General Recommendations for all Career Paths

In the past half century there has been a great increase in the importance of mathematics to our society. The need for trained mathematicians at all levels is on the rise as the use of computers and automation has spread to almost all sectors of our economy. Nowadays, technological, engineering and business problems are often of such complexity that they require a high level of mathematical treatment. Whereas in the past advanced mathematics was generally restricted to the physical sciences and engineering, today there is an ever growing demand for mathematical expertise in the biological and social sciences, as well as in finance and business management and the burgeoning field of data science.

Every student should carefully consider the following five points when deciding on a course of studies during the undergraduate major.

1. **A balanced set of core courses in mathematics and statistics.**

Of course, many of those courses will be determined by the major concentration, which in turn depends on the intended career path. But every student should be sure to take a good balance of courses. Especially, there should be some mix of mathematics with statistics, and of theoretical and pure courses with applied courses. This kind of balance is really crucial for those students who will pursue work in the non-academic world, and for students who intend to undertake interdisciplinary graduate studies. Even students who plan to enroll in graduate studies in mathematics or statistics, or will train to be secondary school teachers, should make sure that they have sufficient breadth at the undergraduate level in order to take full advantage of their later studies.

2. **An extensive exposure to computing.**

One of the main reasons that mathematics and statistics are of such importance in the modern world is that they are so closely allied with computation of all sorts. In virtually every profession based on mathematical or statistical knowledge, computing plays a key role. For this reason, students should take enough courses in computer science, scientific computing or information technology to gain expertise with computational techniques and platforms.

3. **Some coherent studies in another related field.**

It is highly desirable for a student to develop a base of knowledge in another field related to mathematics or statistics. For instance, a successful career might be built on a mathematics major together with a minor in computer science, finance, economics, physics, chemistry, biology, public health or a branch of engineering. If a minor is not feasible, then it is advisable to take a few related courses that complement the studies in the major.

4. **An array of "soft" skills.**

Mathematics and statistics are "hard" sciences in the sense that their subject matter is technical and abstract. Consequently, their usefulness and relevance to the world is hugely dependent upon how well mathematicians and statisticians relate to their colleagues and coworkers. Employers often talk about how it is absolutely necessary for their technical staff to be able to communicate in writing and orally, to interact productively in teams and groups, and to be diligent, versatile and innovative. These people skills are equally necessary in the teaching professions. A good selection of General Education courses and other electives is one way to develop these skills, as are independent studies and projects, extracurricular activities and even hobbies.

5. **An internship, coop or summer research experience.**

One of the best ways to procure a good job upon graduation is to have done an internship or coop beforehand. Employers like to have a chance to see a student in the actual work environment, and the student benefits by trying out the kind of work that the employer offers. For students considering graduate study, it is highly desirable to apply for summer Research Experience for Undergraduates (REU) either at your home university or at sites elsewhere in the country. See the links on this page to the NSF, NSA and other agencies that offer summer research experiences.

Common Career Paths for Mathematics and Statistics Majors

In the course of his or her undergraduate studies, each student will naturally develop some preferences for the various subfields of mathematics or statistics, and those interests will largely determine the student's choice of concentration within the major. Another element in this choice is the range of opportunities that the concentration presents for a subsequent career. While there is no fixed list of occupations that follow from a major in mathematics or statistics, the most common career paths of graduating students fall into some broad categories.

Here, in an unordered list, are some of the main career categories:

- Actuarial science.
- Data science.
- Information technology and computing.
- Business, management, consulting.
- Teaching at the elementary or secondary school level.
- Graduate study in mathematics or statistics, especially for an academic career.
- Graduate study in applied mathematics or statistics, for a career in industry, business or government.
- Graduate study in an interdisciplinary field related to the mathematical and statistical sciences.

Web Links About Careers

Various national organizations in the mathematical sciences offer information and other web links about careers.

On many of these websites there are collections of testimonials from mathematicians and statisticians who have pursued successful careers in a wide variety of areas. Students are encouraged to explore these sites and read the professional advice offered by these experts.

- American Mathematical Society:
  http://www.ams.org/careers/
- Society of Industrial and Applied Mathematics:
  http://www.siam.org/careers/
- American Statistical Association:
  http://www.amstat.org/careers/
- Mathematical Association of America:
  http://www.maa.org/careers/
- Association for Women in Mathematics:
  http://www.awm-math.org/ctcbrochure/toc.html
- Sloan Career Cornerstone Center:
  http://www.careercornerstone.org/

Specific Recommendations Within the Career Categories

Actuarial Science

Actuaries are business executives who use mathematical and statistical skills to define, analyze, and solve complex problems arising in the insurance and pension fields. They create and manage programs to reduce the financial impact of events such as illness, accidents, unemployment, or premature death. Actuaries must understand the entire operation of the insurance and pension fields because their evaluations often influence company policies and practices. Besides good command financial markets, tax and insurance law, regulatory requirements, accounting, and so forth, an actuary must have solid background in applied mathematics and statistics.

Professional status is attained through fellowship in one of two actuarial societies (CAS or SOA). Fellowship is earned, and most of the theoretical training is provided, by passing a series of rigorous examinations sponsored by the societies.

Data Science

In the last few years, the field of data science has exploded. Majors who have taken Linear Regression and have proficiency in SAS, R, or Python are particularly well-poised to take advantage of these opportunities. Students are encouraged to enhance their data science credentials by combining statistical coursework with data science or machine learning coursework in Computer Science, Biostats, or Linguistics. The following site has extensive information on the field of data science: Masters in Data Science.

Information Technology and Computing

A mathematics major can launch a career in the wide-ranging world of information technology and computing services, provided that the major studies are complemented by enough training in computer science. Typically, such a major will also complete a minor, or perhaps a double major, in computer science. Some of the more mathematically intensive parts of IT concern cryptography or animation and graphics. There are also many positions as applications programmers -- that is, computer programmers who tailor algorithms to fit the specific needs of clients and companies. Other occupations in this area include network management, web development, security systems, and mobile computing.

Successful completion of a major in mathematics and a minor in computer science is also good preparation for a graduate program in Computer Science. A Master's degree in this computer science is beneficial for some of the more challenging and innovative opportunities. Further information is available from the Association of Computing Machinery: https://jobs.acm.org/.

Business, Management and Consulting

There is an increasing demand for mathematicians and statisticians in many different areas of business. Besides the clearly defined career path to actuarial science, there are also diverse opportunities in production management, forecasting and financial modeling. A major in mathematics that includes statistics, augmented by a minor in computer science and courses in economics, accounting, finance, or industrial engineering, for example, would provide a solid basis for a business career.

Almost all the positions in this broad range of vocations are advertised with titles that do not include the words "mathematician" or even "statistician." Normally, the positions are for "analysts" of some kind. In recent years there have been burgeoning opportunities in the area of quantitative financial analysis, the practitioners being referred to as "quants." This work focuses on stock market analysis, risk management,

financial derivatives and related products. While a bachelor's degree is sufficient for entry into the field, there is also a strong demand for employees with more training. For instance, there are many Master's degree program in Financial Mathematics, and Ph.D.s in the mathematical sciences are often engaged in work in this field. Some of the many resources on the web include:

http://www.quantnet.com/
http://www.quantfinancejobs.com/
https://www.cfainstitute.org

The problem solving and critical thinking skills possessed by mathematics and statistics majors make them very desirable candidates for positions with consulting firms. These positions are accessible with a bachelor's degree, but they require a quick and adept mind that combines quantitative expertise with business acumen and excellent communication skills. A web search for "quantitative consulting" yields numerous opportunities in this direction.

A mathematics major who wishes to prepare for a career in a government agency would do well to focus on statistics and applied mathematics and to complete a minor in computer science.

Teaching at elementary or secondary school level

There is a continuing demand for qualified mathematics teachers in the nation's secondary schools. Besides training in their major field, future teachers must also complete state certification requirements. School districts across the country are increasingly in need of mathematics specialists in elementary schools. Mathematics majors who are interested in elementary education should consider the possibility of such a career path. Students are also encouraged to explore teaching mathematics in middle school, where there is very high demand for mathematics majors.

Some webpages related to teaching:

1. Teach for America: www.teachforamerica.org
2. Math for America: www.mathforamerica.org
3. A site related to teaching certification and teaching degrees: MathTeaching.org

Graduate Study

There are three main options for graduate study following a undergraduate degree in mathematics or statistics. Students are advised to consult departmental faculty about these options as well as the attributes of particular graduate programs nationwide.

1. A traditional graduate program in a mathematics or statistics department.

Every major research university has a graduate program in mathematics, and the majority are primarily focused on the Ph.D. Many universities have separate departments and Ph.D. programs in statistics, biostatistics and related quantitative areas. The doctoral graduates from these programs find employment either in academic institutions or else pursue careers in government, business, or industry.

There are about 1500 colleges and universities in the United States, which seek to fill their faculty positions with Ph.D.-qualified candidates. These positions involve a mixture of teaching, research and service responsibilities. The particular blend of these activities varies with the type of academic institution (research university, liberal arts college, etc.). This job market tends to be quite tight and there is strong competition for the most desirable opportunities. Those who go into graduate programs intending to teach

at the college level should strive to acquire a broad foundation in both theoretical and applied subjects in the field, along with some experience in communicating the subject matter.

2. A professional Master's degree program in applied mathematics or statistics.

An alternative to the traditional Ph.D.-oriented graduate program is a terminal Master's program, which is now available at an increasing number of universities. These programs tend to be in either applied mathematics or statistics. Normally they grant the Master's degree after two years of study. Upon graduation students are qualified to take competitive positions in industry, business or government. Such a program can also be used as a bridge for a student who intends to do a Ph.D. in mathematics or statistics, a Ph.D. in a field other than mathematics and statistics, or an interdisciplinary Ph.D. One of the longest running Masters in Applied Mathematics programs is at the University of Massachusetts Amherst; see http://www.math.umass.edu/Grad/appliedms.html.

3. A graduate program in an interdisciplinary field that is allied with mathematics or statistics.

Yet another pathway is to graduate-level studies in a field that is related to mathematics or statistics. Students pursuing this path will have undertaken a broad program at the undergraduate level, probably having completed a minor or double major in the other field. Examples include physics, computer science, engineering, mathematical finance, biostatistics, bioinformatics, mathematical biology, or operations research. In addition, it is possible to undertake a professional degree in law or medicine after an undergraduate degree in mathematics or statistics.

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