithms used for public-key cryptology tend to be very mathematical, relying on large prime numbers, exponentiation, or other concepts to prove they're secure," says Greg Rose, a cryptologist in San Diego, California.

Workers use math on the job in different ways, depending on their occupation.



Rose was working as a security engineer when he identified weaknesses in cell phone encryption algorithms. He used cryptology to develop a better way to encrypt the information. "It's very exciting," says Rose, "like solving puzzles."

Unlike Rose, cryptologist Roger Barkan tries to break encryptions created by potential U.S. adversaries. His work for the National Security Agency in Fort Meade, Maryland, involves analyzing encrypted data to decipher this secret information.

To determine if an encryption can be broken, cryptologists like Barkan use statistical analysis to figure out which aspects of encrypted data are clues to solving the encryption—and which are merely coincidental. The results of their inquiry determine whether they design followup tests to look for additional clues.

For example, Barkan might look at an encrypted message and notice that the binary data contain more ones than zeros. His next step would be to use statistics to decide whether the number of ones and zeros is meaningful. This analysis helps Barkan to determine what the encryption scheme is or how the decrypted message may appear. "Ultimately, a good cryptologist needs to be like a detective," he says.

Another task cryptologists have is to ensure that algorithms are as effective as possible. "There are plenty of algorithms out there that work," says Rose, "but their efficiency is becoming more important." For example, cryptologists may refine algorithms so that they take less time to complete and use less computer memory.

The encryption algorithms that cryptologists work on are used around the world to help keep information secure. "I've written a piece of math that millions of people use every day," says cryptologist Bruce Schneier of Minneapolis, Minnesota. "That's pretty cool."

Employment, wages, and outlook. BLS does not collect data specifically on cryptologists. Many workers in this occupation are classified by BLS as mathematicians. In May 2011, BLS data show, there were 2,980 wage and salary mathematicians. These workers had a median annual wage of $101,040.

According to BLS, mathematicians are projected to add about 500 new jobs between 2010 and 2020. Many jobs related to national security are expected to have continued employment growth. Still, competition for cryptologist and other mathematician jobs is expected, given the relatively few number of available positions. Workers may need to relocate to an area where major employers are based, such as near Washington, D.C.

Most cryptologists work for the National Security Agency or other government intelligence agencies or in academia. Some large, multinational corporations also hire these workers, industry sources say.

Many types of businesses—such as banks and cable companies—rely on cryptology to help keep information secure. Most of the encryption algorithms in use today have already been written, however, so the number of jobs with these organizations is small.

Preparation. Cryptologists need excellent math, computer programming, and problem-solving skills. They also must be organized, persistent, and able to think creatively.

Most cryptologists need at least a bachelor's degree in mathematics or a related field to enter the occupation. For some positions, a master's degree or Ph.D. is required. But sometimes, related experience can substitute for education.

For some entry-level government cryptologist positions, workers can have a college degree in a nontechnical field, such as music or history. These workers provide a different perspective when helping to analyze encryptions—and, like other government cryptologists, they usually receive on-the-job training and take classes in subjects related to their work.

Cryptologists who work for the U.S. government must pass a security background investigation and a polygraph test. An internship with a federal agency that employs cryptologists is helpful for gaining experience and contacts in the field.

Health data analyst

Thanks to the work of health data analysts, math provides answers that help people make informed healthcare decisions. Health data analysts collect, manage, and analyze healthcare information. They use this information to identify ways to lower costs and improve services.

Some health data analysts perform mathematical calculations to better understand how a healthcare facility functions. Ellen Berkowitz, a senior health data analyst in Toledo, Ohio, produces reports that compare her hospital's care with that of established best practice standards. She may calculate how long it typically takes for a patient to receive an electrocardiogram (EKG), for example, or calculate the percentage of heart failure patients readmitted within 30 days. Then, depending on the results, Berkowitz tries to identify areas for improvement and reports the data in executive summaries, graphs, and other presentations.

Other health data analysts use statistics to establish connections between healthcare experiences and patients' results—and to make predictions about the future. Analysts like Chet Deshmukh of Apex, North Carolina, for example, may do a regression analysis to determine which factors are most likely to affect stroke patients' rehabilitation and recovery times. "You start to connect the dots to envision certain patterns and trends," says Deshmukh. "You take information specific to one person and try to connect it to the overall population."

Health data analysts' jobs vary by employer and position. Analysts who work for insurance companies, for example, may develop predictive models to help the company determine ways to save costs by encouraging at-risk plan members to take preventive measures.

Most health data analysts work with electronic health records to compile and analyze data. Some analysts transfer data from paper-based to electronic records. Others set up systems for entering health data. Still others specialize in helping their organization meet data collection and reporting requirements.

Workers other than health data analysts also study health data. Medical records and health information technicians, for example, organize and manage data related to patient care. Healthcare administrators, nurses, and case managers sometimes analyze health information. And many statisticians, epidemiologists, and medical scientists focus on interpreting medical and health data.

Employment, wages, and outlook. BLS does not collect data specifically on health data analysts. Some of the duties of health data analysts are similar to those of medical records and health information technicians. BLS data show that in May 2011 wage and salary medical records and health information technicians held 180,280 jobs and had a median annual wage of $33,310.

Health data analysts who perform sophisticated research often have tasks that overlap with those of statisticians or of epidemiologists. In May 2011, wage and salary epidemiologists held 4,610 jobs and earned a median annual wage of $64,220. And BLS counted 23,770 wage and salary statisticians, who had a median annual wage of $73,880, in May 2011.

Anecdotal information suggests that wages for most health data analysts fall between those of the technicians and statisticians—in the $40,000 to $60,000 range.

BLS projects that employment for medical records and health information technicians should grow faster than the average for all occupations, adding 37,700 new jobs between 2010 and 2020. Employment growth of epidemiologists is projected to be faster than average and to add 1,200 new jobs. And statistician employment is projected to grow at an average rate and to add 3,500 new jobs.

Health data analysts work for hospitals, nursing homes, and other healthcare facilities. Other major employers include insurance companies, government agencies, research institutions, and consulting firms.

Preparation. Health data analysts must be detail oriented and have good math and

Health data analysts use math to help people make informed decisions about healthcare.

analytical skills. They also must be able to communicate well so that they can explain their findings to others.

Knowledge of healthcare practices is important for health data analysts. These workers must understand disease classification systems, medical terminology, and healthcare reimbursement methods so that they can interpret data and understand how it relates to improving costs and patient care. Many health data analysts have worked as medical coders. Others have experience in patient care or healthcare administration.

An associate's degree is typically the minimum education required to become a health data analyst. As job duties of health data analysts evolve, some employers prefer to hire workers who have a bachelor's or higher degree, especially for positions requiring higher level statistical analysis. Fields of study may include health information management, health informatics, health services research, or public health.

In addition, coursework in statistics, computer science, physical sciences, and business administration are valuable. Workers also must be comfortable using electronic health records systems, as well as database, spreadsheet, presentation, statistical, and other types of software.

Math teacher

Math is used every day for many things, such as paying bills and measuring ingredients. With the help of math teachers, students gain the math knowledge they need for everyday tasks—and, at higher levels, they learn the advanced math skills required in some careers.

To help their students become more engaged, math teachers frequently use real-world examples. For example, Nikita

Midamba, who teaches algebra, trigonometry, geometry, and basic math for a nonprofit organization in Philadelphia, Pennsylvania, uses nutrition labels and local crime statistics to make math relatable for her students.

Math teachers also may use hooks—such as clips from television shows or commercials—to attract students' attention so that they become intrigued in a lesson or with a problem. Middle school algebra teacher Lois Coles, for example, has her students play games, and she tells jokes at the end of her slideshow presentations. "If you can find ways to make math fun," agrees Midamba, "students will learn it."

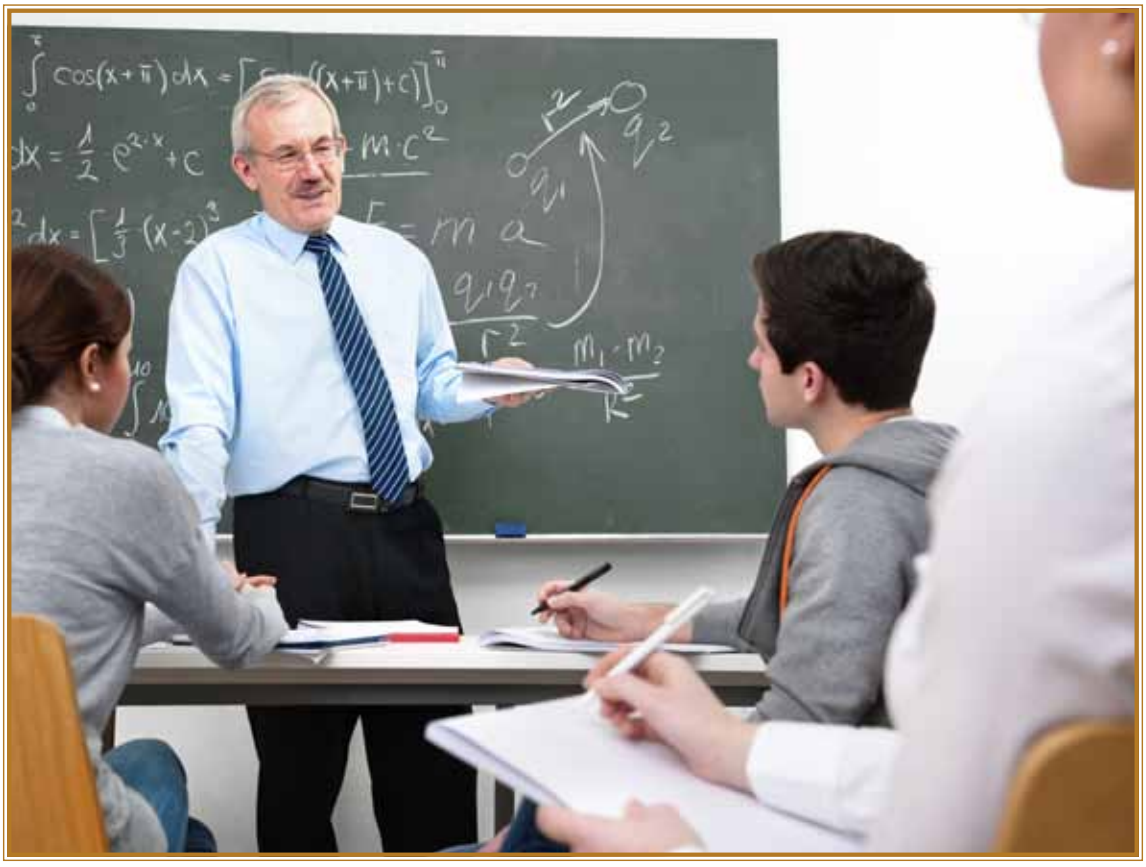
By the very nature of their work, math teachers regularly apply their mathematical knowledge on the job. The types of math that they teach range from basic math, such as addition and multiplication, at the elementary school level to more complex subjects, such as geometry and calculus, in high school. Some math instructors and professors teach statistics, differential equations, and other topics at the undergraduate and graduate levels; some also do original research.

Like all teachers, math teachers spend time creating lesson plans, presenting material to students, and grading assignments. They often use their math skills during these activities. When grading math problems, for example, math teachers check students' work to ensure that students follow the proper steps to get their answers. Teachers also help students prepare for standardized tests.

Some teachers focus only on math. Others, especially those who work with younger students, teach more than one subject. Math teachers may specialize in education for specific groups, such as elementary, postsecondary, or adult literacy and GED students.

Because students learn in different ways, math teachers often use a variety of techniques to present concepts. For example,

(Continued on page 10)



To keep students engaged in a lesson, math teachers may tell jokes or have students play games in class.

Four occupations in which math is prime

Some workers specialize in mathematics—or a particular branch of it. These workers include actuaries, mathematicians, operations research analysts, and statisticians. The table shows BLS wage and employment data for each of these occupations.

Read the detailed profiles for these four occupations, listed under math occupations in the *Occupational Outlook Handbook*, at **www.bls.gov/ooh/math/home.htm**.

Actuaries. Sometimes called actuarial analysts, actuaries use mathematical models to analyze statistical data and to forecast risk. They help develop, price, and evaluate products related to health insurance, life insurance, property and casualty insurance, or pension and retirement benefits.

Actuaries typically need a bachelor's degree in a discipline such as mathematics, statistics, business, or actuarial science. Computer programming skills are also important. To become fully qualified, actuaries must pass a series of exams, but workers need not have passed all of these exams before being hired. Employers often pay for the exams and allow time on the job to study for them.

Mathematicians. These workers advance mathematical knowledge and solve problems using high-level mathematics and technology. They explore new mathematical theories and ideas in specific areas of math, such as geometry, number theory, or logic. And they look for ways to apply mathematical principles to disciplines like engineering or science. Cryptologists, described in greater detail above, are a type of mathematician.

Mathematician jobs typically require a master's degree in mathematics, but many workers have a Ph.D. Some jobs are available for workers with a bachelor's degree.

Operations research analysts. To help organizations solve problems and improve decisionmaking using mathematical models, operations research analysts collect and study information from databases and other sources. They use their analyses to make recommendations related to production, sales, logistics, or other areas of operation.

To enter the occupation, workers must know how to use advanced statistical and database software. In addition, they typically need a bachelor's degree in operations research, management science, or a related field. Degrees in mathematics, engineering, computer science, physics, or other technical fields are also common. Many employers prefer to hire people who have a master's or higher degree.

Statisticians. Statisticians collect and interpret data using a variety of statistical methods and theories. They design surveys and other methods for gathering data representative of a population. Statisticians also identify trends in data, draw conclusions, and assess whether their results are reliable.

These workers typically need a master's degree in statistics, mathematics, or survey methodology. But a bachelor's degree is sufficient for some entry-level jobs. A Ph.D. usually is required for academic or research jobs. Statisticians need computer programming skills and use statistical software to analyze data.

Wages, employment, and outlook in math occupations,* May 2011 and projected 2010–20

Math occupations	May 2011		Projected 2010-20	
	Median annual wage	Employment	Numeric change	Percent change
Actuaries	$91,060	19,590	5,800	Faster than average
Mathematicians	101,040	2,980	500	About as fast as average
Operations research analysts	71,950	65,030	9,400	About as fast as average
Statisticians	73,880	23,770	3,500	About as fast as average

* Table includes the four mathematical occupations BLS profiles in the *OOH*. As the article explains, many other occupations use math.
Source: BLS, Occupational Employment Statistics Survey (wages and employment), Employment Projections Program (numeric and percent change).

Math teachers must be able to break down complicated concepts into ones that are easier for their students to grasp.

(Continued from page 8)

some concepts may be explained using words and graphs along with numbers. Coles and other math teachers combine two or more approaches to reach out to all types of learners. "My kids get it," Coles says. "One way or another, they get it."

Employment, wages, and outlook. BLS does not collect data on math teachers separately. Instead, BLS counts math teachers among other types of teachers.

There were more than 3 million wage and salary elementary, middle, and high school teachers in May 2011, according to BLS. Adult literacy and GED teachers accounted for about 68,000 additional wage and salary jobs. And postsecondary mathematical science teachers held about 54,000 wage and salary jobs.

Median annual wages in May 2011 ranged from $47,370 for adult literacy and GED teachers to $66,680 for postsecondary mathematical science teachers. Teachers typically work during a 10-month academic year, with 2 months off in the summer.

According to BLS, the job outlook for teachers varies by region of employment and the level of education that they teach. Altogether, teachers are projected to add more than 700,000 new jobs between 2010 and 2020. And because math is a subject for which many schools report difficulty finding qualified instructors, math teachers are expected to have better job prospects than other types of teachers.

Most math teachers work in public or private elementary, middle, and high schools. Others teach at the college level. Some, like Midamba, work for community-based organizations.

Preparation. Creativity, patience, and enthusiasm about the subject matter are some of the most important qualities for teachers. But teachers need other skills, too.

"You really have to be able to engage the students and be able to understand where

they're coming from," says Midamba. "You can know math, but that doesn't necessarily mean you will be a great math teacher." The ability to break down complicated concepts into ones that are easier to grasp is also important.

Teachers typically need at least a bachelor's degree. Public school teachers also need a state-issued certification or license. To teach higher level math, workers often must have majored or minored in mathematics or a related field. Teacher education classes and supervised teaching experiences also help to prepare these workers—and may be required for certification. Specific requirements vary by state or employer or by the group of students that workers teach.

Some teachers earn a master's degree, which may lead to higher pay. Those who teach at the college level usually need a Ph.D.

Pluses and minuses of math work

There's a lot to like about jobs that use math. "For something that many people tend to think of as boring, mathematics is actually really exciting," says cryptologist Rose.

Finding opportunities to share that excitement with others attracts workers to these jobs. "Math is something I like," says Midamba, "and it's rewarding for me to be able to show students that math isn't scary and that they're smart enough to do it."

Career satisfaction starts early for math workers. According to the National Center for Education Statistics Baccalaureate and Beyond Study, math majors in 2009 reported higher levels of satisfaction with the challenge of their work 1 year after graduation than many other majors, including those in engineering and engineering technology, computer and information sciences, business, social sciences, and biological or physical sciences.

Studying math often pays off right away: math majors have starting salaries that are higher than college graduates in many other disciplines. (See the box on page 12.)

BLS data show that math occupations (actuaries, mathematicians, operations research analysts, and statisticians) had median annual wages that were more than double the $34,460 median annual wage for all occupations in May 2011. And other occupations that require advanced math skills—such as physicists, engineers, and computer scientists—also had very high median annual wages: often close to or greater than $100,000.

But those personal and financial rewards are usually the result of hard work and study. Most math-intensive jobs require at least a bachelor's degree. Others require a master's degree or Ph.D.

And even after years of study, finding the answers to practical or theoretical problems in math isn't always easy. Health data analyst

Some math problems take years to solve, but workers say the challenge makes their efforts gratifying.

Study math, multiply your earnings

Math majors often fare well in the job market, according to data from the National Association of Colleges and Employers (NACE).

Data from the NACE winter 2012 salary survey indicate that the average starting salary for mathematics majors was $43,800, higher than the average of $41,701 for all 2011 graduates. As table 1 shows, math majors' starting salaries compared favorably with those of other majors in 2011. And graduates who majored in engineering and computer science—two disciplines that use plenty of math—had the highest starting salaries of any majors.

Furthermore, in four of the top five industries in which they were employed, math majors had starting salaries that exceeded $50,000. (See table 2.) According to NACE, there were about 16,000 new graduates employed in these five industries. Job titles for math majors employed in these industries might include operations research analyst, systems engineer, data manager, data mining analyst, cryptanalyst, programmer, financial analyst, actuarial analyst, or teacher.

Table 1: Average starting salaries of selected majors, 2011

Engineering	$61,872
Computer science	60,594
Business	48,144
Mathematics	43,800
Sciences	40,204
Education	37,830
Humanities and social sciences	35,503

Table 2: Average starting salaries of 2011 math majors, by industry

Elementary and secondary schools	$37,550
Insurance carriers and related activities	51,510
Management, scientific, and technical consulting services	53,610
Computer systems design and related services	53,020
Manufacturing	54,120

Source: National Association of Colleges and Employers, January 2012 salary survey.

Deshmukh says it's frustrating when predictions don't always hold true and data quality isn't always optimal.

On the other hand, says Barkan, time spent on a mathematical inquiry or analysis can be gratifying in the end: "The extreme difficulty of our problems makes our achievements that much more satisfying when we accomplish them."

For more information

To learn more about many of the occupations in this article, as well as hundreds of others, refer to the *Occupational Outlook Handbook* (*OOH*), online at **www.bls.gov/ooh**.

Recent articles in the *Occupational Outlook Quarterly* (*OOQ*) focus on people whose math backgrounds are important in their work. "My career: Manager," in the summer 2012 *OOQ*, is available at **www.bls.gov/ooq/2012/summer/mycareer.htm**. And "You're a what? Psychometrician" appears in the fall 2011 issue at **www.bls.gov/ooq/2011/fall/yawhat.htm**.

General information about math careers is available from the following organizations:

American Mathematical Society
201 Charles St.
Providence, RI 02904
Toll free: 1 (800) 321-4267
www.ams.org/careers

Mathematical Association of America
1529 18th St. NW.
Washington, DC 20036
Toll free: 1 (800) 741-9415
maahq@maa.org
www.maa.org/students/career.html

Society for Industrial and Applied Mathematics
3600 Market St., 6th Floor
Philadelphia, PA 19104
Toll free: 1 (800) 447-7426
service@siam.org
www.siam.org/careers

Association for Women in Mathematics
11240 Waples Mill Rd., Suite 200
Fairfax, VA 22030
(703) 934-0163
awm@awm-math.org
sites.google.com/site/awmmath/awm-resources/career

For more information about cryptologists, contact:

International Association for Cryptologic Research
www.iacr.org

National Security Agency
9800 Savage Rd.
Fort Meade, MD 20755
Toll free: 1 (866) 672-4473
customercare@nsa.gov
www.nsa.gov/careers

For more information about health data analysts, contact:

American Health Information Management Association (AHIMA)
233 N. Michigan Ave., 21st Floor
Chicago, IL 60601
Toll free: 1 (800) 335-5535
www.ahima.org

For more information about math teachers, contact:

National Council of Teachers of Mathematics
1906 Association Dr.
Reston, VA 20191
Toll free: 1 (800) 235-7566
nctm@nctm.org
www.nctm.org