CAREERS IN MATHEMATICS

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MATHEMATICS

Teacher, Statistician, Actuary, Operations Research Analyst, Computer Programmer and Systems Analyst

HERE'S A BRAINTEASER PUZZLE FOR YOU:

A FARMER MUST CARRY HIS DOG, A DUCK, AND A BAG OF CORN ACROSS A RIVER. THE boat he has is very small. He can only take one of the three things in the boat with him at one time. If he leaves the dog alone with the duck, the dog will kill the duck. If he leaves the duck alone with the corn, the duck will eat the corn. What is the fewest number of trips that the farmer must make to carry all three things across the river safely?

It might be easier to keep track of this one if you draw some diagrams, or even use stones, coins, or some kind of marker to represent the animals.

Here's another one:

A man is looking at a portrait and says, "Brothers and sisters I have none, but that man's father is my father's son." The man is looking at a portrait of . . .

If you enjoy logic puzzles like this, you might enjoy a career in mathematics. Do you like abstract thought and problem solving? Can you figure out concepts about space and time? Have you always done well in math and school?

Mathematicians don't just write numbers on blackboards. They are problems solvers and innovators, scientists and computer experts, business

owners and private consultants. Many people don't understand just how much math touches their lives daily; that it's not just the classes they have in school.

When the federal government takes the census every 10 years as required by law, experts in mathematics work to make sure all Americans are counted. Before a new drug goes on the market, researchers in mathematics compare data gathered in clinical trials. Lawyers and doctors sometimes have backgrounds in mathematics, as do engineers and computer experts. More and more businesses use *benchmarking,* a standard of mathematical comparisons to judge effectiveness based on data, to guide them in their growth and to determine their customer focus.

Mathematics is a language that describes quantities, qualities, and the relationships of objects to non-objects. Mathematics can describe a hole in the ground or a hole in space. Math can be theoretical or it can be applied – or it can be both at the same time.

And in case you wanted to know, here are the answers to the puzzles:

The Farmer in the Boat: Seven trips. First he takes the duck across and leaves it. Second he goes back. Third he takes the dog across. Fourth he takes the duck back to the first side and leaves it. Fifth he takes the corn across and leaves it. Sixth he goes back for the duck. Seventh he gets the duck and takes it across.

The man is looking at a picture of his son (Hint: change "my father's son" to "me" and it falls into place).

SOME THINGS YOU CAN DO NOW

TALK TO SOME OF YOUR MATH TEACHERS ABOUT PURSUING A CAREER IN mathematics. They'll have unique insights for you, plus they'll probably be very pleased to answer your questions.

Look for people with a background in mathematics where you might not expect to find it. Mathematicians are often interested in music since the scales of music are mathematical. Pythagoras, the ancient Greek mathematician, arrived at theories about music after walking past a blacksmith's shop and hearing the sound of hammers on iron. It's interesting to ask why we enjoy music. What part of our brain reacts to the orderly (or not so orderly) progression of notes?

When you're using a particular software program, think about what works and what doesn't. What would you change if you could write it? What would you keep the same? What are the problems and what might be the solutions?

Mathematics is one of the major underpinnings of science, along with curiosity and the ability to keep an open mind. Think of the greatest scientists, like Sir Isaac Newton or Albert Einstein. Not only could they grasp (or invent or discover) abstract concepts, but also they could express them mathematically.

Read *Fermat's Last Theorem: Unlocking the Secret of an Ancient Mathematical Problem* by Amir D. Aczel. It's a short book (less than 150 pages) about the struggles of a mathematician at Princeton to solve a riddle posed over 300 years ago by the French scholar Pierre de Fermat. The book also gives a nice overview of the history of mathematics and brief autobiographies of some of the misunderstood geniuses in the history of scientific and mathematical studies.

Find a video copy of *Donald Duck in Mathemagicland,* for some neat entertainment. It's an old Disney cartoon and it covers a lot of material. It's also just plain fun and you'll be glad you watched the animated (literally) explanations of the Golden Mean and the Pythagorean theorem. You'll also learn about the mathematics of billiards, something you can use to impress your friends next time you play pool!

HISTORY OF MATHEMATICS AND MATHEMATICIANS

MATHEMATICS IS PROBABLY THE FIRST SCIENCE. INTIMATELY LINKED WITH HUMAN knowledge and achievement, mathematics has also held religious and mystical significances with numbers imbued with power and force of their own. Our superstition about the number 13, officially known as Triskaidekaphobia ("Fear of the number thirteen"), is a remnant of Numerology – the belief in the ability of numbers to tell the future or reveal hidden truths about life.

Mathematics was put to use in practical applications very early on in human history. Prehistoric people tied knots in ropes to keep track of livestock, or as calendars to mark the time between phases of the moon. They also cut notches into wood or bones, or collected stones for the same purpose. Geometric patterns began to show up in pottery and weaving, another sign that people had concepts of space and proportion.

About 5,000 years ago, the Egyptians began using a decimal system, a counting system based on units of 10, like American currency or the metric system. The Egyptian decimal system didn't look much like ours. It resembled the Roman system in that the symbol for the number, for example, was written down 5 times to express the number 50. The Egyptians, unsurprisingly considering the pyramids, figured out geometry to determine area and volume. They also came pretty close to figuring the diameter of a circle, arriving at about 3.16 (as we now know, this number, called *pi*, is 3.14159).

About 2000 BC, the Babylonians began using numbers in a more sophisticated manner. They used base 60; a sexagesimal system. It seems odd until you start thinking about the way we measure time – 60 seconds a minute and 60 minutes an hour. They were interested in square numbers and created lengthy mathematical tables on tablets of dried clay, many of which survive. Both the Babylonians and Egyptians were agricultural and trading communities who needed to keep track of acreage and wealth.

The Greeks built on the discoveries of the previous civilizations and expanded their knowledge into the realm of abstract numbers. Previous uses had been mostly practical. Pythagoras, who lived in about 550 BC, was a widely traveled scholar for whom the Pythagorean theorem was named – even though the theorem predates Pythagoras himself. It states that the sum of the squares of the lengths of the sides of a right triangle is equal to the square of the length of the hypotenuse. Pythagoras was also a religious leader who believed that "all is number."

About 150 years later, in 400 BC, other Greek mathematicians realized that Pythagoras' ideas needed expanding, and so irrational numbers were discovered by his followers. Eudoxus of Cnidus was one of these discoverers. He also founded the Method of Exhaustion, a way of proving statements about areas and volumes.

Eudoxus work appeared in Euclid's *Elements.* Euclid worked out geometry by means of proofs and deductions; in other words, by using abstract thought. He also wrote about music, optics, and astronomy, and worked at the lost library of Alexandria, the most complete depository of knowledge in the ancient world.

But the most famous Greek mathematician was Archimedes, remembered for yelling "Eureka! Eureka!" as he ran naked through the streets of Syracuse upon discovering the loss of weight of bodies submerged in water. He was in the bath himself when he arrived at the answer to the question of how weight displaced water, and thus how to prove that a golden crown was really gold all the way through and not made of a base metal.

Ptolemy, another resident of Alexandria, Egypt, living about 150 BC, was also an astronomer. He arrived at a theory of planetary motion based (wrongly) on the concept of the earth as the center of the universe with all the planets (including the sun), revolving around it. This idea became standard until well into the 16th century AD, when Nicolaus Copernicus published a book in which he argued that the sun stood still and all the planets (earth included) revolved around it.

At about the same time as the intellectual ferment of the Greeks, the Chinese Liu Hui independently discovered Pythagoras' theorem. Liu Hui also came close to discovering pi by creating a "circle" made up of 3,072 sides.

The great Library of Alexandria was destroyed, the Roman Empire collapsed, and Western Europe entered the Dark Ages. In the Arab world, mathematics still flourished. Greek knowledge was saved by scholars at centers of learning that were supported by wealthy rulers. In 825 AD, al-Khowarizmi wrote a book about a decimal system that used place values and zero. His name is the basis for the word *algorithm,* and the word *algebra* came from the title of his book, *Al Jabar Wa'l Muqabalah.*

As European interest in the world expanded during the Renaissance of the 1400s and 1500s, mathematics was used in the service of navigation. Copernicus published his theory, and then the 1600s arrived, with many great thinkers and many advances. René Descartes invented analytical

geometry. Pierre de Fermat originated modern number theory, along with his tantalizing Last Theorem, only proven in the mid 1990s. Sir Isaac Newton invented calculus in England at about the same time as German mathematician Gofftried Wilhelm Leibniz.

In the 1700s, most mathematicians such as Jakob and Johann Bernoulli, Leonard Euler, and Joseph Louis Lagrange expanded on the works of Newton. The 1800s saw the expansion of mathematics into colleges and universities as an academic subject. Debates on "real numbers" helped the French Augustin Louis Cauchy to work on a logical method describing calculus, with the real number itself defined by the German Julius W.R. Dedekind.

George Boole was a mathematician and logician who developed a logical system that computer-based searches are based on. Have you ever noticed the instructions on a computer search engine referring to *Boolean Logic?* That's when you add the words AND, IF, NOT, IF, THEN and EXCEPT to your search string to narrow your search focus. The logic of this system was named for, of course, George Boole.

While most mathematicians may not have anticipated the rise of the computer, Charles Babbage of England devised the first one in the 1900s and called it the Analytical Engine. Even though he never was able to build one of his engines, his friend Ada Byron King, (she was also the Countess of Lovelace), daughter of the poet Lord Byron, is considered the first computer programmer.

As technological advances change almost every part of human life on planet earth, mathematics drives change and serves it too. Mathematicians apply new theories to prove older ones – Andrew Wiles couldn't have solved Fermat's Theorem without the work of others. Einstein's Theory of Relativity challenged Newtonian physics. As our world gets more virtual, it also gets more real, and math applications, functions, and designs become part of everyone's life.

WHERE MATHEMATICIANS WORK

AS A MATHEMATICIAN, YOU WILL WORK IN AN OFFICE OR A CLASSROOM OR BOTH. That means a comfortable environment in modern buildings with all the amenities. With the rise of telecommuting, it might be possible to work from home, especially if you are not a classroom teacher – and even that's changing with the rise of e-education (taking classes on-line). Telecommuting means that you can accomplish most (if not all) of your work from home or your own office. Working from home has many advantages as well as its own obstacles. Family and household duties often intrude on work time. On the other hand, telecommuting offers a day-to-day flexibility that can't be matched in an office setting.

If you teach math for grades 6-12, you'll be in a public or private school setting. You can look at your own school and observe what a typical day is like for your teachers. Teaching in a school means lots of interaction with students and with students' family members. Depending on the budget of the system where you teach, there might be a state-of-the-art computer lab, or you might have very little equipment. Your students might be highly motivated or indifferent. Whatever the situation, you'll need to encourage and inspire learning.

If your goal is an academic career, you'll work in a college or university setting. This means you'll have teaching responsibilities in the classroom and during office hours when students come to you for help or for further information. As a member of an academic community, you'll also participate in departmental meetings on all subjects from hiring new people to working on new curriculums designed to meet the needs of students.

Depending on the kind of appointment you receive at a college, you will be allowed time for research. Universities often set up special fellowships funded by private companies or by individuals. The recipients of these fellowships are paid a full salary for the length of the fellowship (one or two academic years) and have a reduced teaching load so they can pursue scholarly activities. For some theoretical mathematicians, these activities can include considerable time alone, working out solutions to problems. The findings are usually presented in papers at conferences that are attended by other academicians to share information.

If you are working in the private sector, as a computer engineer, for example, or a systems analyst, you'll work with others in your specialty, plus people from other departments or offices. As the nature of modern work changes, people often find themselves working in teams of

professionals who can bring complimentary knowledge and support to projects. A wide range of abilities leads to problem solving, solution development, and a multidisciplinary approach.

If you are a private consultant, you might travel to meet with clients. This might be as simple as traveling across town, or as complicated as traveling across the country, or even around the world. If you are gathering data on a specific population, you might travel to the location to do your research. If you work in a biological science, your work might take place in a laboratory where biological samples are tested.

YOUR WORK DUTIES

SAYING THAT YOU HAVE A CAREER IN MATHEMATICS IS A LITTLE LIKE SAYING THAT YOU live in America – it's a useful description in a broad, general way, but it really doesn't tell you too much about your real life. With technology bringing about daily changes, the duties expected of mathematicians in certain job titles can be pretty fluid. Computers, obviously, have changed almost everything. There are very few jobs that don't require familiarity with common software programs. This revolution in the work place has led to the assumption that everyone has some knowledge of mathematics, plus the flexibility to learn about whatever the new technology serves up.

Teacher Teachers probably spring to mind first, from middle school through high school and on up to the college level. This is an important place to be, which you will realize from your experiences as a student. Maybe you're motivated to teach because of a good experience with a teacher whom you admire or who has meant a lot to you. Teaching means keeping up on the latest methods and the needs of students, planning lessons, classroom instruction, parent-teacher conferences, and lots of student involvement. You've probably noticed that many of your teachers do something extra – coaching or helping run after-school activities.

Two-year colleges hire math teachers, as well as four-year schools. Community college teachers work with a variety of students, all the way from high school graduates to adults sharpening career skills, retired people, and foreign exchange students. Community colleges offer classes on overcoming math anxiety or on the applications of mathematics for specific career fields, like healthcare. Instructors in community colleges have to be very flexible to adapt the curriculum to changing student needs.

At four-year colleges and universities, professors are expected to do research in their field of specialty in addition to teaching. The results must be published and/or presented at conferences where colleagues meet to stay current with new discoveries. College and university teachers either have their PhD or are in the process of earning one. They teach basic classes in calculus and algebra and also advanced topics such as analysis, logic, and number theory. At all levels, teachers communicate their interest in math to students.

Statistician Statisticians are mathematicians who specialize in factual information. Statistical data are the raw materials for all kinds of disciplines, including marketing and social research. If a group of people is being studied for anything from purchasing trends to the kinds of illnesses they succumb to, then a statistician must set up and design the parameters of the study. This includes the questions asked, but more importantly includes deciding who to ask. How do you know you're getting a representative sample? It isn't good enough to just ask the first five people you run into on the street.

Statisticians also design destructive testing experiments to see how long a piece of machinery will work before it breaks down or what kind of stresses it can endure before it malfunctions. While you can't test every lawnmower that rolls off the line, by subjecting a certain number of machines to testing, a representative sample can be determined and then the information applied to the total number of engines.

Job titles vary with the industry or service sector in which statisticians work. An econometrician works with economic data – that's more than money, it's the totality of production, development, and management of material wealth. Those who work in medicine or health research (public, private, or associated with a university) might be biostatisticians, biometricians, or epidemiologists.

Actuary Can anyone foretell the future? Is there a way to avoid costly and/or dangerous mistakes? How much money do you need to save for your retirement? What's the financial risk of starting a new business? How much should an insurance company charge to provide coverage for all subscribers?

Actuaries can answer all of these questions through the collection and analysis of data. As you can tell from the questions, most actuaries work for insurance companies. If you own a car and have insurance, you might have noticed that your premiums are higher than those for your parents. Though it might not seem fair, this is based on information about the age

and gender of the driver and the statistically determined rate of accident and injury for the particular group. If a government agency investigates premium rates, one of the responsibilities of a company actuary might be to testify about the methodology used to arrive at those rates.

With increasing variety of investments available to people, many actuaries work in banking and other financial services helping people and businesses structure the best savings and investing strategies. Think of the importance of pension planning – everyone has to retire some day and everyone wants the best package possible. Actuaries evaluate retirement plans and help design new ones.

Operations Research Analyst Operations Research Analysts apply information to problem-solving situations. This specialty really took off after World War II. During the war, the military began careful studies to reduce the risk of hazardous wartime missions, such as determining the enemy's whereabouts. The industrial boom that took place in this country following the war owed quite a lot to this logical system of analysis, rather than hit-or-miss or lucky guesses. It's more than bookkeeping – it's all about knowing what's going on in an organization so that time and money aren't wasted. Our economic reality gets more complicated all the time and most analysts also have a background in management.

No business, organization, or institution has infinite resources; that is, all the money, time, material, and people that they need. Sometimes tough decisions have to be made that involve people's jobs and livelihoods, or the direction a company or federal agency is going to take with limited resources. The analyst does the research to answer financial questions, questions asked by the people who need to make informed decisions.

Analysts also write technical reports, routine or specialized, on research findings. They also need to present their findings orally, at meetings or presentations. That means they communicate formally and informally with their peers and superiors on a daily basis.

Computer Programmer When you use a particular type of software, do you love it, hate it, or do your feelings fall someplace in-between? Some programs are completely counter-intuitive; they're hard to understand and don't seem to be written by someone who actually uses them, leaving you to waste time to develop your own work-around or to get really frustrated.

Computer programmers learn computer languages, such as COBAL, and write programs – step-by-step procedures for computers to follow so

they can perform all the functions modern society requires. There are all kinds of programmers: Internet programmers, mainframe programmers, and database programmers to name just a few.

Programmers perform their functions on a narrower or broader level. Applications Programmers focus more on a particular program or function. They write the programs for a particular area or even one specific job while a Systems Programmer will work with an entire operating system or network.

Computer Systems Analysts, Engineers, and Scientists

This is a broad term for a broad area. Generally, a systems analyst (also known as a system developer or systems architect) makes sure than an organization has the right hardware and software to perform the necessary functions. You probably know from personal experience what it's like when your computer runs out of memory or someone bought the wrong software, or just the general frustration of dealing with uncooperative software to accomplish homework or school related tasks. Systems analysts make sure that problems like that don't occur in the first place, or work their best to get them fixed if it's too late.

Analysts need to be able to plan ahead and communicate with the people who will be using the system. They think logically and often work in the abstract so that others can perform necessary tasks. You can see how important communication is in this field. There are times when the analyst needs to know what others need before they need it, almost like mind reading. That's because the professional knows what computers can do – and what they can't do. It's as important to understand the limitations of technology as well as its capabilities.

Other Job Possibilities for Mathematicians

- Accountant – analyzing financial information.
- Cryptologist – encoding and decoding information, usually working for a government agency like the National Security Agency.
- Economist – researching, monitoring, and collecting data to help study economic trends. Also creating models for study.
- Financial Analyst – implementing company goals for financial management.
- Numerical Analyst – the designing and testing of models, like equipment used for space exploration.
- Research Scientist – investigating patterns in the biological sciences, creating models of financial transactions, and software design.

- Engineer – building bridges and other structures like dams, estimating costs for structures, and machinery, aeronautical, and automotive design.
- Technical Specialist/Consultant— providing services on a contract basis for several companies or just a few, whenever and wherever needed.

Mathematicians in General While the federal government is the major employer of individuals with the specific job title "mathematician," there will be fewer job opportunities if your training is exclusively in math. Most of the top jobs will require emphasis in at least one other area such as computers, engineering, or statistics.

As with many fields, the farther up you go in the organization, the more administrative work you may find yourself doing. The importance of your communication and "people" skills will become more apparent, as will the ability to look ahead and solve long-range problems. Major employers cite lack of communication abilities as a shortcoming among certain employees, along with too narrow of a focus on solving a particular problem, without seeing cross-application potentials.

On the other hand, mathematicians are highly valued for their analytical skills. The Society for Industrial and Applied Mathematics quotes one employer as saying, "Mathematicians do not always know the answers, but they know the right questions to ask and they know when the questions being asked are wrong."

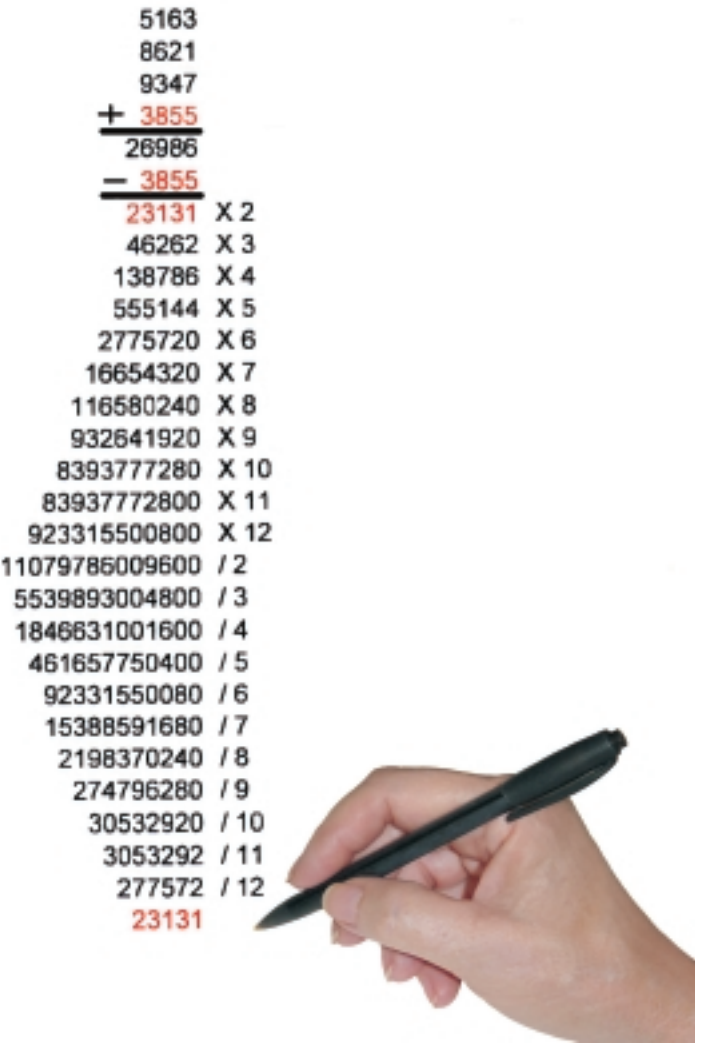
"I might not know where they are now," said one math professor as she explained some of the mental processes of her profession, "but I can tell you which way they went when they left!"

The American Mathematical Society notes that in many branches of the liberal arts and sciences, statistical data and research are critical to advances and new theories. There are mathematical applications in psychology as we learn more and more about the brain and the chemicals that influence our emotional life.

Math even has major importance in the study of literature. For example, an old poem by a previously unknown writer is now credited to Shakespeare. What did math have to do with this? A detailed accounting of words and grammatical structure, metrical rhythms, and the pattern of syllabic stresses were determined quantitatively. The poem was found to follow the same detailed structure of Shakespeare's other works.

Mathematics can be used to model communities, human, or otherwise. What happens when a population of bacteria, ground hogs, or people increases by 50%? What will happen to the environment? To the other organisms? Mathematical modeling gives scientists a chance to make predictions about hazards or upcoming problems.

In the increasingly technical society of the future, mathematics will surely play a more and more important and varied role.



This addition,subtraction,multiplication and division problem was done by 3rd graders back in the 40's. Change the single digit order in the addition with any other single digit order of numbers Then do the calculations. No calculators or computers please.

MATHEMATICS PROFESSIONALS TELL ABOUT THEIR CAREERS

I Am an Actuary "I am a group actuary and consultant for a large employee benefits consulting firm. My responsibilities include helping my clients (primarily large employers) plan, design and budget for their employee benefit programs (including health and dental insurance, disability income programs, and paid time off). I work with my clients to define different alternatives and then prepare cost projections for each. I also help them understand the advantages and disadvantages of each alternative. In this way, our clients have the information they need to make the best decisions for their company.

I've always enjoyed math as a school subject. I knew I had an interest in math probably around fourth grade. In high school, I was a member of the National Honor Society and the Math Honor Society. I also participated in math contests and was a member of the Quiz Bowl team. I had initially planned to teach high school math. Later I became interested in teaching at the college level. I began taking actuarial exams in college, because I didn't want to rule out other opportunities. At the time I graduated, I had several job offers as an actuarial analyst. I hadn't excluded the possibility of teaching actuarial science at some point and I thought the work experience would be valuable in that case.

I think some people tend to shy away from math because the application to our everyday lives isn't always clear. I think most people understand that addition and subtraction are important for everyday activities like shopping and balancing a checkbook, but don't see the direct application of higher levels of mathematics. However, mathematical principles are the foundation of all kinds of issues that affect people on a day-to-day basis. Actuarial science, for example, has affected anyone who has ever bought car insurance, life insurance, health insurance, disability insurance, or received a pension or Social Security. Other types of mathematically related fields influence people in other ways, either directly or indirectly through the goods and services we buy and consume.

I enjoy explaining actuarial concepts to other business people and clients in layman's terms. It's satisfying to me when I'm able to help someone understand an issue that has been confusing. I also enjoy explaining the relationships between the actuarial issues and the issues that might be more familiar to people.

For any student who is interested in going into a mathematically related business field such as actuarial science, I think any kind of business-related class is valuable (economics, finance, accounting, business administration). For any student interested in math of any kind, I'd suggest computer science and communications (both speech and writing) classes. Communication skills in particular are critical for nearly any profession. You can be the brightest mind in your field, but you won't be able to contribute much to the greater community or business if you can't communicate your knowledge, skills, and findings to others.

I'd suggest that the student take as many pertinent math and actuarial science classes that might be available, but also that the student does not lose focus on learning some of the "softer" skills. I'd encourage them to take classes and participate in extracurricular activities that encourage communication, teamwork, and research skills.

I would expect that in the future I will be more involved in managing, reviewing, and supervising the work of less experienced actuaries and will not do as much of the financial cost projection work myself. I will also have a much greater role in managing the employees of my department and the relationships we have with our clients."

I Am an Assistant Professor at a Community College

"In elementary school, I struggled with math through the third grade. I always asked 'why' and was labeled 'difficult' because of that. I wouldn't just memorize things – I needed to understand how it worked. But when I got in the fourth grade and asked 'why,' my teacher explained things to me. After that, math got much easier, and in high school I took the standard classes, algebra, geometry, and trigonometry, plus I belonged to the Math Honors Society.

In college I took Calculus 1 through IV, linear algebra, higher analysis, and numerical analysis. I also took the history of math, which was about number systems and how they evolved. It was a really interesting course. There was a lot of information about the people who developed theories, things about their personal lives.

Why are people afraid of math? Well, we're split. It seems like you either have this tremendous fear of math or you love it – it's a love/hate relationship. Part of the hate comes from early failures. I taught several adult remedial math classes. I also heard time and time again, 'If someone had just explained it to me this way 30 years ago, then maybe I would have gone on to college from high school, or maybe I'd have a better job right now!'

The favorite part of my work as an assistant professor is when the light bulb goes off for my students. You can see it, when a student didn't understand something – and then it clicks. It's a joy to see. It's an excitement that's fulfilling.

Today's student certainly needs to be computer savvy. Everybody does, even more so for mathematicians. Students need to learn what the computer can and can't do for them; they need to understand what's going on behind the scenes.

I'm a strong supporter of the liberal arts and being well rounded. I think it's really important to study a foreign language. Since math is a language, many of the techniques for learning are the same. Before you can learn a language, you have to know what a noun is and what a verb is. Numbers are like nouns, and the operations (plus, minus, etc) are like the verbs. Understanding other languages helps you to think a little more thoroughly and critically. In another language, if you're trying to express yourself

but you don't know the right word, then you rephrase it. It's a way of learning to work on problems; if they don't make sense one way, you rephrase it another way.

Music definitely makes a reasonable companion to math. When I listen to music, I can almost see the numbers in the timing. Visual arts can play a role, geometry goes back to visual arts.

Sometimes students don't see the direct relationship between math and everyday life. Math is masked, done for us; they don't learn the problem solving and logic skills. American society wants to pigeonhole people, and our jobs are compartmentalized. Degrees in actuarial sciences and statistics have math and logic built into the curriculum. All the sciences are built on math. We don't encourage pure mathematics enough. Four or five major mathematical concepts were discovered while mathematicians were working on solving Fermat's Theorem.

My emphasis is on basic number theory, how numbers work. Number theory helps you to understand why numbers mean what they mean. Theorists are asking questions right now that they will leave for others to answer.

In the future, we're going to see more specially developed applied math classes, like math for the heath professions; a sequence of courses for specific majors. I'll be doing lots of curriculum development in the future.

Around here, businesses partner with the local colleges to give people the education they need to become effective employees."

PERSONAL QUALIFICATIONS

WHERE DO THE MATHEMATICIANS END AND THE PHILOSOPHERS START? WHERE DO the philosophers end and the musicians pick up? How about the musician and the mathematician? Just what is a mathematician, anyway? A person who cares only about cold numbers on a blackboard, or a person who sees patterns and structures that other people miss?

If you enjoy problem solving, then you can find a career that interests you in mathematics. It also helps if you enjoy thinking creatively and logically at the same time. It's good to be flexible, to be on the lookout for information that crosses applications.

Theoretical mathematics has an element of art to it, a multi-layered intricacy that can branch off into unexpected directions. Mathematicians see beauty, science and art all in combination.

Mathematicians are also funny. Galileo, scientist, mathematician, and astronomer had a ribald sense of humor, writing satirical essays while a professor at the University of Padua in Italy in the late 1500s.

Sometimes mathematicians are a puzzle to those around them, performing tasks that seem to have no basis in reality. More than one person has tried to establish the record for calculating pi out to where it will at last square – which it hasn't yet. The largest computers and the greatest minds take a crack at it every so often, but no one has yet found repeating digits. Hiroyuki Goto, for one, recited 42,195 digits in nine hours and got in the Guinness Book of World Records, but still didn't "square the circle."

Pi is a fascinating paradox and an elusive quarry. It has its own shape and mystery; the perfect circle seems to reject perfection by refusing to conform to a regular pattern in the equation that solves its size. Mathematicians dearly love this sort of challenge for its elegant insolubility.

If you have trouble with math classes, stop, take a deep breath, and see if you can get some extra tutorial help. It's worth your while to take a fresh look at the subject, maybe improving your grade and therefore your chances of getting into the college of your choice. Bad grades are sometimes a reflection of learning style, not intelligence. It could be that you and your teachers just aren't communicating. Don't waste time blaming the teacher or yourself, but do get the help you need.

If you read about the lives of various mathematicians and scientists, you'll notice that many of them were unappreciated at one time in their lives. Einstein, for example, didn't talk until he was three years old, excelled

in mathematics at a young age, and then ran into problems as an adolescent, unable to conform to the rigid, military standards along which his high school was run. But he kept studying because he was fascinated and delighted by what the mind could discover.

Most mathematicians are pretty delighted about what the mind can discover, and the best ones excel at communicating their excitement to others. This can't be stressed enough if you're going to teach. If you love math, you'll love finding new ways to explain concepts to your students. You'll also understand that not everyone can or will share your enthusiasm, and you'll be willing to meet them at least halfway. If you aren't teaching, remember that you'll be working with non-mathematicians who bring their own skills and strengths to the project at hand.

ATTRACTIVE FEATURES

CONGRATULATIONS! YOU'RE ON THE BRINK OF CHOOSING A WELL-PAYING CAREER IN A field that interests you! Not only that, but you also have the satisfaction of knowing that exciting challenges face you, plus opportunities to excel and be fulfilled in your daily working life. Even with all the problems of corporate downsizing and shrinking university budgets, you can use your skill-sets and abilities to your advantage.

In private industry and the academic world, you can most likely find a job with excellent benefits, such as health insurance and paid vacation time, in a reasonably comfortable physical environment. The skills and accomplishment you gain on your first job will be transferable to promotions within your company or institution, or to another employer if you decide to relocate. You should be able to find work in any city in the country, plus in places that aren't cities. If you telecommute or consult, you could live pretty much where you want and can afford, including a small town.

With the rapid changes in technology, it's possible that you'll be involved in some pretty exciting stuff, like the start-up of a successful new business. If you're involved in pure mathematics, your research might solve some elusive theory and make headlines – at least in scholarly journals.

You'll get to work with people who have the same interests as you do. In business or academia, you might even have the chance to work with your counterparts from other countries and consult with them on mutual problems. Others can provide you with insights and encouragement.

Another plus factor in the dynamic employment situation is that you'll be able to pursue various different interests. The chances of being locked into one narrow function your whole working life is almost nonexistent. With math as your major field of study, you can still nurture your artistic side. You can integrate your love of music or your interest in the biological sciences into your chosen career field.

As you evaluate situations and solve problems, you'll find that what you learn in one situation will apply to the next. You will build up an impressive body of knowledge and experience.

NEGATIVE ASPECTS

WHILE YOU'LL BE WORKING UNDER GENERALLY COMFORTABLE CONDITIONS, PEOPLE who use computers all day are subject to eyestrain and muscle strain. Carpel tunnel, a condition that affects the nerves and tendons in the wrist might seem like a small thing, but it can lead to paralysis. It's also quite costly in terms of workers compensation and what employers have to pay out in medical costs and retraining. You need to learn about proper ergonomics – that is, your physical position in relation to your equipment (the computer, usually). Most employers are very sensitive to this problem but if you are your own boss (a consultant who works at home, or if you run your own business), then you need to be more aware of how you are sitting, how you are placed in terms of the computer height, and any other factors that will affect your overall health. Small injuries tend to get worse with time and age.

A few years ago, it seemed that America was falling behind the rest of the world in graduating scientists and mathematicians. Universities worked very hard to step up their mathematics programs and graduate more students. At first, more students meant more teachers, which in turn meant more jobs. However, this has leveled off considerably and now there are enough PhD holders to fill the academic positions in universities. If you're planning on teaching, you're going to be in competition with many other bright and motivated people. You will have to go where the jobs are, which could mean relocating to a part of the country you don't prefer. Once there, you may have to stay a long time before an opportunity at a desirable school presents itself.

You will need to write, research, and publish in academic journals in addition to maintaining excellence in your teaching methods. Professor Andrew Wiles of Cambridge, England, spent seven years in an attic room pounding out a solution to Fermat's Last Theorem. Even if this sounds like

the work you want to do, your opportunities will be limited by workforce marketplace reality.

If you prefer to work by yourself and not interact much with other people, you might be disappointed to find that in pretty much all kinds of mathematical work you will be dealing with others. As job descriptions and requirements change, people have to be more and more flexible. It isn't possible any more to insist on fitting into one small niche and staying there quietly, left alone, for the duration of your career.

Public education isn't as well funded as it used to be, another reason for the lack of opportunities for traditional academic jobs. There is more emphasis in today's society on educating people strictly for the functions they will perform, and less emphasis on funding public colleges and universities for programs not widely valued by the general public.

Corporate downsizing and restructuring are part of the modern job landscape. If a company thinks it can get by without experts in mathematics, then it won't hire them – or the company might even lay off employees whom they feel they can't fully utilize.

Challenges and flexibility are tough to deal with. In the mid-70's, the idea of everyone having a computer seemed ridiculous – what on earth would you do with it? Now a home without a computer is almost as unimaginable as a home without a television or a car. As a corollary to the home computer phenomenon, think about the necessity of dealing with change before it deals with you. As the market for jobs in pure mathematics levels off, you will need to take responsibility for your own education and extended training as necessary. This isn't necessarily bad news, but it is a reality that you'll need to prepare for.

EDUCATION AND TRAINING

MANY MATHEMATICAL GENIUSES OF THE PAST MANAGED WITH LITTLE OF WHAT WE would recognize as formal education. However, to take such a path today would limit your opportunities for employment and learning – and most of all to meet others who share your interests and enthusiasm.

Since you're already interested in mathematics, chances are you've taken many math classes in high school. If this is not the case, you can still take classes your freshman year in college to get yourself up to speed so that you can graduate with your Bachelor of Science degree in Mathematics.

Many colleges are recommending that students be ready to take Pre-calculus their college freshman year. This means that you need to keep up with Algebra while you're still in high school. Even if you got those Algebra requirements out of the way early on, it might not be a bad idea to take one more class your senior year just to make sure you haven't forgotten anything and to better prepare yourself for college.

Before you apply for college you'll need to take the ACT, the American College Test. Your math score will be one of several factors that prospective colleges consider when reviewing your application. Your grades in high school are also important, and many colleges also require a written essay along with teacher recommendations as part of the package. Some colleges also administer their own Placement Test, so you'll need to check on that at the schools you're applying to.

Once enrolled, you can begin planning the four-year course of study. You'll be taking many classes in the arts, humanities, and the sciences such as biology and geology. A foreign language will likely make up part of your curriculum. Non-math subjects make up a significant portion of your total credit hours. It's also important to have good writing and speaking skills, so that means you'll be taking English and maybe a class in speech or general communications. While you'll need to look at the specific program at the colleges you've selected, most programs recommend classes in one or more computer languages or other computer skills. You'll need computer classes since a computer will be one of your major work tools.

You might wonder why you have to take so many classes that seem to have little to do with your specialties or the subjects you're best at. This is one of the reasons people go to college – to get a broad background of knowledge and experience.

Of course, you'll be studying mathematics. You'll take classes in calculus, calculus with analytic geometry, classes to cross the bridge from elementary calculus to higher math, classes in theory and statistics, mathematical modeling, and discrete structures. You'll need to keep in mind the need for upper division hours; that is, classes at the 300-400 level or equivalent in the school you choose. The college catalog will tell you exactly how much you need of what. You won't need to worry about taking these upper level classes during your freshman and possibly your sophomore years, but you will need to keep prerequisites in mind – those courses you have to take before you can move on to the next ones.

It may take you longer than four years to graduate. Many students, sometimes because of a change in majors, sometimes because of financial constraints, take five years to graduate.

Financial aid in the form of loans, grants, or scholarships, will most certainly be available.

If you decide to go on and get your master's degree, a necessity if you intend to stay in the academic world, it will require about two additional years. As an undergraduate you could take 12 hours a semester or more, nine per semester is all you can probably manage as a master's candidate. If you get a graduate assistantship, you'll teach one or more classes to undergraduate students. You might also qualify for a stipend, which is a grant of cash for living expenses. Stipend awards (and any other financial grants) are based on your academic achievement.

After you've finished your four years of undergraduate work and spent another two years earning your MA, you might decide to go on to earn your Doctor of Philosophy degree, also known as a doctorate or a PhD. PhD programs are lengthy and rigorous, taking between 4-6 years to complete. Candidates in doctoral programs perform extensive research in their field of specialty in addition to course work.

Some doctorate programs include majors in the following:

- Algebra
- Complex analysis
- Dynamical systems and chaos
- Geometry
- Logic
- Number theory
- Numerical analysis
- Ordinary differential equations
- Partial differential equations
- Probability
- Real and functional analysis
- Representation theory
- Statistics and topology

EARNINGS

CAREERS IN MATHEMATICS CAN BE HIGH PAYING, ESPECIALLY IN PRIVATE INDUSTRY. Colleges and universities tend not to pay quite as much, while the federal government, the leading employer for mathematical fields, pays a good salary with benefits. Of course, it also depends on the field you choose. Even more important is choosing the field you are best suited for and enjoy the most.

If you are interested in teaching in a college or university, your salary can range anywhere from $40,000 to $60,000, depending on your degree. With a PhD, several years of teaching and publishing credits, and advanced theoretical work, you would be earning on the higher end of that scale.

The median earnings for college graduates with a bachelor's degree in math is about $40,000. This figure is pretty much the same for statisticians, mathematicians, and actuaries. Computer programmers with a BA can expect to earn about $45,000. As with all jobs, depending on location, your experience and education, and the nature of the company, some salaries can average significantly lower, with starting pay around $30,000.

Just as salaries can be lower, they can also be much higher, over $100,000 in some cases. Naturally, education and experience play a large part. A mathematical statistician starting out with the federal Bureau of Labor Statistics will earn $27,000, while a mathematician who has been working several years for the Department of Energy can command $110,000.

OPPORTUNITIES

SOME PROFESSIONALS ARE CONCERNED ABOUT THE NUMBER OF DOCTORATE HOLDERS (people with their PhD degree) since it seems that universities graduate more people than they can employ as professors. If you are interested in the study of pure mathematics, it's important to understand the competition and current job situation. It's hard to get a position at a university where you will have ample time to yourself to do research. Don't give up hope, however, if that's the kind of work you want to do.

Another reason for the decline in employment for mathematicians is simple job description; job titles frequently don't include the word

mathematician. A systems analyst needs a math background, for example, but the title alone doesn't tell you that.

One employer that still uses mathematician in the job title is the federal government. Look at *www.usajobs.opm.gov* and click on Current Job Openings. After you answer a question ("Are you a current or former Federal Employee?"), you can search for jobs alphabetically. There are many listings under "mathematician" and "mathematical statistician."

Don't forget to search under some of the other job titles described in this report. The National Security Agency is one of the main employers, with the various branches of the military also needing experts in math. For example, jobs listed under the "Mathematician" heading with the United States Department of Commerce, National Institute of Standards and Technology include the following "Critical Shortage Occupations:"

- General Engineer
- Materials Engineer
- Civil Engineer
- Mechanical Engineer
- Electrical Engineer
- Computer Engineer
- Electronics Engineer
- Chemical Engineer
- Metallurgist
- Computer Scientist
- Physical Scientist
- Physicist
- Chemist
- Mathematician

The necessity to be trained in math plus an allied science field becomes clear pretty quickly when you read various job descriptions.

If you're considering a math-based computer career, you're looking at an expanding field. Many job categories are expected to grow faster than the average.

An operations research analyst with a master's or a PhD is a highly sought employee. Positions for operations research analysts and computer programmers are growing fast, with jobs for programmers increasing the fastest.

There are some special things to keep in mind for programmers. As computing gets more complicated, employers expect more education and experience. Programmers often work on a temporary or contract basis. If you're working a contract, you work on a specific job for a set period of time. You are not a full-time employee of the company so you don't get any benefits like health insurance or vacation time.

GETTING STARTED

TAKE A LOOK AT THE AMERICAN MATHEMATICAL SOCIETY'S (AMS) RESOURCES FOR undergraduates in mathematics on the Internet *www.ams.org/employment/undergrad.html*. There is excellent information on scholarships and grants for mathematicians. The AMS is just one of several professional organizations with which you should become familiar.

Are you in a math society at school? Is there a chess club or are there other after-school clubs that could provide an opportunity for you to flex your mental muscles?

Talk to your school counselor about applying to colleges, if you haven't already. Your choice of schools will depend on a number of factors, such as your grades, financial ability, or ability to get some kind of funding in the form of scholarships or loans. Look at the different programs offered at different schools and try to find some that will suit you best. See how frequently different classes are offered at the school of your choice. Some colleges don't have enough faculty to teach important classes frequently enough, which means your graduation date could be delayed if you've got to wait a year for a course to appear on the schedule.

Think about your other interests. What classes do you enjoy taking? Is there a connection between your math skills and your science skills? How about history or biological sciences? Once you get into college, you'll see connections and cross-applications in your course work that you probably don't recognize now.

Do you have the time to "shadow" someone in a career field that interests you? It might be a good experience to spend the day with a mathematician or systems analyst and see what their work day is like. Talk to your high school counselors and see if they can help you to make some arrangements. Your school might already have a program in place for matching up students with professionals. If you're near a college, community college, or university, call the mathematics department and see if you can talk to one of the professors.

WEB PLACES

- **A model of the first computer, the "difference engine"**
  www.museums.reading.ac.uk/vmoc/babbage/
- **The Analytical Engine Online**
  www.brookscole.com/compsci/aeonline/course/index.html
- **The Computer Museum of America**
  www.computer-museum.org
- **Expand Your Mind!**
  www.expandyourmind.com/logicproblems/
- **Math at the Movies**
  http://world.std.com/~reinhold/mathmovies.html
- **Mayan Numbers**
  www.vpds.wsu.edu/fair_95/gym/UM001.html
- **Plus Magazine**
  www.pass.maths.org.uk
- **SOLSTICE: An Electronic Journal of Geography and Mathematics *www.imagenet.org/***
- **Eric Weisstein's World of Mathematics**
  http://mathworld.wolfram.com/
- **The MacTutor History of Mathematics archive**
  http://www-groups.dcs.st-and.ac.uk/~history/
- **Cut-The-Knot, fun, intelligent, interactive math**
  http://www.cut-the-knot.com/content.html
- **The Math Forum**
  http://forum.swarthmore.edu/
- **Mathematics at About.com**
  http://math.about.com/science/math/msubcar.htm

SOCIETIES AND ORGANIZATIONS

- **American Mathematical Society**
  www.ams.org
- **American Statistical Association**
  www.amstat.org
- **Association for Women in Mathematics**
  www.awm-math.org
- **Institute for Operations Research and the Management Sciences (INFORMS)**
  www.informs.org
- **Mathematical Association of America**
  www.maa.org
- **National Council of Teachers of Mathematics**
  www.nctm.org
- **Society for Industrial and Applied Mathematics**
  www.siam.org
- **Society of Actuaries**
  www.soa.org