

being second (21%). In contrast, Canada's greatest item affecting carbon footprint is mobility (30%), and its second greatest is shared between shelter and service (18% each).

Further Reading

Berners-Lee, Mike. *How Bad Are Bananas? The Carbon Footprint of Everything*. Vancouver, BC: Greystone Books, 2011.

Goleman, Daniel. *Ecological Intelligence: How Knowing the Hidden Impacts of What We Buy Can Change Everything*. New York: Broadway Books, 2009.

MARIA DROUJKOVA

See Also: City Planning; Climate Change; Electricity; Energy; Farming; Fuel Consumption; Green Design; Green Mathematics; Recycling; Traffic; Wind and Wind Power.

Careers

Category: Mathematics Culture and Identity.

Fields of Study: All.

Summary: There are a wide variety of careers in many disciplines available to those with a mathematics background.

"What can one do with a mathematics degree other than teaching?" It is a question asked by many aspiring mathematicians. In fact, a more accurate question to ask should be "What can't one do with a math degree?" Actually, the study of mathematics extends far beyond mere number crunching and doing fast mental arithmetic in grocery stores. The fact is that studying mathematics can prepare one for numerous careers.

In general, companies believe that studying mathematics develops analytical skills and the ability to work in a problem-solving environment. These are the skills and experiences that are essential assets to one's success in the workplace. Precisely, mathematics is often the quintessential element to fluently communicate with people of various backgrounds. It is the ability to efficiently process a manifold of information and deliver the technical details to a general audience that makes

mathematicians valuable. Having a mathematics background not only helps people broaden their pool of career options, it also helps to land some of the best jobs available.

According to an article published in the *Wall Street Journal* on January 26, 2009, a "mathematician" is considered to be the best occupation in the United States. This ranking was determined based on five criteria inherent to every job: environment, income, employment outlook, physical demands, and stress. In fact, five out of the six "best jobs" in terms of low stress, high compensation, autonomy, and hiring demand in the *Job Related Almanac* by Les Krantz are all mathematics related: (1) mathematician, (2) actuary, (3) statistician, (4) biologist, (5) software engineer, and (6) computer systems analyst. In this entry, a collection of possible career opportunities appropriate for someone with a mathematics background is provided, and a list of resources is given on how to find a job with different levels of academic degrees. The lists are by no means exhaustive and should only be used as a reference.

Analytical Thinking

Why is mathematics a required subject in school curricula at all levels? Why is mathematics so essential for the proper functioning of everyday tasks in society? Why do most people who excel in their field credit their success to their formal training in mathematics? One possible reason is that a proper training in mathematics provides people with abilities to think and solve problems critically in novel settings.

A Web site sponsored by the Department of Mathematics at Brigham Young University provides a list of possible career options for someone with a background in mathematics. Some of the more common professions include actuary, architect, chemical engineer, college professor, computer scientist, cryptanalyst, economist, mechanical engineer, quantitative financial market analyst, and statistician; some less well-known career options include air traffic controller, animator, astronaut, epidemiologist, geologist, hydrologist, lawyer, market research analyst, composer, physician, technical writer, and urban planner. Certainly, a fixed set of mathematics curriculum will not prepare one for all the jobs listed here. What will be consistent is gaining the ability to solve problems analytically and critically.

Not many people know that the San Antonio Spurs Basketball Hall of Famer David Robinson had a B.S.

in mathematics from the U.S. Naval Academy. Even Michael Jordan toyed with the idea of being a mathematics major in his early college years. It is perhaps not surprising that one of the world's most influential bankers and financiers, J. P. Morgan, majored in mathematics, but not many would think that mathematics would find its way into entertainment. For example, American actress Danica McKellar, who had a leading role in a television comedy-drama *The Wonder Years*, is a well-known mathematics author and education advocate. The popular television drama, *Numb3rs* featured a mathematician who helped his brother in the FBI to solve crimes with his mathematical genius. A few popular movies that successfully portray mathematicians in society include *Good Will Hunting* (1997), *A Beautiful Mind* (2001), and *Proof* (2005).

Although it is seemingly impossible to categorize every branch of mathematics in society, career options available for those who study under common branches of mathematics include the areas of applied mathematics, actuarial mathematics, financial mathematics, and other emerging fields.

Applied Mathematics

Applied mathematicians often solve problems that originate in physics, chemistry, geology, biology, or various disciplines of engineering. Mathematics is used to model physical phenomena, to answer questions derived from observations, to learn characteristics of large quantities, and to make predictions and improvements for future events. A representative mathematical training includes coursework in numerical analysis and methods, computer programming, computer languages, applied and experimental statistics, and probability theory, as well as a few courses in another field of interest.

Often, a typical applied or computational mathematics problem is interdisciplinary in nature and derived from realistic demands in industry. People who wish to gain a general sense of what these types of problems entail are encouraged to attend mathematics-in-industry workshops that are available in Europe and some parts of the United States and Asia. Mathematics in Industry and International Study Groups maintains a Web site that provides updated information for future study groups and meetings. The Society for Industrial and Applied Mathematics (SIAM) maintains a list of example organizations, corporations, and research

institutions that hire mathematicians and computational scientists with an applied mathematics training. These organizations, corporations, and research institutions include the following:

- Aerospace and transportation equipment manufacturers such as Aerospace Corp., Boeing, Ford Motor Co., General Motors, Lockheed Martin, and United Technologies
- Chemical and pharmaceutical manufacturers such as DuPont, GlaxoSmithKline, Kodak, Merck & Co., Pfizer, and Wyeth
- Communications service providers such as Clear Channel Communications, Qwest Communications and Verizon
- Electronics and computer manufacturers such as Bell Laboratories, Alcatel-Lucent, Hewlett-Packard, Honeywell, IBM Corporation, Motorola, Philips Research, and SGI
- Energy systems firms such as Lockheed-Martin Energy Research Corporation and the Schatz Energy Research Center (SERC)
- Engineering research organizations such as AT&T Laboratories—Research, Exxon Research and Engineering, and NEC Laboratories America
- Federally funded contractors such as the Mitre Corporation and RAND
- Medical device companies such as Baxter Healthcare, Boston Scientific, and Medtronic
- U.S. government agencies such as the Institute for Defense Analyses, NASA's Institute for Computer Applications in Science and Engineering, National Institute of Standards and Technology, Naval Surface Warfare Center, Supercomputing Research Center, and the U.S. Department of Energy
- U.S. government labs and research offices such as the Air Force Office of Scientific Research, Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories
- Producers of petroleum and petroleum products such as Amoco, Exxon Research and Engineering, and Petróleo Brasileiro S/A, Petrobras

Actuarial Mathematics

An actuary is a risk management professional who helps design insurance plans by recommending premium rates and making sure companies are designating enough funds to pay out on claims. Actuaries may also help create new investment tools for financial institutions. The main type of mathematics an actuary uses on a daily basis is applied statistics, which involves arithmetic, basic algebra, and practical applications such as using numbers and math to generate tables and graphs. Actuaries should also have a general understanding of business, economics, and corporate finance, all of which have mathematical components.

Most actuaries have at least a four-year degree in mathematics, business, economics, statistics, or, in some cases, a specific degree in actuarial science. As computer modeling replaces traditional graphs and tables, computer and programming skills have become increasingly important as well. The last step to becoming a licensed actuary is to get certified by passing a series of exams sponsored by either the Society of Actuaries or the Casualty Actuarial Society. The list of possible job choices for someone with an actuarial background is relatively small compared to that of the applied mathematicians. These include the following:

- Consulting firms such as Daniel H. Wagner Associates, Deloitte Touche Tohmatsu, Ernst & Young, Hewitt, McKinsey & Company, and KPMG
- Banks or related financial institutions such as AIG, ING, Capital Management, Chase Manhattan Bank, CitiGroup, Fidelity Investments, Goldman Sachs & Co, HSBC, JP Morgan Securities, Lehman Brothers, Mercer Investment Consulting, Merrill Lynch, Morgan Stanley & Co, Standard and Poor's, TD Ameritrade, and Wachovia Securities
- Brokers such as Acordia, Benfield, Cooper Gay, Heath Lambert, HLF Group, March & McLennan, and Willis Group
- Actuarial software development companies such as Actuarial Resources Corp. (ARCVal, HealthVAL, STAR, UltraVAL, CARVM), BLAZE SSI Corp., EMB America, Integrated Actuarial Services (Total Solution, RAAPID), TAG, and WySTAR Global Retirement Solutions (DBVAL, DCVAL, OPEVS)

- Miscellaneous jobs in large companies and government agencies such as ACTEX Publications, Casualty Actuarial Society, Coca-Cola, Ford Motor Co., International Actuarial Association, National Association of Insurance Commissioners, and the Society of Actuaries
- Insurance companies including both property and liability insurance, and life and health insurance such as AFLAC, AAA of CA, Allstate, Blue Cross and Blue Shield, Safeco, Sun Life, Universal Care, and WellPoint

Financial Mathematics

Financial mathematics is the development of mathematical tools and computational models used in the financial industry and on Wall Street. People in this profession are referred to as “quantitative analysts,” or “quants.” As new quantitative techniques have transformed the financial industry, banks, insurance companies, investment and securities firms, energy companies and utilities, multinationals, government regulatory institutions, and other industries have all come to rely on applied mathematics and computational science.

Sophisticated mathematics models and the computational methods and skills needed to implement them are used to support investment decisions, to develop and price new securities, and to manage risk, as well as for portfolio selection, management, and optimization. For example, modern hedge funds depend on these sophisticated techniques, as do pricing of bonds and commodity futures. Typically, someone who is interested in working in financial service and investment firms such Citibank, Moody's Corporation, Morgan Stanley, or Prudential will need to have a solid background in mathematical modeling, numerical and computational mathematics, applied statistics, business, economics, and finance.

Emerging Fields

Biomathematics and Bioinformatics. This emerging field can be thought of as a computer science/mathematics/biology hybrid that integrates mathematics and computer technology in the study of biological sciences. Broadly speaking, bioinformatics is the recording, annotation, storage, analysis, and searching/retrieval of nucleic acid sequence (genes, RNAs, and DNAs), protein sequence, and structural information. Mathemati-

cians in this area contribute to the development of new algorithms with which to detect patterns and assess relationships among members of large data sets.

Computer Visions and Computer Graphics. Mathematicians in the field of computer vision work on developing theoretical machine learning algorithms to extract meaningful information from images. The images take on various forms such as waveforms from voice recorders or three-dimensional images from a magnetic resonance imaging (MRI) device. Its example applications include (1) artificial intelligence and controlling processes (for example, industrial robots and autonomous vehicles), (2) pattern recognition and verification (for example, public surveillance and biometric identification), (3) modeling and processing (for example, medical image analysis and terrain modeling), and (4) communication (for example, brain-computer interface for people with disability). Mathematicians in the field of computer graphics develop ways to represent and manipulate image data to be used by computers. The most well-known applications under this category are the video game and computer animation industries, where various transformation matrices and interpolation techniques are used to create smooth and believable subjects in successive frames. Companies such as Pixar and DreamWorks hire mathematicians in their research divisions to come up with innovative ways to enhance visual effects to be more aligned to reality. Other companies that hire mathematicians with backgrounds in computer vision and graphics include Siemens, Hewlett-Packard (HP), Honeywell, Flash Foto, GeoEye, Nokia, Microsoft, Apple Inc., Amazon.com, and Google.

Operations Research. This is a highly interdisciplinary branch of applied mathematics that uses methods such as mathematical modeling and optimization to solve problems that require a complex decision-making process. Mathematical areas such as game theory and graph theory have become useful tools in solving problems under the umbrella of operations research (OR). Examples of disciplines that use OR are financial engineering, environmental engineering, manufacturing and service sciences, policy-making and public sector work, revenue management, and transportation. Almost all companies hire operations research analysts to use mathematics and computers to develop software and other tools that managers can use to make decisions such as how many people to hire and retain in order to maximize productivity and minimize costs.

It is worth reemphasizing that having a mathematics degree or a mathematics-related degree increases one's chance of securing a position in nearly any company. Even areas that are traditionally viewed as pure mathematics such as combinatorics, number theory, topology, algebraic and differential geometry, analysis, and algebra often turn out to have real-world applications; for example, number theory in cryptography, Fourier analysis in speech recognition, and differential geometry in face recognition. Some additional career choices are as follows:

- Nonprofit organizations such as the American Institute of Mathematics (AIM), and SIAM
- Publishers and online products such as Birkhauser, Springer, and Elsevier Science
- University-based research organizations such as the Institute for Advanced Study, the Institute for Mathematics and Its Applications (IMA) and the Mathematical Sciences Research Institute (MSRI)
- Government agencies such as the National Security Agency (NSA) and the U.S. Department of Defense (DoD)
- Teaching at academic institutions. To teach at the high school level, one needs a bachelor's degree in mathematics and a teaching credential; to teach at the community college level, one needs a Master of Science or Master of Art degree in mathematics; to teach at the college level, one needs a Ph.D. in mathematics, mathematics education, applied mathematics, or statistics

Online Mathematics Jobs Listings

The American Mathematical Society (AMS) has an extensive set of resources to help someone in the market for academic positions and is the premier source for information on careers in mathematics. This includes a list of job postings organized by country and state. It has useful features such as an e-mail service that notifies applicants of all new job listings and an online storage of curriculum vitae (academic resume) and transcripts that can be used repeatedly for different applications. In addition, it allows one to register for the job fairs at the annual AMS meetings and has a list of graduate programs for students.

The Math-Jobs Web site lists international and national job openings for mathematicians in both industry and academics.

The Mathematical Association of America (MAA) has a comprehensive set of resources for students, faculties, professional mathematicians, and all who are interested in the mathematical sciences. In particular, MAA Math Classifieds helps people to find career in the diverse field of mathematics.

The *Chronicle of Higher Education* has academic and nonacademic job advertisements. Use the searchable index to find mathematics jobs.

The Mathematical Sciences Career Information by AMS-SIAM has information on nonacademic jobs, profiles of mathematicians in industry, job search tips, and links to many online job-posting services.

Further Reading

Lambert, Stephen, and Ruth J. DeCotis. *Great Jobs for Math Majors*. Chicago: VGM Career Horizons, 1999.

Sterrett, Andrew. *101 Careers in Mathematics*. 2nd ed.

Washington, DC: The Mathematical Association of America, 2003.

Tyler, Marya Washington. *On-the-Job Math Mysteries: Real-Life Math From Exciting Careers*. Waco, TX: Prufrock Press, 2008.

JEN-MEI CHANG

See Also: Accounting; Mathematics, Applied; Problem Solving in Society; Professional Associations.

Caribbean America

Category: Mathematics Around the World.

Fields of Study: All.

Summary: The diverse islands of Caribbean America have produced notable mathematicians.

The Arawaks, Caribs, and other pre-Columbian peoples lived in the area of the Caribbean Sea before Spanish, French, English, or Scottish sea traders settled there. Linguists explore the different languages that were spoken in the Caribbean, traces of which can be found in the twenty-first century. Along with these languages, there

were possibly different numerical systems. Sea merchants needed bookkeepers and accountants to keep track of their business, and although Port Royal and other places in the seventeenth-century Caribbean were notorious for piracy and lawlessness, there were also many counting houses and legitimate business operations.

The development of schools and universities led to more mathematical opportunities. According to the United Nations, the Caribbean America region encompasses Anguilla, Antigua and Barbuda, Aruba, the Bahamas, Barbados, the British Virgin Islands, Cayman Islands, Cuba, Dominica, the Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Netherlands Antilles, Puerto Rico, Saint-Barthélemy, Saint Kitts and Nevis, Saint Lucia, Saint Martin (French part), Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, and the U.S. Virgin Islands. By the end of the twentieth century, there were numerous Caribbean mathematicians, and *The Caribbean Journal of Mathematical and Computing Sciences* has published volumes of research articles.

Mathematicians in the Caribbean, and around the world, have also worked on mathematics history and research that is specifically related to the Caribbean area, like C. Allen Butler, who investigated optimal search techniques for smugglers in the Caribbean. Mathematicians have also discussed the high numbers of university graduates who have left the Caribbean, and they have created educational initiatives and mathematical texts designed for Caribbean children. The Caribbean and Central America areas combine for a joint Mathematical Olympiad. The most well-known mathematician in the region is perhaps Keith Michell from Grenada who, after completing his doctoral thesis from the American University, was a professor at Howard University, and then returned to Grenada, becoming prime minister in 1995, a position he held until 2008.

Barbados

On the island of Barbados, although education was an important facet of colonial life from the late nineteenth century on, few students were able to continue with mathematics. One exception was Merville O’Neale Campbell, who had become fascinated with mathematics at an early age and won a scholarship to study at Cambridge University in England. He then went to teach at the Gold Coast (now Ghana), completing his doctoral thesis, “Classification of Countable Torsion-