CORE SUDDEN SELECTOR'S SERIES, #10

SUDDEN SELECTOR'S GUIDE TO Mathematics Resources

JOHN MEIER, ANNIE ZEIDMAN-KARPINSKI, AND NASTASHA JOHNSON

Helene Williams and Jane Monson
Volume Editors

Sudden Selector's Guide
to Mathematics Resources

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FOREWORD

Is subject-area knowledge for collection development still necessary or even important in these days of tight budgets, vendor selection, patron-driven acquisitions, and nearly-instant access? My answer continues to be a resounding "Yes!" It is vital for selectors to have an understanding of how their subjects "work" in terms of research, publication, and selection; selectors link a library's collection to its local audience, meeting the needs of researchers and faculty as well as the broader community. Selection by vendors, in the form of approval plans, can indeed create workflow efficiencies, but it takes a knowledgeable selector to set up an effective plan that can account for local needs as well as budgetary and space restrictions. The time saved by such plans allows selectors to both hone the margins of a collection to strengthen it and to conduct increasingly valuable liaison work with user groups. Patron-driven collections fill immediate demands and can indicate trends, though a selector needs to keep track of the overarching goals of a collection—something individual patrons rarely, if ever, think about. Thus, the need for selectors familiar with their disciplines as well as the production and dissemination of information in it is imperative. The ongoing purpose of the Sudden Selector's series is to provide current information on selection in specific subject areas in order to assist selectors in creating a manageable process in unfamiliar subject territories.

Helene Williams
Editor, Sudden Selector's Guide series
March 2012
Updated March 2018

PREFACE

On the Sudden Selector's Series

The Sudden Selector's series was created by the Collection Management Section (formerly Collection Management & Development Section) of the Association for Library Collections & Technical Services (ALCTS) division of the American Library Association. It is designed to help library workers become acquainted with the tools, resources, individuals, and organizations that can assist in developing collections in new or unfamiliar subject areas. These guides are not intended to provide a general introduction to collection development but to quickly furnish tools for successful selection in a particular subject area. There are many tools that are pertinent for all subject areas and although not explored in detail in the guides, the following should be mentioned.

GUIDES TO COLLECTION DEVELOPMENT

Evans, G. Edward, and Margaret Zarnosky Saponaro. *Collection Management Basics*, 6th ed. Westport, CT.: Libraries Unlimited, 2012.

This text serves as an authority on all areas of collection development, from user assessment, collection development policies, evaluation, deselection, and legal issues. This popular resource, in its many editions, has served as a standard text in collection development training.

Johnson, Peggy. *Fundamentals of Collection Development and Management*, 4th ed. Chicago: American Library Association, 2018.

This guide by one of the key authorities in collection development covers many of the same areas as Evans and Edward. Johnson provides a comprehensive overview of the issues such as policies, planning, developing and managing collections, marketing and outreach activities, and collection analysis. The writing is engaging and its information is useful for both beginning professionals and seasoned selectors.

Disher, Wayne. *Crash Course in Collection Development*, 2nd ed. Westport, CT: Libraries Unlimited, 2014.

This title is part of the Crash Course series from Libraries Unlimited and is aimed toward a new selector without any selection experience or for those with little to no professional experience. Although the general concepts covered may be useful for beginning academic librarians, it is focused toward the needs of public librarians.

Gregory, Vicki L. *Collection Development and Management for 21st Century Library Collections: An Introduction*, 2nd ed. Chicago: American Library Association, 2018.

This approachable guide provides brief introductions to the major issues and workflows in collection development and management, and also includes examples of vendor lists, an assessment report, and an e-resources license.

Burgett, James, John Haar, and Linda L. Phillips. *Collaborative Collection Development: A Practical Guide for Your Library*. Chicago: American Library Association, 2004.

This guide provides first-hand experience and advice for successful collaborative collection building. The guide provides models and strategies for research, budgeting, promotion, and evaluation.

Alabaster, Carol. *Developing an Outstanding Core Collection: A Guide for Libraries*, 2nd ed. Chicago: American Library Association, 2010.

This handbook provides instructions on how to build an adult public library collection from the ground up as well the tools to maintain an existing collection. The guide provides a wealth of resources for public library collection development as well as sample core lists.

REVIEW SOURCES

Choice
www.ala.org/acrl/choice

Reviews in *Choice* magazine, published monthly by the American Library Association, and *Choice Reviews Online* are targeted to academic library collections and reviews emphasize the importance of the title in collection development and scholarly research. Choice includes approximately 600 reviews (per month) organized by subdiscipline for books, electronic media and internet resources and as well as publisher advertisements and announcements for new and forthcoming publications. *Choice Reviews Online* provides access to issues from 1998 to the present. There are added features to the online version of the magazine including personalized profiles and title lists and an advanced search screen.

Library Journal Book Reviews
www.libraryjournal.com/?subpage=Reviews%2B

Library Journal Prepub Alert

www.libraryjournal.com/?subpage=Prepub%20Alert

Library Journal magazine provides brief reviews of titles on all topics and is aimed at both public and academic libraries. The reviews provide a brief summary of the title and recommendations for library audience and selection. Reviews are available in print issues of the magazine and online through various databases and as a weekly e-mail for new review title alerts.

Booklist
www.ala.org/offices/publishing/booklist

www.booklistonline.com

Booklist, a publication of the American Library Association, publishes more than 8,000 recommended-only reviews of books, audio books, reference sources, video, and DVD titles each year. *Booklist* also provides coverage of ALA award winning titles and is available online with enhanced content such as advanced searching options and personalized profiles and lists.

Publisher's Weekly
www.publishersweekly.com

This magazine is also available through an online subscription and serves as a trade publication for professionals in the library and publishing fields.

Its coverage includes industry news, trends, events and book reviews. More than 7,000 book reviews are published annually and written by both freelance reviewers as well as well-known authors. The reviews are divided by fiction and nonfiction.

ELECTRONIC DISCUSSION LISTS AND WEBSITES

COLLDV-L
https://lists.ala.org/sympa/info/colldv

COLLDV-L includes issues of acquisition but also covers more broad issues of collection management, such as policy development, deselection issues, and collection evaluation. It is a moderated discussion directed towards library collection development professionals, bibliographers, selectors, and others involved with library collection development.

ERIL-L
www.eril-l.org

ERIL-L's purpose is to cover all aspects of electronic resources in libraries. In addition to collection management librarians, participants include reference personnel, systems librarians, and vendors with topics ranging from use statistics to product issues to licensing. The list is moderated and archived.

Association for Library Collections & Technical Services (ALCTS), Collection Management Section (CMS)

CMS is a former section of ALCTS. The purpose of CMS was to contribute to library service and librarianship through encouragement, promotion of, and responsibility for ALCTS activities relating to collection management and development, selection, and evaluation of library materials in all types of institutions. The section has developed an array of publications, online courses, and other tools for the training and further development of collection management. In early 2021, ALCTS and sections became part of the larger CORE: Leadership, Infrastructure, Futures division. Follow developments and links from the CORE site: http://www.ala.org/core/.

This list is not meant to be exhaustive, but simply an introduction to some of the resources available for getting up to speed in collection development. As the Sudden Selector's guides are subject-specific, most of the above resources are too general for inclusion in the main text. However, personnel responsible for collection development should ultimately be familiar with most of them. Additionally, for the most exhaustive bibliographies for further research, consult the guides to collection development listed above.

Doug Litts
Smithsonian Institution Libraries
American Art Museum & National Portrait Gallery
Editor, Sudden Selector's Guide Series, 2006–2009

Helene Williams
Editor, Sudden Selector's Guide Series, 2009–2018
Updated 2018

Updated 2018

INTRODUCTION AND OVERVIEW

This book is meant to provide the new librarian, the new-to-math librarian, or the general reader interested in mathematics libraries at colleges and universities an overview of how modern library collections are created to serve mathematics students, faculty, and researchers. This is also more than a collection development book. All aspects of our jobs as contemporary librarians are interconnected, so we address topics like information literacy instruction, scholarly communication, and general liaison work. We also acknowledge and try to explain broader issues in higher education such as math in general education, women in mathematics, and social media in academia. Throughout the text, the terms mathematics and math are used interchangeably (maths is often used in non-US English speaking countries in lieu of math).

Of all faculty served by libraries, mathematicians are universally fierce defenders of the library. In our experience, everything is potentially an important book, journal, or resource for mathematicians. Yet, we do not have unlimited budgets and time, so this book will help you focus on the core needs of your users through an understanding of the profession, your institution, and your library. Mathematicians also value and use older materials and print, so weeding materials is a greater challenge for math than other sciences. In addition to this book, the following are three earlier works that are essential companions for a math librarian.

Fowler, Kristine K. 2004. *Using the Mathematics Literature*. New York: Marcel Dekker.

This edited volume was created by Kris Fowler with contributions from librarians, mathematicians, and other academics. While over a decade old, it is still useful for new researchers in mathematics as well as librarians serving mathematical audiences. The first few chapters provide an introduction to the field and a review of information sources including databases, though most do not exist in the same form today. The later chapters recommend resources about branches of mathematics, from history of mathematics to number theory to mathematical biology.

Tucker, Martha A., and Nancy D. Anderson. 2004. *Guide to Information Sources in Mathematics and Statistics*. Westport, Conn.: Libraries Unlimited.

This annotated collection of books, journals, and other information sources in mathematics was authored when academic resources were first becoming available online. Most chapters address a specific type of library material, such as dictionaries, encyclopedias, books, series, and journals. Some materials are in print and others online, though many of the URLs and links are no longer reliable, and some publishers and societies have changed. Particularly useful for librarians even today are the chapter of resources for math librarians and a review of scholarly communications in mathematics at the time the book was published.

Anderson, Nancy D., and Lois M. Pausch. 1993. *A Guide to Library Service in Mathematics: The Non-Trivial Mathematics Librarian*. Greenwich, Conn.: JAI Press.

The signature book on the role of the mathematics librarian, this edited volume begins with three chapters on math librarians in academic libraries, public libraries, and special libraries. The remainder of the book lists resources by type: journals, monographs, and reference materials. Those categories are subdivided by branch of mathematics, such as linear algebra or real analysis, and codes are used to indicate the most appropriate library for the materials (academic, public, special). The breadth of this book and especially the first three chapters have enduring value for librarians wishing to familiarize themselves with math.

ACKNOWLEDGEMENTS

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Know the Discipline

There is geometry in the humming of the strings.
There is music in the spacings of the spheres.
—Pythagoras (Murchie 1967)

This chapter will give a brief history of mathematics and an overview of the major branches of the field. It is meant to help librarians who do not have in-depth knowledge of mathematics understand the scope of the subject. We also provide context of the mathematics department within the university and undergraduate curriculum. Finally, we talk specifically about women in mathematics.

HISTORY OF MATHEMATICS

Mathematics is the foundation of science both in ancient origins and in modern discoveries. Understanding math is essential to be a functioning member of society. It is also astonishingly elegant. From the construction of the pyramids in Egypt to the search algorithms of Google and forecasting in the New York Stock Exchange, mathematics lies underneath almost every common and extraordinary human endeavor. There is an entire field that studies the history of mathematics. It is "the only universal language" that communicates across all national boundaries (Changeux and Connes 1995). In fact, many mathematicians find themselves historians by hobby if not by training, particularly later in their careers. For this reason, it is a good idea for math librarians to understand the basics of historical research and cultivate relationships with history librarians.

Mathematics began in ancient civilizations around the world. Archeological evidence and ancient texts contain simple yet significant mathematical history. The earliest known mathematical writings are 70,000 years old. Clay tablets that are thousands of years old from Babylonian civilizations included fractions, quadratic equations, and algebra. Formal study of mathematics and theory in the Western world began in Greece around 500 BC (Pickover 2009). Mathematics and philosophy intermingled during this time. Different civilizations gave birth to mathematical concepts that were then joined through commerce and communication: Arabic numerals and algebra came from the Middle East and the concept of zero developed in Mesopotamia, while the Chinese independently developed negative numbers and decimals. You can learn more about these developments by exploring the literature in the classics and area studies. There are also many rich histories of mathematics to consider, and while these are outside the scope of this book, Sardar, Ravetz, and Van Loon's *Introducing Mathematics* (2011), as well as Gowers, Barrow-Green, and Imre's *Princeton Companion to Mathematics* (2008), are excellent places to start.

Mathematics in all of its forms has overlap with other academic disciplines. The closest are computer science and statistics, which often developed from or may still be part of math departments. Engineering, economics, physics, and other sciences use mathematical formulae and techniques frequently. Now that computers are used in almost every academic discipline in some way, from digital humanities to bioinformatics data analysis, math is a pervasive, albeit hidden, foundation across all departments at colleges and universities.

The archetype of the mathematician as a solitary genius who is inspired to discover great mathematical truths, as depicted in the movie *A Beautiful Mind*, is only one part of the whole story. Mathematicians are creative, hard-working scientists who study for many years to have the skills to create proofs and ideas that improve our understanding of the world. Librarians should not be intimidated by mathematicians, since they are also human. They value the library as their lab space. Most collaborate a great deal with other mathematicians, scientists, and researchers. The pursuit of knowledge in mathematics is a conversation that often starts with the statement of the problem (or an unproven truth called a *conjecture*) and the use of current mathematical methods (or development of new methods) to create a proof.

PURE VS. APPLIED MATHEMATICS

Within mathematics departments there are many fields of study. They have historically been divided into two groups: pure mathematics and applied mathematics. Pure mathematics is "motivated by its intrinsic interest or elegance rather than its application to solving problems in the real world" (Clapham and Nicholson 2009). Most mathematical theories or methods begin as pure mathematics, with the only intention being to solve a mathematical problem. Applied mathematics uses mathematical methods to solve a "real-world" problem.

The difference between pure and applied mathematics is not actually quite as large as it appears at first. It is more a product of intent rather than function. Both approaches attempt to create mathematical tools to solve problems, with the primary difference being that applied mathematicians already know how the tools will be used. A method from pure mathematics can seem abstract and later be used by engineers and scientists in application—though at a recent university graduation ceremony, a pure mathematician tried to describe what graduating seniors had learned, joking that it could result in no weapons nor anything else harmful or practical. Most mathematicians agree that it is a diverse field and they appreciate areas of cross-fertilization. While the various kinds of math should support one another and make them stronger, understanding how different areas of mathematics diverge in interests and use will be an important part of making the collection work for local users.

During a panel discussion at a 2006 international meeting of mathematicians, some of the luminaries in the field make the point that in an academic setting, in addition to pure and applied, mathematics also has an additional dimension. Lennart Carleson calls them three different faces: pure, applied, and finally, general education (Ball 2007). It is worth pointing out this distinction here because while we like to think of math as one monolithic entity, there are many complex facets to consider. When thinking about math librarianship, the best answer to a given question might depend on the audience. Following the Association of College and Research Libraries' (ACRL) *Framework for Information Literacy for Higher Education*, which compares scholarship to a conversation (2015), learning to communicate and use mathematical vocabulary is like learning a foreign language. Starting with a list of keywords that reflect the research interests of local faculty is important, and speaking with a senior faculty member of the department should give you a sense of the breadth of the work being done. Visiting the department's homepage and reading its newsletter are also great places to start.

While a list is a relatively easy way to learn the vocabulary of math, another method is to create a concept map, or a web with the major areas in one large bubble and the different aspects of each area underneath (see the example shown in Figure 1-1). The benefits of this kind of visualization include seeing possible overlaps between subjects, and a better sense of the proximity of related subjects.

MAJOR AREAS OF MATHEMATICS

Below is an incomplete list of major areas within mathematics. Each one will have different levels of granularity within it. Many subjects overlap, so it is always interesting to ask where there are emerging or longstanding connections in research. It is important to look up unknown terms as an exercise in learning the vocabulary and syntax of a new language (James 1992).

Accounting Mathematics & Actuarial Science. Accounting math is the use of the principles of mathematics and statistics for business and financial data processing and decision-making. Similarly, actuarial science is the use of mathematical and statistical principles to determine business risks. Actuarial scientists are often practitioners working in insurance and finance.

Algebra. Mathematicians who are algebraists study field theory, polynomials, matrix theory, and group theory. This area uses letters and symbols to represent functions, numbers, and quantities. This advanced use of algebra goes beyond the basic algebra that many students in other majors struggle to understand.

Analysis. Mathematicians in this area study real and complex numbers and use analysis in research on real functions, sequences, operator theory, integration, and potential theory. Analysis proceeds from the development of calculus and often involves geometry. It has applications in physics, such as quantum mechanics, as well as signal processing, including Fourier analysis.

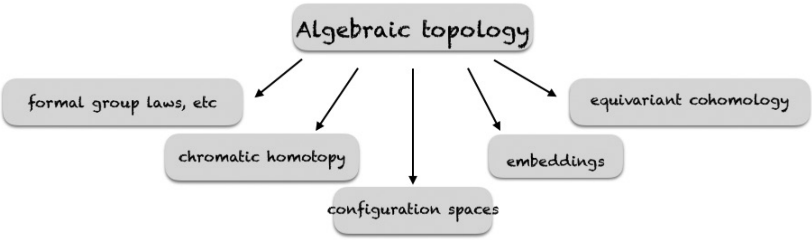

Figure 1-1: Example concept map for algebraic topology

Applied Mathematics. While many areas of mathematics can be applied, there are various methods to do so including calculus, numerical analysis, game theory, systems, and operations research. This area encompasses primarily real-world applications of mathematics and frequently involves other disciplines like physics and engineering. This could involve a collaboration between mathematicians and scientists from other disciplines, or it could be the work of a mathematician with expertise in applying mathematical methods on their own. Applied math can also be found in biology, financial trading, economics, medicine, meteorology, nanotechnology, sports, and various social sciences.

Differential Equations & Differential Geometry. There are actually many areas that use ordinary and partial differential equations and integral equations to solve problems, with applications from nanotechnology to astrophysics. Similar to analysis, differential mathematics uses the derivative aspects of calculus in advanced methods geometry or algebra.

Discrete Mathematics. This area uses numbers (such as integers) that have distinct values to study combinatorics, programming, and operations research. Discrete mathematical functions operate on these sets of numbers rather than infinite or continuous functions and operations. This explains why it is often studied within the context of computer science and cryptography.

Geometry & Topology. Geometers and topologists can study general and differential geometry, manifolds, and spaces within the context of space, planes, points on a plane, and surfaces. They can study these "shapes" either in traditional geometry or in curved space and higher dimensions.

Logic & Foundations. Logicians study language, reasoning, statements, and proofs. Many say this area is the foundation of mathematics, as it addresses ambiguities caused by using natural language to describe pure mathematics. Logicians are close to philosophers in their methods and may even overlap in publication and correspondence, so they have unique needs. This area also resembles and overlaps with theoretical computer science.

Mathematical Physics. Physicists use math as a tool, and many mathematicians build these tools. This area includes the mechanics of solids, quantum theory, statistical mechanics, and fluid dynamics. This is one of the younger mathematical fields, and is often included within applied mathematics.

Number Theory. This area of mathematics studies the relationship of numbers and variables, specifically integers. Combinatorics is one of the ways integers, including infinite sequences, are used to find minimum or maximum values. Number theorists work most frequently with other pure mathematicians.

Statistics & Probability. Probability is the study of the likelihood of an occurrence, measured in a ratio of likelihood of it happening and not happening. Statistics is the science of collecting and processing data to make inferences about real-life and complex scenarios. There may be statisticians or probabilists in a math department or separate statistics department (more on this later). Statistics is applied in a wide variety of ways, so research in this field is often multidisciplinary. Some faculty working in this field may have dual appointments to other departments or collaborate frequently with others.

Mathematics Education. Rather than work in a distinct field of mathematics, some mathematicians choose to focus specifically on the teaching of math to K-12, undergraduate, and graduate students. Sometimes math outreach and engagement with the public is also included under this umbrella. Graduate students and faculty in any area of math who also have teaching responsibilities will find the study of math education and pedagogy useful.

History of Mathematics. Finally, there are some mathematicians who focus on (or dabble in, as mentioned before) the history of mathematics, including studying the works of major mathematicians.

Although this group may be small, it is worth noting here because of the evolution of mathematical science as a discipline and the fact that math seldom goes out of date. One will find that mathematicians appreciate and highly value their discipline's history.

Other than the two main types of mathematics, pure and applied, there is not a standard number of other areas. The digital preprint repository arXiv (see Chapter 5 for more on this resource) has thirty-two categories for math papers, while the official Mathematics Subject Classification (MSC) scheme has sixty-three main subheadings. Even the areas listed above cannot always be grouped into either pure or applied mathematics, and some can be described as either depending on the particular faculty member or research project. A mathematician may identify him- or herself as a logician, combinatorialist, or algebraist, but is more likely to identify with a small set of areas that align with his or her particular research interests. There may also be defined research groups in the local department, such as a fluid dynamics research lab.

When you begin your work as a math librarian it is important to know enough to tell the difference between the various areas of math, such as algebra and geometry, and develop a sense of how they are related—for example, how algebraic topology uses abstract algebra to study the structure of shapes or sets of points. Familiarity with the fields will increase over time, though there is never a perfect distinction for all cases. Mathematicians cannot always agree either. For example, at a recent discussion of "big data" at Penn State, two faculty argued whether homology theory was grounded in probability theory or was part of algebraic geometry.

WHERE MATH FITS (OR DOESN'T) IN THE UNIVERSITY

Mathematics as a discipline relates closely to other departments on a university campus. The closest two are computer science and statistics, which often emerged from mathematics departments and are in many cases still connected. When these newer departments were created in the mid-twentieth century, some professors operated on the margins between them. Today there may be faculty positions shared between an ever-expanding number of departments, for example math and biology. A math librarian will likely be working with other related fields, which may include computer science and different forms of applied math. The exception to this is large engineering programs which may contain a computer science department, but not a math department. Historically, these collections have been split due to their needs for a space large enough to hold sizable collections. While this is changing as formats and departmental needs are being reconfigured, there can be some interesting differences and odd splits of collections due to local context and historic relationships.

Although mathematics is arguably the foundation of hard sciences, technology, engineering, and medicine, mathematicians do not act like researchers in the other sciences. In our experience, their research practices resemble those of faculty and students in the humanities. How mathematicians use library resources, especially in theoretical math, resembles the information-seeking behavior of those in the humanities, rather than other researchers in STEM (science, technology, engineering, and mathematics) fields. Even though mathematicians use peer-reviewed journals as the primary mode of scholarly communication, they consistently use books more often than do researchers in other STEM fields (Dotson and Franks 2015). Until recently, mathematicians relied heavily on print journals of interest in their subdisciplines, but the availability of digital versions in arXiv has replaced the reliance on print for journal articles. Mathematicians use arXiv to browse for items of interest and puruse important articles from journals in their field (Nelson 2009).

Mathematics is clearly an important part of computer science, statistics, large parts of engineering, and specific aspects of physics. Without a sound foundation in mathematics, advanced study in any of those fields would be difficult. However, the way mathematics is currently taught in K-12 schools in the United States has been unsuccessful for the vast majority of students for many years. Nationally, our understanding is that about sixty percent of incoming college students need some sort of remedial math education (Grubb et al. 2011). Until these issues can be addressed and remedied, colleges and universities will continue to struggle to place students in a wide variety of "introductory" math courses. Research by scientist and educator Carl Wieman, who is encouraging profound changes in the large introductory lecture classes, suggests that we have the tools to change how we teach this material. Redesigned classes that emphasize active learning and a decrease in class time spent on lectures are of particular benefit to women and minorities, who are even more underrepresented in STEM fields than in other areas, and particularly so in mathematics (Wieman 2014; Freeman et al. 2014).

In many academic departments, the mathematician's work is at odds with the bulk of the teaching expected from the department. This tension sets up an interesting dynamic, as the department faculty are usually interested in very different topics than the remedial and lower division classes that constitute the large part of the courses offered. And while some departments value having research faculty teach lower division classes at least some of the time, they are not given much guidance on how to teach the material to beginners who have little interest in what they think constitutes math. Though math faculty tend to have smaller research grants than those in other STEM fields and may also have fewer graduate students, they focus primarily on upper-level classes. Most universities hire a combination of adjunct faculty, graduate students, and instructors to teach the bulk of lower-level mathematics courses, often called "service" courses that are taken primarily by non-majors.

ROLE OF THE LIBRARY IN UNDERGRADUATE MATHEMATICS EDUCATION

The library can be a place where students learn about how mathematics is done. Throughout high school even the best students do not need to read their textbooks closely to do well in math classes, the textbook being largely the repository for the required homework problems. Upon entering higher education, students sometimes need to be taught that a college math textbook is an important resource for learning and reviewing concepts covered in class. User-centered libraries in academic settings will have multiple print copies of the (large, heavy, expensive) class textbooks on reserve, especially for the large or multi-section iterations of required math courses (such as calculus). Even when a class moves to a new edition of a textbook, which may happen frequently, the older editions typically circulate heavily for a number of years afterward. This could be due to the fact that little changes in the actual content of the book between editions, but it also indicates the fundamentally unchanging nature of mathematics. Universally, students like that the books are on reserve in the libraries on campus. Our users appreciate not having to carry such large, heavy books all the time, and those who are on a limited budget may appreciate not having to purchase these expensive resources themselves. We also encourage libraries to consider having additional resources to help students with math homework when possible. The University of Oregon math program offers homework help in the library space, although there are several other tutoring labs elsewhere on campus (Schaack and Zeidman-Karpinski 2017). Students frequently use public computers for online homework rather than for accessing the collection. The library may therefore offer a variety of learning resources for a wide range of users, including students learning the basics as well as sophisticated researchers.

More broadly, the mathematics department and its associated library resources can play an important role in supporting all undergraduate education. The success of students in math is the focus of the Mathematical Association of America (MAA) Committee on the Undergraduate Program in Mathematics (CUPM), which has some applicable sections for libraries (more about the MAA can be found in Chapter 3). According to the *2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences*, "having librarians, financial aid experts (including those who can help students to make reasonable budgets), tutoring coordinators, and peer mentors speak with students can make the department seem accepting of and interested in them" (CUPM 2015). The guide also recommends "providing spaces where students can gather in small or large groups to work (or play, or eat lunch) together . . . placing comfortable seating areas near faculty offices . . . [and] providing blackboards, journals, a coffee pot, and refrigerator in student areas." A math library or library with math materials can serve this function admirably.

WOMEN IN MATHEMATICS

While the library profession is strongly female, STEM librarianship has a wider mix of both men and women (NSF 1994). But while most institutions are working on gender equity in the sciences, mathematics is one area that has remained intransigent despite well-meaning efforts to change this. As Meier has noted in his research about awards in mathematics (Meier 2017), the first woman to be honored with a Fields Medal was the late Maryam Mirzakhani in 2014 for her work in geometry and dynamical systems. By contrast, Nobel Prizes have gone to more women and sooner, although few of them have been in science and medicine. The age limit restriction for the Fields Medal may have played a part, as medalists have to be under forty years of age and it used to be common for women to earn PhDs at a later age than men. The newest research shows that women now earn PhDs in the same amount of time as men (Van Noorden 2015); however, fewer women are getting PhDs in math overall (Cleary, Maxwell, and Rose 2011).

No matter what does or does not change, women in math face unique difficulties. We cannot possibly do them all justice here, but some of these challenges include:

- stereotypes about what women are capable of (Bahadur 2013; Manin 2007);
- disapproval in the face of the challenges of teaching, research, and publishing;

- as visible minorities in their field, being asked to take on more mentoring responsibilities, both formal and informal (i.e. female students gravitating to them for advice or check-ins);
- more requests to represent the department on diversity-related committees (Mayock 2016).

Regarding the lack of diversity in the math profession, mathematician and blogger Piper Harron writes in the American Mathematical Society (AMS) blog *inclusion/exclusion*: “Statistically speaking, you are probably taking up room that should go to someone else. If you are a white cis man (meaning you identify as male and you were assigned male at birth) you almost certainly should resign from your position of power. That’s right, please quit” (2017).

While Harron’s appeal for white males to resign might not be taken seriously by everyone, it was certainly noticed in mathematical circles. The aforementioned blog maintains an ongoing dialog regarding issues of diversity in math. We hope that by being aware of some of these issues, librarians can lend our support to students and faculty and try to make our collections and spaces inclusive. One never knows who will find the book or journal that inspires a career or helps someone when it is needed most. We’ll speak more about diversity within the field in the next chapter.

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TEN HELPFUL MATH PRONUNCIATIONS

1. LaTeX—*LAY teck* or *LAH teck*. A way to tag a document so that math equations are formatted correctly—"The LaTeX template for the [university] masters thesis isn't working! Do you know someone who can help me fix it, so I can file my thesis and get out of here?"
2. Lie Groups—*LEE Groups*. It's no lie: Sophus Lie was an excellent mathematician. Lie groups combine algebra and geometry all into one fun subject. Who knew one could think about the shape of collections of matrices?
3. Euler—*OY ler*. A Swiss mathematician from the eighteenth century and the hardest-working man in the math business, Leonhard Euler contributed to pretty much all of math but had special fun with series such as 1 + 2 + 3 + 4 = ...-1/12.
4. Euclid—*YOO klid*. You may think that Euclid and Euler were contemporaries, but you'd be off by something like 2000 years. Euclid gave us axiomatic mathematics, geometry, infinitely many primes—all before indoor plumbing was even a dream.
5. Homotopy—*HOMO toe pee* or *HOma toe pee*. Homotopy is a fancy word for deformation. Supposedly, homotopy theorists can't tell the difference between coffee cups and donuts, but we've observed them navigate the two just fine.
6. Abelian—*ah BEE lee an*. Making adjectives from a noun can be confusing. Niels Henrik Abel was a person and thus a noun. Abelian refers to the fact that you can add or multiply in any order you choose.
7. Cauchy—*KO she*. Augustin-Louis Cauchy was one of the founders of analysis, which is the careful development of calculus—so Cauchy helped make calculus kosher. Now Cauchy's name is associated with convergent sequences.
8. Riemann—*REE mann*. A huge contributor across mathematics, fortunately Bernhard Riemann set the foundations of differential geometry just in time for Einstein to use them to describe the workings of the universe.
9. Lebesgue—*luh BAYG*. Henri Lebesgue was another mathematician who worked through details of calculus, and has a type of integral named after him. His arguments were anything but vague.
10. Ramanujan—*ra MA nah jin*. You may remember that movie about the prodigy mathematician Srinvasa Ramanujan from India who credited the goddess Lakshmi for giving him solutions in his dreams.

This list was developed in collaboration with Dev Sinha, Associate Professor of Math, University of Oregon. Additional name pronunciations may be found at http://pronouncemath.blogspot.com.

two

Know the Users

The library is the mathematicians' laboratory.
(Halmos 1985)

This chapter will discuss ideas for connecting with faculty and students in the math department. We will give examples drawn from our experiences and highlight strategies to identify the relevant needs of local users. We will also discuss some of the unique opportunities and challenges of working with mathematics faculty and students.

MATHEMATICS DEPARTMENTS AND LIBRARIES

With most journals and many books available online, most libraries have seen lower door counts from faculty and graduate students in the STEM fields. While math faculty and graduate students place a high value on print and older materials, even their habits are changing. With a wide range of materials available online through legal and not-so-legal channels, we can surmise that mathematicians can now more easily find what they need by simply downloading articles or e-books to their personal or work computers. Since the library is one of the few institutions dedicated to preserving access to both historic and current collections, it is an essential component of the scholarly communication environment. As an example, mathematicians may scan arXiv to see what work is being produced yet still want a final peer-reviewed copy. Even researchers who prefer to read journal articles electronically may also prefer books in print form.

Operating a small branch library has a different set of challenges than working in a well-staffed larger one. Since small math libraries located close to math departments seem to have more lasting power than many other discipline-specific libraries, we will discuss some of the difficulties we have encountered working in these libraries. In these branches it is possible that qualified members of the department have after-hours access. Usually this privilege is reserved for faculty and instructors as well as graduate students who have passed their comprehensive exams. If this is the case at your library, consider a system that both protects the privacy of patrons and allows them to record the books they have taken to their offices after hours. One way to implement security is to require that the faculty and graduate students meet with a librarian or staff member before getting a key or key card for after-hours access. At that meeting, review how to physically get to the collection and record checkouts and remind them not to let anyone else use the space. Sadly, there may still be a fair amount of the collection that needs replacing periodically due to poor compliance with these procedures. In one case, a faculty member died unexpectedly. A few weeks later his friends in the department cleaned out his office and returned a stack of unaccounted-for library books that had long-since been declared missing and replaced at the expense of the mathematics library budget.

In addition to the print journal and monograph collections, housing textbooks is an important use of the physical library space. Undergraduates, graduates, and faculty alike cherish the textbook collection for in-course use, research, and historical value (CBMS 1990). For example, in one author's recent experience, a math graduate student group asked for a special collection of seminal textbooks for their student lounge located within the math library. Again, these are local concerns for consideration at individual math libraries.

Those who have math collections interfiled with larger STEM or general collections have their own set of challenges. Space and budget allocation are usually the top concerns. Math is the foundation for many other science disciplines, so the department may have large enrollments in introductory and required classes while not having a large number of majors. Most math departments also fail to generate much income or media coverage for the institution. Math departments are usually some of the oldest on campus and may have to compete with new and "sexy" departments for resources and support, including subscriptions and print space. With the long-standing history of the knowledge of math research, it can be hard to make the case for the newest, say, algebra book, much like it can be hard to ask for the newest bible commentary. The long historical nature of math materials can be a drawback when vying for space and resources in the general collection.

IDENTIFYING INSTITUTIONAL NEEDS

The following are suggested steps for identifying the collection development needs of your institution:

1. Assess the current collection;
2. Assess the needs of users;
3. Align with strategic directions;
4. Share with others;
5. Review and assess impact;
6. Repeat steps 1 through 5.

When selecting library materials in mathematics, it is important to regularly evaluate the unique needs of the local university. The first steps are to assess both the current collections and user needs. Other sections of this book will help you compare the core resources of the discipline with what is in your collection, but it is more important to tailor the collections to local users. There are a number of methods to use, including direct contact with constituents and indirect information gathering.

In order to assess the research focus of the local mathematics department, it is often good to start with the department faculty website. Information about the department and its mission may vary greatly, depending on the size of the institution. In order to get a more detailed look, search for research groups and centers that focus on certain fields of mathematics. Then investigate the department directory where most faculty will have their research areas listed. These may be easy to compile and review, but it may take some time to become familiar with the groupings they use. Look also for endowed or post-doctoral positions, as they may indicate an area of excellence in the department. Another option is to look at the strategic plan of the college or school that houses the mathematics department. Looking at the strategic plan will give you a high-level view of the emphasis of the math department, as well as high-impact math-related initiatives on campus. For instance, there may be a goal of opening a new center or enrolling more undergraduates.

That type of information is important, both directly and indirectly, to the math library.

Bibliographic analysis (or citation analysis) is another way to quantitatively assess the focus of the mathematics department. You can use databases to identify journals in which the most faculty work is published, and searching the citations of those articles can help you estimate what faculty read most frequently. MathSciNet, the primary abstracting service for math, can be used to find the papers of individual faculty members and the works they cite, while large, comprehensive science databases such as Scopus and Web of Science can be searched by author affiliation (Google Scholar has even improved in this area in the past few years). More information about these platforms can be found in Chapter 5. Many universities also use research tracking and profiling tools such as VIVO (https://duraspace.org/vivo), SciVal (https://www.scival.com), InCites (https://clarivate.com/products/incites), and ORCID (outlined in Chapter 3) that can show the research output of an entire department or school.

The most direct way to gather input is to simply ask department members and users what they want and need. This is a great opportunity to learn more about faculty and student research (mathematicians are used to explaining their work), and the benefit of showing interest in their work makes it worth the effort. We often make decisions with anecdotal information or because of top-down mandates, but we can make better-informed decisions by talking to the very patronage for whom our math libraries exist. There is a wide spectrum of ways to gather feedback. It can be as simple as putting a suggestion or feedback box in the library with slips of paper for users to complete. We have sometimes asked departmental representatives to write out a list of topics that the department is interested in and how extensively they want to collect in that area. This list can be useful for setting up approval plan profiles and may be revised regularly with departmental input. If the library does not use approval plans, collecting faculty research interests is a good way to make an informal plan for collecting books.

On the other end of the spectrum, you can create a formal print or online survey asking users questions about collections, space, and what they value most, and then cross-reference the replies with their demographic data. Asking visitors informally about why they are visiting the library may also help you find unexpected needs or uses. Consider website usability tests to determine what parts of the library website are being used, or look at access statistics to find out what databases and links are visited and for how long. Again, this type of information gathering provides feedback and data about users that is sometimes overlooked. One of the authors distributed a survey via departmental e-mail and within the library to face-to-face users about their use of the space and the materials in the library (Witt et al. 2014). From these results she was able to ascertain the importance of the print and online collections, as well as plan a space modernization project.

OUTREACH STRATEGIES FOR LIAISON LIBRARIANS

The following are some good routine practices for math liaison librarians to help them stay informed as professionals.

- Daily—read e-mail and social media updates from publishers, societies, and departmental distribution lists. Chat with patrons who most frequent the library.
- Weekly—visit the department; they may sometimes have a tea or other social event or host a guest speaker. Go to websites for math and science news. Check the week's journals for book reviews.
- Monthly—check Amazon.com and your book vender or consult your approval plan for new e-books and monographs. E-mail the department with library news or simply ask for book or journal recommendations, or send a newsletter featuring new books and library information. Post new books on the library web page. Scan monthly journals and magazines.
- Annually—attend conferences to speak with vendors and other librarians. Do a review of all journal subscriptions. Review new faculty appointments and add their research interests and publications to a list of subject areas to acquire and retain for the collection.

CONNECTING WITH STUDENTS, FACULTY, AND STAFF

> *How can you tell an introverted mathematician from an extroverted mathematician? An introverted mathematician stares at their shoes while they talk to you, and an extroverted mathematician stares at your shoes. (Hale 2003)*

In order to build successful collections, librarians need to build good communication with users. The physical library collection is still more important to mathematicians than it is to other scientists. Mathematicians appreciate the ability to browse for a specific proof or subject, in much the same way researchers in other disciplines used reference materials in the past. It is simply easier to browse materials in print than online, and studies show that reading dense information is faster and easier on paper (Singer and Alexander 2017). Furthermore, librarians need to go outside the library into the spaces and events where they can connect with math faculty and students, to learn more about their habits and needs.

Interestingly, the mathematics department may have more international professors than departments in other science disciplines. The diversity in nationality, ethnicity, and gender of mathematics faculty can vary greatly between institutions, and these demographics are changing as more women and international scholars advance in the profession. There are a number of historical events that have impacted the composition of math departments over the past century. In the 1980s and 1990s, a diaspora of Russian mathematicians fled the Soviet Union for Western Europe and the United States. Thus, many mathematics departments in the United States have a significant number of Russian faculty of a certain age range (Vladlen 2015). There is also an expanding number of Asian faculty members, in addition to Western European, Indian, or South American graduate students and faculty. It is important to think about their unique needs and interests, especially if international, foreign language, or translated materials from these areas has not been a collecting focus in the past. Be mindful of the many different cultural backgrounds and learn to pronounce names from various nationalities. For professional development in cultural awareness, seek out your campus offices of diversity and inclusion, human resources, or international students.

Many departments have regular seminars and lectures on specific topics. The math department might have something like a weekly tea, with beverages and snacks. At Purdue the department has a *daily* coffee and tea in the library. This might have been more widely practiced at one time, but seems to remain a tradition in some departments. Sometimes these social events are also followed or preceded by talks or discussions. While it is not mandatory to attend the talks, the teas are a great place to meet people and ask them about their research. Even though some of these interactions with faculty and students can be awkward as you search to find common interests, we have also enjoyed hearing terrible puns and dry jokes and developed an appreciation for a certain razor-sharp sense of humor on the part of mathematicians that is usually both self-deprecating and insightful.

Other important contacts to make in the math department are the administrative assistant to the department head and other support staff. These are the individuals that keep the academic machine moving; they keep the faculty organized, they run many of the programs and events, and they know all the faculty and students in the department very well. Regular conversations at the beginning and end of the year can be helpful in finding out about new faculty and departing ones as well. Department support staff also know about new positions and other departmental changes. Depending on the size of the math department, there may be from one to a dozen support staff. There are opportunities for regular interaction with them, such as setting up a meeting time with the department head or graduate student coordinator. It is also useful to greet them one on one as often as possible. If they know the librarians and their expertise, they will call on the library more frequently. This notion holds true to the traditional expectations of what a librarian is: a friendly and knowledgeable face.

STRATEGIES FOR COMMUNICATING WITH MATH FACULTY

Expect that your department will have a standing in-person faculty meeting. Before asking for time to present at one of these you should understand the dynamics of a department very well. Initially we thought attending a meeting would be an easy way to introduce ourselves to everyone at once and let faculty know what we can do to help. We have found that faculty meetings tend to involve complicated departmental dynamics. Exceptional situations—for example, if the library is acquiring or cancelling a large collection, making a significant change to the library catalog, or embarking on another similarly large project—may be a reason to try to meet with the full department. If you do present at or attend a faculty meeting, keep in mind that you are walking into an ongoing conversation between department members that started before you arrived and will continue after you leave.

Working with any group of faculty will present challenges, as a math librarian will learn if they work with math department liaisons to the library. This may take the form of a faculty committee or a single faculty member. If neither exists, the mathematics department chair is the best contact for instituting a group or establishing a relationship with an individual person. When dealing with a formal liaison within the math department, it is best to communicate library news to them and encourage them to share it with the entire department. Be prepared for possible negative reactions, such as concerns and gripes about the library and the collections. Depending on the institutional culture and history of the department's relationship with the library, an appointment to serve on a library committee or as a liaison faculty member could be either coveted or considered a low-effort, meaningless position. In the case of the formal library representative, build a strong relationship with this person so they can be an advocate within the department. It is important to find out who they are and what they value, but also to communicate to them the value of librarians and the evolving nature of the library. During a math department faculty meeting at one university, a former committee member described the library committee as the place librarians come to when they want to cut journals. It took a few years to change the conversation to library services, scholarly communication issues, and new uses for library space.

Some faculty in the mathematics department may be interested in a regular way to learn about new books. Considering the love shown for libraries and books by mathematicians, this should not be surprising. Traditionally, libraries have had "new book" shelves to showcase recent arrivals. However, since many books are now acquired electronically our new book shelves may look empty most of the time. One alternative or supplement to the new book shelf can be a weekly or monthly e-mail announcement of new books in the library. This could also include new journal subscriptions, databases, or library guides. If there is a regular newsletter or a new library service announcement, these can be combined into a single communication to the math department. It may be possible to e-mail all faculty, graduate students, or the entire department directly, but an intermediary such as the department head, faculty liaison, or administrative assistant can also distribute it.

Hopefully, the math department will allow librarians to join its general e-mail list. If something goes out that might be library-related, a librarian can reply to it immediately and directly. However, it is important to find a balance between keeping in touch and overloading faculty with messages they will start to ignore. Try to limit e-mails to regular announcements or important and pressing news. You may find that you can limit communication to one e-mail per term if you stay in close touch with the departmental representative. Do not be afraid to visit offices for in-person follow-up if you'd like to interact and get additional faculty responses.

USER ENGAGEMENT

In an effort to create a welcoming space, many of us have worked on outreach activities in addition to the daily activities of the library. March 14th is often celebrated as Pi Day, because March is the third month and therefore the date can be written as the first few numbers (3.14) of the mathematical constant ϖ, spelled "pi." Math libraries and libraries with math collections have hosted activities like providing puzzles for patrons to assemble, supplying math- or pi-themed coloring sheets (check Pinterest.com for ideas), and serving food like pizza (pie) as well as sweet and savory pies of all kinds. Giveaways are popular and have included shirts, 3D-printed items like pins or cups, or anything else math-related the library has collected over time. Of dubious utility are applications that can find the numbers of a person's birthday in pi. Activities such as window decorating contests throughout the library or math department can also be engaging. Feel free to think big, try new ideas, and use the occasion as a chance for outreach to the math department.

One of the goals of user engagement and outreach is to promote collection and service strengths to our most important audiences. Remember to keep a connection to the collection through books or surrogates for other material, such as displays showing print book covers or "dummy" books with URLs for the e-book versions printed on them. It is often possible to solicit giveaways from math publishers or electronic resource vendors (major math publishers and vendors are listed in later chapters). The library could also develop promotional materials that can be given away and serve as a physical connection between users and the library. These activities should be assessed for impact either by attendance numbers or user feedback. Keeping users involved in the library creates a dialog that can inform future decisions and planning.

INFORMATION LITERACY

In general, undergraduate mathematics students' use of the library, even at the highest levels, does not involve much more than checking out textbooks. However there is some concern in our profession that if students do not need to do research as undergraduates, they will not be prepared to do research when they become graduate students. It is worth considering ways to have conversations about library resources with the students and faculty in the department. Bussman and Bond's work on this suggests that everyone could use instruction in basics such as how to use the catalog, get journal articles, and use interlibrary loan for material the local library does not own (Bussmann and Bond 2015). It may be worth expanding your understanding of who your collection's stakeholders are. This may include math education students, future actuaries, undergraduate researchers, K-12 students in summer "future scientists" programs, and the like. Each of these groups presents an opportunity to engage with the collection, both print and online, in different but important ways that should not overlooked.

A new librarian should research the course offerings in the math and statistics departments. The authors found that math history courses made the most use of the library's collection of historical research material. Other assignments where the library collection could be well used include: a research paper, biography of a mathematician, summary of math or statistics in the news, and short presentation on a class topic. These assignments all provided a good entry point for teaching information literacy. The authors also found that applied math and statistics classes might have more need for instruction than those in pure math, specifically classes where the instructor has students using news or journal articles and finding flaws with the presentation, studies, or methods used. Math education classes may be more receptive to instruction around library resources, although education librarians may provide that information. Quantitative reasoning courses also present an opportunity to provide instruction around data literacy. Curriculum mapping with an emphasis on information literacy and informed learning that includes the math department is a good idea when exploring opportunities to collaborate and embed instruction (Buchanan et al. 2015).

Some math librarians feel that focusing their efforts on graduate students is the most productive way to reach patrons. These students will likely get training from their peers, mentors, and others in their department. Some of the instruction will be informal and some will be more formal, generally in beginning-of-the-year orientation settings. Beyond reaching graduate students informally, it is a good idea for math librarians to work with whomever is organizing these orientations to arrange for participation as a presenter. Mathematics graduate student associations are good to work with as well. There may be several groups in just one department; usually there is at least one general group in addition to those for women and other minorities in mathematics. There will likely be groups for those with interests in specific fields, like applied math or other more focused topics. These groups normally meet regularly and may be interested in knowing about library resources. Even short presentations can be effective for giving a quick introduction to the math librarian and the collection's core resources. Graduate students have a vested interest in the core collection, as well as learning about best practices in data and research management.

An example of a successful presentation could be the librarian helping the local chapter of American Women in Mathematics find resources for women in math. Other invitations have come about when a student attended a more general workshop and then asked for something specifically for math students. Librarians have had success with providing instruction on the following topics: covering sources for proofs; using LaTeX and the library catalog; finding theses, dissertations, and other collected works; searching MathSciNet or arXiv; managing citations; and finding information about careers for math majors.

The threshold concepts defined in the *ACRL Framework for Information Literacy for Higher Education* (ACRL 2015) are as useful for mathematics as they are for any other field. Two threshold concepts are inherently central to mathematics: "authority is constructed and contextual" and "scholarship as conversation." These are the foundational principles of how mathematical proofs are written, published, and verified. For example, where would the previously unknown Indian math prodigy Srinivasa Ramanujan, have been without the well-known English mathematician G.H. Hardy inviting him to Cambridge? His work done in isolation in India could have remained in obscurity. These two principles undergirded and gave the context to his mathematical authority.

Another instance of the importance of authority being constructed and contextual is the prominence of a site like MathOverflow (http://mathoverflow.net). This website enables math questions to be raised by anyone and answered by the community. The quality of the answers is extremely high, and even working mathematicians think carefully about what they post and follow the threads in their areas of interest.

The threshold concept "research as inquiry" in mathematics can also be interesting and complex, an example being the publication of the solution to the Poincare conjecture, a famous topology problem first proposed in the nineteenth century. Grigori Perelman published his solutions without peer review on arXiv but never in a journal, so the most-cited article on the Poincare conjecture is another mathematician's explanation of his proof. It is worth noting that while research is certainly a conversation and anonymous peer review is still a valuable part of the research process, true anonymity in many fields of mathematics can be difficult to achieve—only a small number of other mathematicians in the world can understand some papers, and even fewer can verify the work.

We maintain that the high cost of mathematical books and journal subscriptions for a relatively small audience of readers demonstrates the concept "information has value." Both "scholarship as conversation" and "information has value" are evident in the publication of the book *Uncle Petros and Goldbach's Conjecture* (Doxiadis 1992). The book itself is a proof with a story, and the book's publisher offered a million dollars in prize money to the first person to solve the problem within two years of the announcement. While the prize went unclaimed, this scenario shows how strong the community is and how vital it is to maintain an ongoing dialogue within the discipline.

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FIRST THINGS TO DO AS A NEW MATH LIBRARIAN

1. Introduce yourself to the math department office staff.
2. Find your departmental liaison, if there is one. If not, find an informal one, perhaps at the water cooler, a departmental tea, or in the break room.
3. Figure out what the major areas of research are in your department. The department's web page will likely have a lot of good pointers.
4. If you are new to math, learn some of the vocabulary. Make a list of vocabulary words, just like you'd do if you were learning a foreign language.
5. Update your collection of textbooks that are circulating or on reserve to include the most recent editions used by large classes.
6. Review your reference and print book collection for common themes and gaps.
7. Match your journal collections to the expertise and priorities of your math community.
8. Look for gaps, embargoes, and missing years of coverage in your electronic journal collection.
9. Attend math departmental functions—picnics, teas, talks, and other gatherings.
10. Ask questions. Mathematicians are used to explaining what they do even to other mathematicians, and they really do like to talk about their areas of interest.

three

Know the Profession

The most persistent myth of mathematics education is that what is covered is the same as what is learned. We didn't cover much, but we sure did learn. (Mitchell 2002)

This chapter will discuss professional resources for math librarians and those that have collection responsibilities for mathematics. Librarians are always eager to help others, including other librarians, and there is no exception in the STEM librarian community. Going beyond the local library and math department is essential for increasing your expertise and keeping up to date with collection development for math. We will start with professional associations for librarians before moving on to mathematician groups, and finally look at other resources for professional development.

MAJOR SOCIETIES AND ORGANIZATIONS FOR MATH LIBRARIANS

Because there are few librarian-oriented groups within mathematics professional societies and organizations, many math librarians find most of their professional development and participation within professional library societies. These include ACRL—which is the largest division of the American Library Association (ALA)—as well as the Special Libraries Association (SLA).

SLA PAM, https://connect.sla.org/pam/home. The library organization that is most focused on mathematics is the Mathematics Roundtable of the Physics-Astronomy-Mathematics (PAM) division of SLA. During every SLA Annual Conference, PAM holds a Mathematics Roundtable discussion. Often a mathematician, publisher, or librarian will present on a topic related to mathematics libraries. Other PAM division events include topics of interest to math librarians, including an all-sciences poster session and related round tables (such as computer science). With only a few hundred members, the PAM division is a close-knit group that welcomes new members and provides support through activities beyond the SLA conference. Membership is diverse, as it is for SLA as a whole, with librarians representing government agencies and labs, corporate libraries, and academic institutions. There is a PAM newsletter that often covers topics in math librarianship.

In 2016, due largely to financial pressures, SLA made the decision to restrict access to some online content and networking opportunities to paying members only. Members of each unit within SLA decided how much they rely on having conversations with other SLA members and non-members. PAM members have found this type of cross-pollination to be useful, and the electronic discussion list has been run independently of SLA software support for over seventeen years (see section below on the PAM electronic discussion group).

ACRL STS, https://www.ala.org/acrl/aboutacrl/directoryofleadership/sections/sts/acr-stsec. The Science & Technology Section (STS) of ACRL requires membership in the parent organizations of ALA and ACRL, both larger umbrella groups within the profession. Because STS is larger than PAM it holds fewer events and discussions that address mathematics specifically, though there are a number of math librarians active in the organization. STS has programming during two annual conferences, the ALA Annual Conference and Midwinter Meeting, as well as at ACRL's biennial conference. At the Annual Conference, the organization holds a large program, a poster session, a research forum, and multiple discussion groups. At the Midwinter Meeting the main session is a discussion group. STS organizes online chats on STEM librarianship topics throughout the year as well. STS publishes a biannual newsletter, the *STS Signal*, primarily dedicated to organization, business, and conference news. It also publishes the online journal *Issues in Science and Technology Librarianship* (www.istl.org), which often features math-related library literature.

ELECTRONIC DISCUSSION GROUPS

PAMNet, https://listmgr.nrao.edu/mailman/listinfo/pamnet. SLA's PAM discussion group, hosted by the National Radio Astronomy Observatory, does not require membership in SLA or PAM to join. Since the division has a math round table and many active math librarians, the discussion group is a great forum for asking questions and learning about the job. Besides the business of the organization such as conference events, newsletters, and membership news, PAMNet also has job postings, academic and publishing news, and discussions of issues in the profession. Some publishers are members of the list and will engage librarians in discussion of materials cost, access, and quality issues. Discussions follow news of freely available, open access (OA) publications; other scholarly communication topics; and additional items of interest to librarians. Librarians also discuss specific books or journals that may have questionable quality or editorial review. Other collection development support available through the list includes discussions of space management and weeding, core mathematics collections, and methods of engaging with math faculty and students.

STS-L, https://lists.ala.org/sympa/info/sts-l. Many, but not all, e-mails are cross-posted between PAMNet and STS-L, the electronic discussion group for STS, so membership on both lists is recommended. Membership in STS-L is not limited to members of STS. In addition to general business, STS officers and committee members promote online discussions that are open to any participant. Beyond the association, the e-mail list is active with job postings, discussions of professional news, and research projects by librarians. Because STS has broad STEM subject coverage, few topics are specifically related to math librarianship, but are rather broader science librarian issues. In comparison to PAMNet, there seems to be more discussion around information literacy and research rather than collection development.

MENTORING PROGRAMS

PAM Conference Buddy Program and Formal Mentorships, https://connect.sla.org/pam/mentoring/mentoring. The PAM division of SLA has two types of mentoring: the Conference Buddy program, and formal mentorships. Even experienced librarians can use help when orienting to a new conference, and using the Conference Buddy program is a good way to take full advantage of what makes SLA different from other conferences. A new math librarian would also find the formal mentoring program valuable, as it is explicitly designed for new librarians or experienced librarians with new roles in physics, astronomy, or math.When possible, the program tries to match librarians with mentors who share job responsibilities and work in a similar type of library.

STS Sci/Tech Library Mentors Program, http://www.ala.org/acrl/aboutacrl/directoryofleadership/sections/sts/stswebsite/mentors/mentorinfo. Similar to PAM, STS has a mentoring program based within their organization. It also matches science and engineering librarians with a mentor who has similar job experience and communication preferences. STS also holds a welcome for new members and first-time conference attendees at its membership meeting and breakfast during the ALA Annual Conference.

NMRT Mentoring Program, http://www.ala.org/nmrt/oversightgroups/comm/mentor/mentoringcommittee. ALA's New Member's Round Table (NMRT) is a great way for new librarians with diverse backgrounds and job titles to get acquainted with ALA and the profession. This mentoring program includes shorter-term opportunities for help at conferences, similar to the Conference Buddy program, as well as more formal, longer-term career mentoring, and is not restricted to librarians of any particular type. It is less likely that they will be able to match librarians of the same job responsibility, but since NMRT is a very large organization there may be a rough match for broad interests. NMRT arguably does some of the best conference orientations in the organization for both the ALA Annual Conference and Midwinter Meeting.

MAJOR SOCIETIES AND ORGANIZATIONS FOR MATHEMATICIANS

Librarians can benefit from attending conferences and other activities of mathematical societies to engage and network with mathematicians on the issues they care about. These events can also be useful for librarians who have a mathematics or statistics background and want to keep current with those professions. While none of these groups has a specialized membership category for librarians, some have collection development resources or special conference rates for librarians. They also hold regional, national, and international meetings that can provide an immersive experience for librarians and may offer programming on some scholarly communication topics. These organizations are listed in order starting with those that offer the most opportunities and information tailored to librarians.

AMS, http://www.ams.org/publications/librarian. The American Mathematical Society was founded in 1888 and is the largest organization of mathematicians, with about 30,000 members both within and outside the Americas. The annual Joint Mathematics Meeting with the MAA is the largest conference of mathematicians in the world. Programs and presentations often cover high-level mathematics, but occasionally there is programming on scholarly communication and math education that may be of interest to librarians. Librarians also benefit from a reduced registration rate for the meeting. The AMS holds meetings in regional sections throughout the United States, which may not have content for librarians but are good networking opportunities. The AMS also provides a portal for librarians on their website, which goes beyond the society's role as a publisher of books and journals to engage and support librarians in their jobs. The portal has featured profiles of math librarians and scholarly articles by librarians.

MAA, http://www.maa.org/press/information-libraries. The Mathematical Association of American (MAA) is focused specifically on mathematics at the undergraduate level, and is roughly half the size of the AMS. Historically, it split from the AMS in order to provide a home for research focused on the teaching of mathematics. Members include high school teachers, university faculty, and undergraduate and graduate students along with many mathematicians, statisticians, and those with a general interest in mathematics. Librarians can benefit most from the promotional materials the MAA produces that celebrate mathematics and promote math awareness and literacy. They also present math at a very approachable level for the general public, which is of great benefit for librarians without prior experience in the subject.

SIAM, http://www.siam.org/journals/librarians.php. The Society for Industrial and Applied Mathematics (SIAM) is an international community currently numbering more than 13,000 individual members. There are over 500 organizational members, including universities and libraries that receive discounts for the society's electronic products and publications. SIAM specifically focuses on applied mathematical and computational methods and how they are applied in many different areas. Applied mathematics in partnership with computational science is essential for solving many real-world problems. Engineering librarians and libraries also work with SIAM as a publisher and society due to the importance of applied mathematics within the engineering field. SIAM holds a large annual conference and sponsors many smaller regional and specialized conferences.

ASA, http://www.amstat.org/. With over 18,000 members, the American Statistical Association (ASA) focuses mainly on the discipline and profession of statistics. While this focus is broad, encompassing everything from health sciences to business and engineering, many of the fundamentals are based in mathematics. Mathematical statistics faculty and graduate students, along with those working in computation, may be interested in the conferences and communications of this professional organization.

BLOGS AND WEBSITES

What's New, https://terrytao.wordpress.com/. Terence Tao is a Fields Medalist and professor at UCLA, who posts to his blog three to five times per month. Most of his posts discuss (and perhaps prove) mathematical theorems and problems. Occasionally he will write about events and issues in the mathematical profession. Other mathematicians contribute to the blog and some books have been published as a result of discoveries that have been made there.

Gowers's Weblog, https://gowers.wordpress.com. Timothy Gowers is a British mathematician who has become a leader in scholarly communication issues in math. Gowers was the focal point of a

2012 Elsevier boycott, when mathematicians pledged not to publish with or review for the commercial publisher until its journal prices became more reasonable. His is primarily a blog of math problems and theories, but Gowers is still instrumental in many new publishing initiatives in math.

New and Noteworthy, http://www.edwardfrenkel.com/about/. A strong advocate for math in society, Edward Frenkel is a University of California - Berkeley mathematics professor who wrote *Love and Math*, a bestselling book about mathematics for a wider audience. His website is professionally designed and fun to explore. It contains some recent popular essays and videos of his work.

inclusion/exclusion, http://blogs.ams.org/inclusionexclusion/. Individual members of the AMS contribute to this relatively new blog on underrepresented and marginalized groups of people in mathematics. They tackle difficult subjects related to the math community, in addition to math education and encouraging new students. It gives a voice to mathematicians from underrepresented groups and their allies. In the discussion on math and diversity in Chapter 1, we mentioned Piper Harron's popular post in this blog regarding the field's lack of diversity.

Starter Pack, http://blog.mrmeyer.com/starter-pack/. Dan Meyer, a former high school teacher of mathematics, blogs weekly about teaching math using new technology and pedagogy. His blog is useful for college math teachers and also provides examples that are suitable for lower-level undergraduate instructors. Meyer also covers conferences, trends, and current issues in math.

Devlin's Angle, http://devlinsangle.blogspot.com. Mathematician Keith Devlin from Stanford University, also known as "The Math Guy" on National Public Radio, blogs semi-monthly on this website. The focus is on applying math to everyday questions, but also occasionally on how to teach or learn mathematics. The goal is to make mathematical thinking approachable for more people.

Carnival of Mathematics, http://aperiodical.com/carnival-of-mathematics/. This "blogging round up," where posts from around the internet are collected, is sponsored by a different math-related blog each month. The purpose is to bring contributions from math blogs and websites that focus on a specific theme or topic together into one collection. The best thing about this blog is that it helps spread awareness of other math-related websites and blogs.

Quanta Magazine, https://www.quantamagazine.org. The "Abstractions" blog (https://www.quantamagazine.org/abstractions) is part of the *Quanta Magazine* website and covers topics from astronomy to physics to math. Not all of the weekly posts will be about mathematics, but there are enough that it is worth checking regularly. The magazine is also a good source for news about math discoveries, and an even better place for profiles on mathematicians and statisticians among the multiple sciences covered.

Chalkdust, http://chalkdustmagazine.com. *Chalkdust* is a magazine that covers mathematics applied to real world problems and explained in an accessible manner. The weekly blog (http://chalkdustmagazine.com/blog) highlights good examples for teaching mathematical concepts and having fun with math.

RESEARCH DATA MANAGEMENT

An emerging field of interest for math librarians is finding and accessing data sets. Much like with books and other physical materials, locating data sets is becoming commonplace for librarians (Witt et al. 2014). Notably, it is also an area of increasing interest for mathematicians, who are realizing more and more that librarians have the expertise to assist with this level of research support. Mathematicians often create algorithms that process data, rather than producing or collecting data themselves. However, locating others' processes can be helpful to the overall research design.

Within statistics there are many interdisciplinary topics that involve genomics and other areas with established data management practices; however, the statistician is often not responsible for that aspect of the research project. The increasing number of federal agencies that mandate a data management plan (DMP) as a requirement for grant funding does affect many mathematicians, who often look for funding from the National Science Foundation, Division of Mathematical Sciences, or even the National Institutes of Health or Department of Energy for collaborative projects. Math librarians are assisting with those DMPs at pre-proposal and post-proposal stages. It is more difficult to provide assistance in this area for pure mathematicians, who usually do not produce or use data. Statisticians and applied mathematicians may have some data, but it is often produced as part of an interdisciplinary project where another researcher does the data maintenance. The data may wind up in a digital repository like the commercial venture Figshare (https://figshare.com), the grant-funded Archaeology Data Service (http://archaeologydataservice.ac.uk), or even the internationally funded Human Genome Project (https://www.genome.gov/human-genome-project).

There are also opportunities to help math faculty who are developing code and algorithms that need more persistent storage than the open source code-hosting site GitHub.com. During and after the project, there are opportunities to code the project data or formulae for preservation and findability. Math faculty can be wonderful advocates with their research collaborators on aspects of research data management, preservation, and access that are also of value to librarians. Librarians should be proactive with the service and information they provide in support of data management. As an example, one of the authors contributed metadata for a set of MATLAB code deposited in the local university repository.

RESEARCHER IDENTIFICATION

One relatively new tool that is part of the modern scholarly communication system is the unique research identifier. Traditionally, authors of papers and presentations or principal investigators on grants were only identified by name. In some disciplines, names were abbreviated using the surname and initials for first and middle names (e.g., G. H. Hardy). With the digital publishing revolution, print space may no longer be an issue but maintaining these scholarly conventions has made it difficult to disambiguate authors from one another. With greater availability of international literature and a massive growth in the amount of published research, there are more authors every year. To address these demands, digital platforms have been set up to provide unique author identifiers for multiple systems: publishing, citation, grants, and even university administration.

The leading common platform is the ORCID (Open Researcher & Contributor ID) system, where researchers can sign up for a unique, persistent code that can be connected to a large number of systems including publisher platforms and funding agencies. While ORCIDs are becoming more integrated, they are not required by many publishers or grant agencies nor are they used in all citations or other traditional scholarly communication author references. This may be changing partly due to pressure by university administrators, who are interested in quantifying the scholarly output of their institutions. Additionally, with the growing number of international authors and prevalence of international collaborations, it is important to distinguish researchers with common names. For librarians, the fact that ORCID identifiers are interoperable with Elsevier's Scopus author identifier and

Thomson Reuters' ResearcherID systems make them very useful for citation tracking. Mathematics is already a leader in this practice. Within MathSciNet a specific record is set up for each mathematician, and arXiv also has an author records system that can be matched to the other identifying IDs.

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Witt, Michael, Courtney Earl Matthews, Nastasha Johnson, Amy Barton, Charlotte Erdmann, and Marianne Stowell Bracke. 2014. "Collection Development in the Context of Research Data." Presentation given to subject librarians at Purdue University. https://docs.lib.purdue.edu/lib_fscm/3.

TOP TEN SOURCES OF HELP FOR MATH LIBRARIANS

1. PAMNet electronic discussion list
2. STS-L electronic discussion list
3. Math section of Guide to Reference: Essential General Reference and Library Science Sources
4. Math chapter of Magazines for Libraries
5. Math department chair
6. Math department administrative assistants
7. Math department faculty
8. Math/STEM library support staff
9. ALA conferences, specifically STS/ACRL events
10. SLA conferences, specifically PAM events

four

Books and Publishers

"Philosophy [i.e. natural sciences] is written in this grand book . . . written in the language of mathematics . . . "—Galileo (1623)

In this chapter we will focus on collecting books, including textbooks, research monographs, series, and e-books. We will start with the history and background of different types of math books in libraries, and then cover many of the publishers of mathematical material including professional societies, university presses, and commercial publishers. Math shares some commercial and academic publishers with other STEM fields, but it has unique characteristics among those. We will also discuss the use of approval plans and book reviews for help in making selection decisions.

BOOKS

Acquiring books for mathematics is often a balance between teaching and research, reflecting the twin missions of the university. Depending on the size and nature of the institution, the library, and the mathematics department,

Case Study: University of Oregon

At one of our campuses, the math department administrative staff keeps the librarians up to date on new textbook adoptions for classes and, when possible, supplies copies of the textbooks to be placed on hold. Since these can be returned to the math department when the course moves on to a new textbook, it is an ideal way of keeping the reserve collection current and prevents the purchasing of new textbooks that are not needed for the permanent collection. The math department also donates textbooks and, on request, has provided instructor solution manuals for the reserves collection. While we sometimes purchase student solution manuals for textbooks in high enrollment classes, the full instructor solution manuals are usually not easily available for purchase. Solution manuals are always popular with our patrons, and can be so heavily used that they require repair (which we would not normally do for materials that we do not plan to keep) or frequent replacement. The library always checks with current instructors before placing the materials on reserve, especially instructor solution manuals. Solution manuals do not age well and we rarely recommend adding them as permanent collection items. Because the library and math department share physical space, we have helped each other with operational support such as package delivery and building issues that inevitably arise (leaks, security, etc.). The library can also rely on the math department to maintain information for students, like keeping an updated master list of office hours. Clear documentation about who is doing what (such as a memorandum of understanding), as well as regularly scheduled meetings, have been vital to keeping the relationship productive.

the balance will shift between what are considered textbooks (including study materials) and monographs (detailed and specialized research works). As seen in the previous chapter, most publishers in mathematics focus on research monographs and series, while textbooks are less frequently published. In addition to those textbooks published by math or STEM publishers, many general textbook publishers like McGraw-Hill produce textbooks in mathematics. Research monographs in math tend to be less expensive than in other STEM fields.

If the math department is small or mostly made up of teaching faculty, the library's main role will be to provide textbooks, reference books, study guides (such as McGraw Hill's *Schaum's Outline* series), and popular mathematics books. As mentioned in Chapter 1, when more research faculty and graduate students are present, the library will also need to collect books in their major research areas and fields. While it was common to say "just buy everything" a few decades ago, weaker budgets now require that every factor be considered: book type and format, publisher, topics covered, and cost.

There can be overlap between the categories of research monograph and textbook in math, particularly at the graduate level. At some large research universities, librarians have collection development policies (or common practices) that explicitly discourage purchasing textbooks for the collection. Textbooks become outdated quickly in some subjects—but once again, mathematics is somewhat unique. Textbooks in math are read closely and contain important ways of explaining the discipline that are often timeless. Some highly regarded series like Springer's excellent *Undergraduate Texts in Mathematics* may contain introductory explanations of concepts in mathematics, but are also used by mathematicians of all levels.

Teaching undergraduate students how to read and use a math textbook may require some explicit instruction. In most non-math textbooks, an aside or "fun fact" may be presented in a box offset from the body of text. Conversely, in math these boxes often contain crucial content needed for solving the homework problems or understanding the core concepts. In study groups at both the graduate and undergraduate levels, students provide each other with a vital means for comprehending the math as they work through problems in order to gain understanding and achieve mastery of the material. These study groups may also read the text word for word, out loud to each other to enhance understanding. With some guidance, everyone—especially lower division undergraduates—can use the resources productively.

How mathematical concepts are explained may change from textbook to textbook and over time, but most textbooks in math will not age as poorly as those in other fields. A general rule is that it is fine to keep a single copy of a class-adopted textbook in the permanent collection. However, if the textbook is for a topic that is not a major focus of research in the department, there is no need to purchase research monographs in that area. For example, while most departments teach a lot of calculus, it may not be an area of focus for research. In that case, keep only a few carefully selected calculus textbooks.

CLASSIFICATION AND ORGANIZATION

Most mathematics books are shelved under QA in Library of Congress Classification (LCC) or 510 in Dewey Decimal Classification. Computer science is included in the QA section at QA76, but in a class of its own in Dewey at 000. Some book series are classed together, since they were once simpler to catalog and shelve this way. Now it may be possible to classify them according to topic, so a user browsing the library shelves can serendipitously discover books on the same topic more easily. In some cases, the math and science material may be separated from the main library collection in smaller branch libraries. This makes assessing the collection easier, since there are fewer materials overall, and the physical collection is relatively uniform.

COURSE RESERVES

As mentioned earlier, undergraduate mathematics courses are very textbook-driven. Some libraries provide one or more copies of textbooks through course reserves in order to reduce the financial burdens on students. Particularly in large "service" courses such as calculus, which have thousands of students, the overall savings to students can be very high. Course reserves can include solutions manuals, provided in collaboration with the department. Some of these items may be subject to very high use and need frequent repair or replacement due to wear and loss. While course reserves can be one of the most popular services provided by the library, in order to maintain their profits many textbook publishers create new editions every two to three years with only minor changes. This means that libraries need to plan for recurring budget costs when committing to provide textbooks on course reserves.

The math librarian is often responsible for the decision to keep textbooks for classes in the regular collection. Collection development policies should explicitly state whether only the latest edition, a single copy, or all copies are usually retained. Textbook collection parameters are a good starting point for a new collection development policy. Fortunately, course reserves can sometimes be supplied by the campus bookstore or by the department or a faculty member. The department or faculty member may ask the publisher for additional copies for their teaching assistants and graders. The library should utilize both of these options for building the course reserve collection. Some may only be temporarily loaned to the library, and partial catalog records can be created for these items.

E-book versions of textbooks may provide the option of allowing more than one student access to a book at one time. Due to high enrollment in some foundational math courses, unlimited user licenses are preferred so that no students are denied access while attempting to access the book. While the initial investment is more expensive than single-user licenses, the benefit is greater in accessibility. Librarians should negotiate for fewer digital rights management (DRM) restrictions when licensing e-books, since students may want to print sections for reading or homework. Many textbooks are not available to libraries as e-books, even though students can buy individual electronic copies. Some publishers even separate their textbook publishing divisions from the rest of the company so textbooks are not included in e-book packages. Due to the complex nature of math some students may still prefer print textbooks to e-book versions, so libraries should supplement print with electronic (Baron 2015).

Some faculty are exploring open educational resources (OER), such as open textbooks, which offer content for free or at a reduced price for course materials. These resources are particularly popular in introductory, large enrollment classes such as algebra or pre-calculus. Librarians should support this effort as it benefits both students and library budgets through reduced costs. Sites with high quality open educational content are growing, thanks in part to a national movement to make education more affordable and reduce student debt. Some of these sites are hosted locally on university servers, while others are simply content posted on a personal Google Drive account. Because material can be located just about anywhere, it is prudent to connect with local OER resources. As of this writing, some reputable sources of open textbooks in mathematics include the following:

- OpenTextBookStore
  http://www.opentextbookstore.com
- Stitz Zeager Open Source Mathematics
  http://www.stitz-zeager.com
- Open Textbook Library
  https://open.umn.edu
- OER Commons
  https://www.oercommons.org
- American Institute of Mathematics
  https://aimath.org/textbooks
- OpenStax
  https://openstax.org
- FlatWorld
  http://catalog.flatworldknowledge.com

An innovative approach to both online textbooks and homework is LON-CAPA (https://lon-capa.org). LON-CAPA, which stands for Learning Online Network with Computer-Assisted Personalized Approach, is an open-source, open-network interactive course management system. It was created by physics faculty at Michigan State University in the 1990s, a time when existing publisher-created online textbook systems fell short of meeting the instructional needs of students and allowing for requested customizations by instructors. Nearly 150 institutions worldwide now use the platform, including Purdue University, where it is integrated into a three-course calculus sequence with online textbook content, homework assignments, and student quizzes (Purdue University Libraries 2018). It is worth knowing about this and other open publishing options like it that are in development in math departments across the country.

CONFERENCE PROCEEDINGS

Mathematics conferences publish their proceedings as both print monographs and electronic documents online. These proceedings may also be published as special issues of journals, though this is less common in math than in other fields. Over the years, many conferences have followed the pattern of starting with print publishing, then moving to electronic files on CD, and now to digital publication on the web. Depending on whether or not the sponsor of the conference relies on publication of the proceedings for income, they may only sell a print or electronic version.

Many smaller conferences simply publish papers by posting them to the conference website. A book series published by a society publisher may encompass the proceedings from a conference, such as the 1981-2000 conference proceedings of the Canadian Mathematical Society (CMS) published by the AMS. The conference name may be a subtitle, where the main title describes the conference itself. For example, the AMS and the CMS have published a book that is the collected proceedings of the CMS, titled *CMS Conference Proceedings: Constructive, Experimental, and Nonlinear Analyses* (Théra 2000). Since the titles are not uniform, it can be difficult for librarians to ensure they are collecting all the proceedings of a particular conference.

Similar to library conferences, abstracts are submitted for talks that are presented at mathematics conferences. It is likely that a talk given at a conference will become a journal article, apart from the original conference presentation, perhaps with reference to it. For example, in 2012 Professor George Andrews, the outgoing president of the AMS, gave a lecture during the Joint Mathematical AMS/MAA meeting entitled "Our Challenges." It concerned the challenges arising from the intersection of science and math research, Common Core standards, and higher education. Later that year he published the article "Drowning in the Data Deluge" (Andrews 2012), which was a written version of that talk. When conference proceedings are shorter or earlier, less

Wikipedia in Mathematics

Librarians have varied opinions on the value of Wikipedia as an information source, as do mathematicians—see, for example, the Mathematics Stack Exchange thread "Are mathematical articles on Wikipedia reliable?" (https://math.stackexchange.com/questions/744132/are-mathematical-articles-on-wikipedia-reliable). Certainly, there is controversy regarding its reliability concerning social and political issues. With scientific topics, there may be a lack of depth or users may have difficulty identifying the primary sources used for the articles. However, in the area of math, Wikipedia can be an extremely useful source of information for librarians, students, and even mathematicians. Perhaps because of the complexity of mathematics and the intense specialization and focus of the field, articles in Wikipedia are detailed and accurate with almost no controversy. Sources are often math books or journal articles and are well cited in the articles. There are few news stories or opinion pieces and the explanations are reliable.

comprehensive treatments of a topic, they are considered less significant than peer-reviewed journal articles or books in the mathematics literature.

REFERENCE BOOKS

Reference books in mathematics have served patrons in many ways over the years. Much like the evolution of the general reference collection, math reference books have changed to be more useful to more people. For some resources this means moving them into the circulation collection, migrating to e-book versions, or withdrawing them completely. The increase of internet reference sources, both publisher- and community-driven, have reduced the need for many types of reference materials. Given that math has relied heavily on paper books and that many math collections are still in print, we will describe the main types of reference books that are still useful in the modern math library. We will also point out some of the core works that are still important, even in the most streamlined math reference collection. Overall, most math reference books can be moved into the circulating collection and then assessed for weeding or retention based on similar criteria to other materials.

For a more comprehensive review of reference books, the *Guide to Reference: Essential General Reference and Library Science Sources* (Whitlatch and Searing 2014) is a useful source (an archived version of the online version can be found at http://wayback.archive-it.org/6087/20160223151512/http:/ www.guidetoreference.org/HomePage.aspx).

ENCYCLOPEDIAS

Before Wikipedia there were print encyclopedias, and still today there are mathematical encyclopedias that are worth collecting and keeping in the reference collection. Some "encyclopedias" in math are not like their analogues in the humanities, so be sure to investigate the content of each set. For example, they may be more like research monographs with collections of articles about fundamental topics or recent advances in the field.

Encyclopedia of Mathematics and its Applications (1973–2019) is a book series with over 150 volumes from Cambridge University Press, each focusing on a particular topic.

Encyclopedia of Mathematics, https://www.encyclopediaofmath.org. Formerly published by Springer, it contained basic entries as well as longer survey articles in multiple volumes. It is now an open access wiki project in collaboration with the European Mathematical Society.

The On-Line Encyclopedia of Integer Sequences, https://oeis.org, is a collaborative collection of number sequences with references to papers in each entry, as well as information about how to generate them mathematically.

Wolfram MathWorld, http://mathworld.wolfram.com, was started in the 1990s by Eric Weinstein. Now owned by Wolfram Research, it remains a reputable and continuously updated free dictionary and encyclopedia.

BIOGRAPHIES

Collected biographies are a type of reference book that could easily be moved to the circulating collection. Students doing biographical research for course assignments may need multiple biographical sources, so keeping copies of these in reference may also be necessary. Certainly, the importance of history to mathematics makes biographies useful no matter how old they may be.

Biographies of Women Mathematicians, https://www.agnesscott.edu/lriddle/women, contains biographical essays with both alphabetical and chronological indexes. It features the first women to receive PhDs before 1930 as well as prizes, awards, and honors for women mathematicians. This is an ongoing project of students in mathematics courses at Agnes Scott College to illustrate the numerous achievements of women in the field.

Thomley, Jill E. and Sarah J. Greenwald. 2013. *Great Mathematicians*. Ipswitch: Salem Press. This volume covers more than fifty of the best-known figures in mathematics from all world cultures, from antiquity to modern times. Examples include Euclid, Pythagoras, Blaise Pascal, Joseph Fourier, and Alan Turing. Each entry includes a portrait, dates and places of birth and death, biographical details, a discussion of the person's significance, and suggested sources for further reading. Entries were selected from the larger set entitled *Great Lives in History*, published by Salem Press from 2000–2017. This work has a bibliography and an index.

HANDBOOKS

Handbooks in mathematics provide a place for mathematicians, physicists, and other STEM users to quickly access collected formulae and equations. Since they are often organized by topic or concept it is possible to browse for a potential mathematical tool, whereas most internet sources require that users know the formula name. One exception is Wolfram|Alpha (https://www.wolframalpha.com), created by the same company that owns Wolfram MathWorld. Wolfram|Alpha is especially useful as a tool for natural language computations and serves as a great online resource for formulae. It has a premium version called Wolfram|Alpha Pro with some additional features and no ads.

Higham, Nicholas J. 1998. *Handbook of Writing for the Mathematical Sciences*. Philadelphia: Society for Industrial and Applied Mathematics. This is a reference tool primarily for those learning to write research mathematics for publication (e.g., graduate students). Included are chapters on standard English use, writing for papers and talks, the publishing process, and using computers for writing and research. There is also a glossary and bibliography (though they are now dated), a subject index, and an appendix on TeX and LaTeX, languages used for rendering equations and other characters unique to math. While both *Mathematics into Type* (Swanson 1999) and *Handbook of Typography for The Mathematical Sciences*

(Krantz 2001) provide better coverage of those topics, it is still a good selection for those serving graduate programs in mathematics.

CRC Standard Mathematical Tables and Formulae (https://www.crcpress.com/CRC-Standard-Mathematical-Tables-and-Formulas/Zwillinger/p/book/9781498777803) contains formulas, tables, figures, and descriptions, including many diagrams, group tables, and integrals not available online. This new edition incorporates important topics that are unfamiliar to some readers, such as visual proofs and sequences, and illustrates how mathematical information is interpreted. Material is presented in a multi-sectional format, with each section containing a valuable collection of fundamental tabular and expository reference material.

DIRECTORIES

Print directories in mathematics have been made essentially obsolete by the internet. Now, information on membership is usually available on the website of a professional association. An important resource is the *Combined Membership List* (CML), which lists members of the largest mathematical societies in the United States and is now only available online. The CML is a list of names and addresses, updated monthly, of all persons who are members of the AMS, MAA, SIAM, CMS, American Mathematical Association of Two-Year Colleges, and Association for Women in Mathematics. This directory is also available in print as the *Combined Membership List of the American Mathematical Society and the Mathematical Association of America*.

There is a strong incentive to archive directories for historic research purposes. Directories of graduate programs in the discipline may also be valuable to the collection. All of these kinds of directories may be useful to bibliographic researchers, historians, librarians, or university and department administrators.

BIBLIOGRAPHIES

A number of reference books in mathematics are bibliographies of mathematical works. These may be lists of books or articles written on a specific subject or by a particular mathematician, or intended for use in collection development.

May, Kenneth O. 1973. *Bibliography and Research Manual of the History of Mathematics*. Toronto: University of Toronto Press.

This book is a collection of published writings on the history, biography, and bibliography of mathematics. Librarians, historians, mathematicians, and students will find this resource useful for tracking items published before 1973. The first part of the book is a research manual that consists of brief comments on information retrieval and storage and historical analysis and writing. The method is very dated and based on printed cards. The second part is a bibliography of about 31,000 entries, alphabetically arranged by author, with sections such as biography (the strongest section), mathematical topics, historical classifications, and information retrieval.

Dauben, Joseph W. 2000. *The History of Mathematics from Antiquity to the Present: A Selective Annotated Bibliography*. Providence: American Mathematical Society.

Compiled with the assistance of thirty-eight contributing editors, this volume lists works that span and cover the history of mathematics. The scope encompasses primary sources, histories, and general reference works. The book is organized both chronologically and by mathematical and historical topic and contains author and subject indexes. The electronic version contains over 4,800 entries, about double the number of items in the print edition it replaces, and is divided into fifty-two PDF files. This edition of the work is currently only available for purchase as compact discs. Given the format, it is difficult to decide how useable it might be at this time.

DICTIONARIES

Like encyclopedias, print dictionaries have largely been replaced by online dictionaries and Google. However, certain types of specialized dictionaries such as translation dictionaries, quotation dictionaries, and concise volumes are sometimes simpler to flip through in print rather than searching online.

Gaither, Carl C., Alma E. Cavazos-Gaither, and Andrew Slocombe. 1998. *Mathematically Speaking: A Dictionary of Quotations*. Boca Raton, FL: CRC Press.

This dictionary contains over 1,000 quotations from mathematicians, non-mathematicians, and some fictional characters. Sources are from over 800 historical and twentieth-century journals and books in mathematics, works in fiction, and famous authors. Quotations are grouped by broad subject area, such as calculation, analogy, deduction, and topology. The bibliography lists quotes by source, with rather extensive author and subject indexes. This source is also available online through NetLibrary and CRCNetBase.

Clapham, Christopher, and James Nicholson. 2009. *The Concise Oxford Dictionary of Mathematics*. Oxford: Oxford University Press.

This dictionary is a standout when compared to other mathematics dictionaries because of its detail, depth of entries, and breadth of scope. It covers pure and applied mathematics, including statistics and areas such as fractals, game theory, and chaos theory. The 2009 web edition has been updated from previous print editions with more terms used in college-level mathematics, an expansion of computing terms, and the addition of biographies of prominent mathematicians, including Nobel Prize winners and Fields Medalists.

TRANSLATION DICTIONARIES

English was not always the main language of mathematics publications. In addition to a strong history of German writing, French and Russian mathematicians were published in their native languages. Translations of these classic and contemporary works are important to the future study of mathematics, since fundamental proofs and theories can last a long time (for example, Fermat's Last Theorem of 1632). While translation is happening increasingly online and electronically, there may still be a place for multilingual mathematics dictionaries, such as the ones listed below, that are in many math library reference collections.

Lohwater, A.J. and Ralph Philip Boas. 1990. *A. J. Lohwater's Russian-English Dictionary of the Mathematical Sciences*. Providence, RI: American Mathematical Society. http://ega-math.narod.ru/Quant/AJL.htm.

This dictionary has over 15,000 Russian mathematical terms with English equivalents and translations. It includes stress markings on Russian words and contains a brief Russian grammar section with appendixes that contain noun declensions, verb conjugations, lists of numerals, and root lists. A similar alternative is the *CRC Russian-English Dictionary of Mathematics* by Oleg Efimov (1992).

Peeva, Keti Georgieva. 2000. *Elsevier's Dictionary of Mathematics in English, German, French and Russian*. New York: Elsevier.

This very large monograph contains over 11,000 entries with more than 4,750 cross-references. It covers all the major fields of mathematics, from elementary to advanced: arithmetic, geometry, discrete and applied math, logic, algebra, and game theory. It also includes commonly used terms in computer architecture, hardware, communications, system and application software, and programming. There is not yet an electronic version available.

ISI Multilingual Glossary of Statistical Terms, http://isi.cbs.nl/glossary.htm, was created by the International Statistical Institute and last updated in October 2009. This multilingual glossary of statistical terms includes more than 3,500 terms, with each available in as many as twenty-eight languages. It covers almost all European Union languages in addition to Afrikaans, Persian, Russian, Turkish, and Ukrainian. Entries range from basic to more advanced terms encountered in graduate studies and research, including applied mathematics and specialized fields of statistics such as biostatistics. Specialists from several countries contribute translations, and users can offer suggestions for any missing translations (these are vetted by editors before being added to the glossary).

Lewisch, Ingrid, and Alfred S. Posamentier. 2014. *Mathematisches Fachwörterbuch: Englisch-Deutsch, Deutsch-Englisch*. Linz: Veritas.

This is a good aid for native English speakers reading mathematics texts in German or for native German speakers reading such texts in English. A smaller, less comprehensive dictionary than the others mentioned, it focuses on the basic terms of mathematics. It is designed to supplement a general language German-English dictionary and assumes the reader has basic working knowledge of both languages. The two main parts contain English- to-German and German-to-English translations; a third part includes additional material like suggestions for speaking and writing mathematical expressions and idioms and notes on the differences between British and American English.

OTHER TRANSLATION RESOURCES

There are some resources that were translated from Russian to English regularly during the Cold War era, either published as journals by commercial publishers or by US government agencies as technical reports. It is possible to find a direct mapping of these publications–for example, the Soviet publication *Akademiya Nauk SSSR. Doklady* was translated and published in the United States as *Soviet Mathematics—Doklady*. This is useful for researchers looking to obtain a translation of the original article or determine if one exists. It is also useful for correcting erroneous or confusing citations, where the original Soviet journal name is translated but the English volume and edition are used. Some unique reference books that can help with this are listed below.

- British Library Lending Division and International Translations Centre. 1982. *Journals in Translation*. 3rd ed. United Kingdom: British Library Lending Division.
- National Translations Center. 1969. *Consolidated Index to Translations into English*. New York: Special Libraries Association.
- National Translations Center. 1986. *Consolidated Index to Translations into English II: 1967-1984 Cumulation of Translations Register-Index*. Chicago: National Translations Center. 3 volumes.

TABLES

Before there were computers and scientific calculators, slide rules were used for calculation. Engineers and physicists would come into a library to consult logarithmic tables kept in the reference section. Many libraries still have these tables as well as other artifacts of an earlier age. These volumes have very little practical value, even as artifacts of their time. Unless they are rare or in a foreign language, there are few reasons to retain these books even in storage.

PUBLISHERS

Mathematicians can be very opinionated about publishers, trusting some and recommending the library purchase as many books as possible from them. Librarians need to balance budget realities with this input, so it is necessary to be familiar with the key publishers in mathematics. We start with society publishers, as mathematicians generally hold them in higher regard than purely commercial publishers. Professional societies are important to mathematicians, as mentioned in Chapter 3, so mathematicians publish with and read society publications quite frequently. Next are university presses that may be small in the market, but have high-quality publications. Finally, commercial publishers are addressed in the following order: first are reference book publishers that the authors have found reliable, followed by other publishers listed by their percieved reputation among mathematicians (also according to the authors), which is somewhat related to the number of books published.

Society Publishers

Mathematical societies are among the most popular and highly recommended publishers by mathematicians and researchers. Perhaps their success is not surprising given that their members are loyal and often constitute both the author and audience for these publications. Listed below are many of the same societies previously mentioned in Chapter 3.

AMS, http://www.ams.org/publications. The AMS publishes between seventy-five and ninety books per year. At press, they had twenty-seven book series including ten series co-published with partner presses. While everything published by the AMS is of high quality, a library should first purchase the items of particular interest to the local math department. The AMS has added a number of e-book collections over the years, starting with their earliest volumes through the current year. They are available as frontlist subscription or backfile purchases, and librarians can decide based on their budget which option works best. E-books are DRM-free and accessed via IP authentication. Exemplar series to start with are Graduate Studies in Mathematics, Student Mathematical Library, and The University Lecture Series. Purchasing these series as e-books allows libraries to put older print versions into storage since these are backfiles, but many mathematicians will still want to browse and read the physical copies.

SIAM, https://www.siam.org/books. SIAM publishes research monographs and textbooks, and currently has seventeen book series. The SIAM e-book collection can be purchased or leased annually and provides book chapters as unrestricted PDF files. Institutional membership with SIAM affords the library a discounted rate on books and journals, so it works out in favor of most libraries to have such membership. Since applied mathematics overlaps frequently with engineering and other sciences, it is usually possible to purchase these resources collaboratively with other subject librarians.

MAA, http://www.maa.org/publications/books. The MAA publishes about fifteen new books each year, which frequently focus on teaching mathematics and research at the undergraduate level. They publish eight series, of which MAA Notes and MAA Textbooks are the most significant. Most libraries can afford to get all of the MAA books published in any given year due to their affordability. The MAA sells individual e-book downloads via their website, and access to some current and past MAA e-books can be found through University Publishing Online, a service of Cambridge University Press. AMS acquired the MAA Press as an imprint in 2017.

EMS, http://www.ems-ph.org/books/book_series.php. The European Mathematical Society (EMS) does not publish many books; its entire catalog dating from 2004 has approximately 200 titles. Within its dozen book series, the EMS mainly publishes collected works and conference proceedings, but also a few research series. Recently the publisher has offered e-book access through subscription to universities with IP authentication.

University Presses

Many universities and higher education institutions of varying sizes and statures also host publishing houses. We list here three of the longstanding and most renowned of the national and international presses.

Cambridge University Press, https://www.cambridge.org/us/academic/subjects/mathematics.

Cambridge publishes about forty-five books annually in mathematics, including the respected series the *London Mathematics Society Lecture Notes*. Along with their own e-books, Cambridge provides the University Publishing Online platform for publishers without their own e-book service (similar to the MAA). Titles can be ordered individually or in e-book packages.

Oxford University Press, http://ukcatalogue.oup.com/category/academic/mathematics.do.

Oxford University Press publishes a number of mathematics reference books, research monographs, a few popular science titles, and over eighty book series. They publish an average of twenty academic titles annually for higher education. Their online website Oxford Scholarship Online (OSO) also hosts books from seventeen smaller academic presses. Their textbooks are marketed separately and may not always be available as e-books through OSO. Librarians can work directly with Oxford to identify individual titles or groups of e-books to purchase at any time, though there may be some delay between the publication of a book in print and its online availability.

Princeton University Press, https://press.princeton.edu/subjects/mathematics.

Princeton University Press publishes research monographs, textbooks, and books on popular science topics in mathematics. Princeton publishes approximately twenty books in mathematics annually, with nine current series. These series may be new research volumes or collected works; some have new titles only every few years. Annals of Mathematics Studies has been published for almost eighty years by the press, and is now available with some of their other series through the publisher DeGruyter. Their non-series titles are mainly for general science readers, with several offered annually. They also publish textbooks for undergraduates and graduate students. One outstanding book in their catalog is the classic *Princeton Companion to Mathematics*, mentioned previously in Chapter 1.

Commercial Publishers

Springer, http://www.springer.com/mathematics. Springer, the foremost commercial publisher in mathematics, has historically been the strongest publisher in the field and is highly respected by mathematicians. Springer publishes over 500 titles annually and has almost 100 book series in mathematics, including the important title Lecture Notes in Mathematics. Between eighty and ninety textbooks are published each year, often in series such as Undergraduate Texts in Mathematics and Graduate Texts in Mathematics. Springer will also publish a few large reference works every year, such as handbooks and encyclopedias. Most of their books are published in English, but a sizeable minority (especially historic volumes) are in German and occasionally French or Italian.

Their Springer Book Archives offer online access to their extensive historic collection (dating from 1842 to 2005) as e-books, which is especially beneficial to mathematicians but may not be affordable for all libraries. Springer also publishes the Kluwer and Birkhauser imprints, and these may be excluded from their large book packages. Presently, electronic access to *Lecture Notes in Mathematics* can only be purchased as part of a package with other electronic math books. Similarly, the important *Lecture Notes in Computer Science* is essential for the field of computer science, as there is overlap with math, but it is sold as part of a different collection. The cost of these packages is significant and for many, unavoidable, but it may be possible to get a series either as a subscription or one-time purchase for perpetual access. The backfiles are also available in sections divided by decade and subject.

One of the nicest features of Springer's e-books is that patrons have the option of paying a minimal fee ($24.99 in 2019) for a personal print copy of any electronic book that the library has purchased. These books are regularly assigned as class texts as well. In a field like mathematics, this is a useful and popular way to address both the needs of our users for different formats and the space constraints of many of our library spaces.

World Scientific, http://www.worldscientific.com/page/mathematics. World Scientific is a publisher that began in 1981 as a small house in Singapore but is now international. They publish seventy-five series in mathematics with about 100 books annually. Though they started publishing mainly advanced research monographs, the publisher has diversified into a wide range of topics including pure and applied mathematics and mathematics education. Their authors had typically been from Asia, but now include European and American authors and institutions. Though not everything from World Scientific is of the highest quality, the quality of the proofreading and editing has improved with time and their works can increase the depth of a collection. They publish some series based on mathematical awards, such as the Fields Medal and Wolf Prize, which are mainly reprints. All of their titles except textbooks are available in electronic format, either through their own platform or third-party e-book vendors.

Wiley, http://www.wiley.com/mathematics. Wiley publishes research monographs and textbooks in mathematics, some through their Wiley-Blackwell imprint. While they have a stronger focus on statistics, there are a number of books for pure or applied mathematicians including five notable series: Pure and Applied Mathematics, Probability and Statistics, Statistics in Practice, Computational Statistics, and Discrete Mathematics and Optimization. Wiley is not necessarily a major publisher in mathematics. While Wiley's book quality is good, the frequency of math title publication is low; however, it can be a source of additional books in a particular mathematics topic. The Wiley Online Library provides access to their e-books with book chapters as unrestricted PDF files.

Elsevier, http://www.elsevier.com/physical-sciences/mathematics. Despite being a large STEM publisher, Elsevier publishes less than fifty books in the mathematical sciences annually (although their editors visit university campuses frequently as part of an effort to increase the number of books in mathematics they publish). Elsevier also owns the imprints Academic Press and North Holland. Despite having less than a dozen book series, some are important to the field such as the North Holland Mathematical Library. Their monograph catalog includes textbooks and a few popular mathematical titles, but focuses primarily on research materials. E-books are available through ScienceDirect as a frontlist each year in the math subject collection, with backfiles for previous years. The Heritage Collection of books dates as far back as 1580, which may be of particular interest to those studying the history of math and science.

Elsevier has had a troubled relationship with mathematicians, primarily due to the high costs of their journals. Since 2006 when the editorial board of *Topology* left to establish a new journal, mathematicians have had a negative view of the publisher. As mentioned in Chapter 3, in 2012 Tim Gowers organized a boycott of Elsevier by mathematicians who wrote, refereed, or edited for Elsevier journals. Despite many concessions from the publisher, such as making most of their pre-2008 journal articles OA in addition to other policy changes, there is still a stigma associated with Elsevier among math faculty. Librarians should beware that title changes and other gaps may exist in Elsevier math journal runs.

De Gruyter, http://www.degruyter.com/mathematics. De Gruyter annually publishes about sixty books in mathematics, and along with partner presses has over thirty book series. Their most significant series are De Gruyter Studies in Mathematics and Expositions in Mathematics. The majority of their books are published in English, but almost a quarter over the last ten years were in German. A few of their books are used as textbooks in undergraduate and graduate classes.

Taylor & Francis, http://www.taylorandfrancis.com. Formerly a small publisher, Taylor & Francis has grown through many acquisitions of other publishers. They have the large science and engineering book catalog of CRC Press, which includes hundreds of reference books and textbooks. The Routledge imprint also publishes a few books annually in mathematics.

FREE ONLINE BOOKS

Users may have the expectation that the full text of most items is available online, and are frustrated that books under copyright are not freely available. Most books published prior to 1923 are in the public domain, meaning online versions can often be downloaded in their entirety for free. As noted previously, mathematicians often find older works useful and many classic mathematics texts are in the public domain. The following are platforms for accessing free, public domain books online.

Google Books, http://books.google.com. In the past decade, the Google corporation has partnered with libraries to scan their book collections for digital preservation and access. Google makes titles in the public domain accessible via its Google Books platform, and is sometimes allowed to display "snippets" or excerpts from those that are still under copyright. These snippets can be useful for finding a particular theory, portion of a proof, quote, or definition.

Hathitrust, http://www.hathitrust.org. Hathitrust is a partnership of libraries that curates the large-scale digital collection resulting from various scanning initiatives, including Google Books and the internet Archive, and includes unique special collections materials. For works that are not completely accessible, users may utilize Hathitrust to confirm citation information by searching in the full text of these books.

COLLECTION DEVELOPMENT TOOLS

Approval Plans

Approval plans specify the books that a library receives automatically from a book vendor, sometimes called a "book jobber." Librarians meet with a vendor representative to develop book slips (formerly print, now electronic), exclusions, and automatic ordering criteria. These criteria include classification range, book type and price, publisher, and series. It is a good idea to review your approval plan immediately when starting a new liaison position, since it contains details of past collecting patterns. You should also review your approval plan regularly with your vendor representative. Publisher changes or large-package purchases made by the library as a whole may have an impact on your plan. Some approval plans can also generate regular alerts when new books are published. These are useful for both librarians and key users who may identify books for purchase.

In mathematics, approval plans can help librarians acquire books from many of the main commercial publishers as well as most academic presses. There may even be small publishers handled by a robust approval vendor. There are some publishers you will want to exclude due to poor editing quality (Nova Science) or because they primarily publish reprints (Dover). Especially in mathematics, where books are kept longer by libraries and reprinted often, reprints should not be purchased automatically. Another type of material to review prior to purchase are *festschrifts*, which are collections of articles in honor of an individual. These may already be available to patrons through journal subscriptions or the previously printed versions of the individual articles.

Because many mathematics publishers will identify individual books or series as "textbooks," some approval plans will mark these in a textbook category that may be excluded from the approval plan. Math librarians should remove these blanket exclusions so as not to overlook miscategorized research monographs or textbooks for course reserves. One way to receive book series is to have a standing order with the publisher, but an approval plan is an alternative.

If the library annually purchases large e-book collections, approval plans in those subjects should exclude books from those publishers to avoid duplication. Math librarians may still get requests from some faculty for print versions of e-books that were previously purchased. It is unwise to rely on leased or aggregate e-book collections instead of print books, but they can be an occasionally useful supplement to the collection.

There is some overlap between math and other subjects within approval plans due simply to the call number ranges. In LCC, computer science is embedded in the math range, but most approval vendors will separate it out. This is not a problem if math and computer science are the responsibility of one librarian. It is a good idea to consult with engineering librarians, and occasionally other science librarians, on applied mathematics books or other interdisciplinary topics. Be aware that logic books may be classed in philosophy (LCC: B) since they may be more popular with logicians than philosophers.

Patron-Driven and Demand-Driven Acquisitions

For a variety of reasons, many libraries are moving towards building collections through patron-driven acquisitions (PDA) programs (also known as demand-driven acquisitions), which rely on the purchasing of materials directly requested by patrons. These items may be discoverable through the online catalog, or by use statistics collected from e-book collections. Some libraries also track interlibrary loan requests and database link redirects to inform acquisitions. Whether through a formal program or via link redirect statistics, the goal is for the collection to reflect the needs and interests of the patrons.

Mathematics has not been significantly affected by PDA, since most of the society and commercial publishers do not publish with this model. There are some textbooks and study manuals that are available through PDA, and math librarians can leave the purchase of these relatively inexpensive books to their patrons. Occasionally there may be duplication between print and e-books, but since mathematicians and students still largely prefer print there is more benefit than cost in that case.

Book Reviews

Book reviews are very helpful tools for making informed collection decisions, particularly in a complex subject like mathematics. Luckily, mathematics publishers have a tradition of including book reviews in the core journals in the field. They are often written by mathematicians whose authorship is indicated in the review (a "signed" review), and can range in length from short (under 500 words) to medium (500-1500 words) to very long (3000+ words). These book reviews are most commonly found in mathematics education journals, review journals, or general-interest research journals. Although there are now other methods of discovery including online book retailers and internet search engines, book reviews in journals can be a great way for both mathematicians and math librarians to find new books to purchase. Below is a list of core journals with the type and length of book reviews featured in each issue. For a more exhaustive list, please see the mathematics chapter of *Magazines for Libraries* (LaGuardia and Katz 2018).

- *American Mathematical Monthly* (1-2 medium, signed book reviews)
- *Bulletin of the American Mathematical Society* (4-8 very long, signed book reviews)
- *College Mathematics Journal* (1-2 medium, signed book reviews)
- *Mathematical Gazette* (10-25 short to medium, signed book reviews)

- *Mathematics Magazine* (6-8 short book reviews)
- *Mathematics Teacher* (5-10 short, signed book reviews)
- *SIAM Review* (5-15 short, signed book reviews)

Most of the journals above are now available electronically, which makes it easier to regularly check for new book reviews. The index *MathSciNet* (covered in depth in Chapter 5) is very important for collection development, since it includes reviews of almost every math book published. These reviews, written by mathematicians, tend to highlight important proofs and information rather than focus on the quality of a book. Another great source for book reviews is *MAA Reviews* (https://www.maa.org/press/maa-reviews), a large database of books and book reviews. It includes the MAA's list of books recommended for undergraduate libraries, which is useful for collection development. Access requires either a MAA membership or a subscription. *MAA Reviews* also posts new book reviews on Twitter using the handle @maareviews.

Major Prizes

It is useful for the mathematics librarian to track major prizes in math in order to collect the most vital works in the field, as many popular mathematics books focus on a major discovery or award. Some prizes are given for a particular discovery, which may be tied to one or more specific research papers. Others are given for excellence or promise in a particular area of mathematics. Collected papers of math prizewinners are often published as books in the years following the award. Some publishers, such as World Scientific, have also gone back into the past and collected the papers of one or multiple prizewinners. The following are the most prestigious prizes in the field of mathematics.

Fields Medal, https://www.mathunion.org/imu-awards/fields-medal. Established by the International Mathematical Union in 1924, the Fields Medal is awarded every four years to one or more mathematicians under the age of forty (Albers 1987). It is the longest established award in mathematics and the most notable, although it does not have the same high monetary value as the Nobel Prize. Since there is no Nobel Prize in mathematics, this is the oldest and most prestigious award in the field (Meier 2012).

Wolf Prize in Mathematics, http://www.wolffund.org.il. This prize has been awarded by the Wolf Foundation in Israel since 1978.

Abel Prize, https://www.abelprize.no. Established by the government of Norway and modeled after the Nobel Prize, the Abel Prize was first awarded in 2003.

Millennium Prize Problems, http://www.claymath.org/millennium-problems. There are six, previously seven, unsolved problems in mathematics whose solutions carry a cash award and international recognition.

Elsevier awards a number of prizes associated with their journals, which are intended to support young researchers in the physical sciences and mathematics. Arising from the boycott mentioned previously, they include a monetary award to support publishing of research. https://www.elsevier.com/awards.

INTERNATIONAL PUBLISHERS

Mathematics may seem at first glance to be a universal language of numbers and symbols, but in practice mathematicians communicate in words. English is the current *lingua franca* of mathematics, taking over from German, which replaced Latin and Greek. Russia and France have also been historic powerhouses in mathematics, so many classic texts are in those languages. Though mathematics books are still published in many non-English languages, even international scholars will ask for English language translations over versions in their native language due to the universality of English. An exception may be special, unique collections of non-English-language mathematics books. While many books and research articles published internationally are in English, there are venues for ordering foreign-language materials and publications from smaller international presses, some of which are listed here.

Harrasowitz, https://www.harrassowitz.de. Harrasowitz is a book and periodical vendor for academic libraries specializing in materials from Germany, Austria, and Switzerland. Their service, OttoEditions, provides regular updates on new publications based on parameters set by the library. In mathematics they cover research monographs from the main European publishers like Springer and the EMS, but may also include smaller press titles that are not covered by US approval plans and book vendors. Different types of books including conference proceedings, research monographs, and occasionally textbooks are included. Books may be in German or English or contain multiple languages, and this is indicated on the notices Harrasowitz provides. E-book availability is noted separately for books available in multiple formats.

Casalini Libri, http://www.casalini.it. Casalini Libri is an Italian book vendor for academic libraries which regularly handles a few titles in mathematics. Their monographs are primarily in Italian, but a few are published in English or in multiple languages. Many of their titles are the proceedings of conferences or workshops in Europe, but there are a few textbooks and dissertations handled as well.

D.K. Agencies, http://www.dkagencies.com. D.K. Agencies is a South Asian book vendor that focuses on India but also includes titles from many surrounding countries. They offer e-mail or paper notifications for mathematics titles, though sometimes books on physics or other STEM titles may appear on this list. Most of these books are not available through other vendors or approval plans.

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TOP TEN DAILY SOURCES OF MATH

1. xkcd webcomic (http://xkcd.com)
2. FiveThirtyEight (formerly Nate Silver's blog) (http://fivethirtyeight.com)
3. Scientific American (http://www.scientificamerican.com)
4. I Love Science (https://www.facebook.com/IFeakingLoveScience)
5. Science Daily—Math (http://www.sciencedaily.com/news/computers_math/mathematics)
6. Reddit—Science (filter by field for Mathematics) (https://www.reddit.com/r/science)
7. Math Overflow (http://mathoverflow.net)
8. AMS Math Digest (http://www.ams.org/news/math-in-the-media/mathdigest-index)
9. Bedtime Math (http://bedtimemath.org)
10. Twitter—hashtags #math, #maths, #mathematics, #mathchat, and more

five

Journals and Other Resources

Mathematics does not require laboratories or equipment . . . it will be impossible to maintain a first class research mathematics department . . . with a third class library. (University of Oregon mathematics department letter to library dean, 2009)

In this chapter, we will focus on subscription and licensed materials including serials, databases, and software. We discuss commercial indexes and abstracting services, but also include some freely available sources. While Google Scholar and ArXiv are increasingly used by mathematicians and students, there are a few math-specific databases that are still valuable for their unique and curated metadata. Journals are covered to help librarians manage their subscriptions to print and electronic serials. Finally, the chapter will close with a highlight of some of the field's widely used software, both free and licensed.

SCHOLARLY COMMUNICATION IN MATH

A good background on the history of scholarly communication in math is Bartle's "A Brief History of the Mathematical Literature" (1995). The lifecycle of math research often begins in peer collaboration, partnerships with graduate students, or during local discussions called seminars. It may evolve to presenting a sketch of a proof or theory at a conference, often with no more than an abstract having been written. Presentations often lead to full-length publications in either a journal or book, though any step in this process may not happen at all. The most valued academic product in mathematics is the peer-reviewed research article in a prestigious journal. Depending on the branch of mathematics, the research publication process may have more in common with that of the most closely associated discipline. For example, applied mathematics may involve lab work that leads directly to a journal publication, while a lecture or seminar in theoretical computer science may eventually be published as a book chapter. The resources in this chapter support the process of information discovery and publication of research.

As journal costs rise almost every year, lower-income-generating departments like math can see heavier subscription cancellations. In addition to their support of arXiv, several math journals have moved from for-profit publishers to much lower-cost alternatives. Most recently, this happened with the *Journal of K-Theory* (k-theory is a subset of algebraic topology). The entire editorial board resigned and started the journal *Annals of K-Theory* at a fraction of the cost.

Open Access

Mathematicians are staunch advocates for open access, which aspires to make the products of scholarly work free for all to read. Some OA publishing models shift the costs of scholarly publishing to authors, which is a significant deterrent. Mathematicians typically do not have the large research grants of other STEM faculty to cover author fees. In support of our math departments, it has become increasingly important for libraries to advocate for OA initiatives either by joining consortial partnerships such as arXiv, negotiating lower author fees, providing author funds, or supporting new funding models for journals. Recent trends suggest that more math publishers are softening their positions toward the idea of open access.

INDEXES TO THE PERIODICAL LITERATURE

There are only a few bibliographic databases used in mathematics, so it is easy for the math librarian to focus on licensing and teaching these core resources. They are also relatively low cost compared to other abstracting and indexing databases in the sciences and engineering. Librarians should balance the costs and benefits of each indexing database in light of the available full-text searching systems, including library discovery search engines. While most mathematics journals will be indexed in these systems, it is hard to focus the results on only the math literature. Indexing and abstracting databases may also have controlled vocabulary, higher quality metadata, and greater historical coverage.

MathSciNet, http://www.ams.org/mathscinet. MathSciNet is one of the most frequently consulted databases that librarians teach to students in mathematics (Brown 1999). Researchers in pure mathematics and certain other fields find it particularly useful because of its focus on the math literature, while excluding other STEM and humanities journals. It is based on the AMS' *Mathematical Reviews* serial publication, which began in 1940. In addition to being the primary index of the mathematics literature, MathSciNet provides reviews of journal articles and books. These reviews summarize the key research findings of a paper or book and may even contain links to related entries in MathSciNet. Full-text articles are linked to publisher websites and a library link resolver can be added. It now contains citation information as well, which enables citation-based exploration. Each journal indexed also has an impact rating called the Mathematical Citation Quotient (MCQ).

At press, MathSciNet indexes almost three million items, 750,000 authors and 1,800 journals. It uses the Mathematics Subject Classification with over 6,000 categories, which was last updated by the AMS in 2010 in collaboration with zbMATH (see next section). It has accomplished author disambiguation since its founding and has detailed author pages that include all alternate names, publications, citations, co-authors, and other useful data. MathSciNet terms have been used to code data for archiving and preservation. The AMS has added links to historic math books, many of which are freely available online due to library digitization projects. They continue to partner with other mathematical societies to bring additional citations and full-text links into the system (Dunne 2015). The AMS employs many librarians and metadata experts to keep up with new publications. The blog *Beyond Reviews* (http://blogs.ams.org/beyondreviews) provides news on MathSciNet, including historic background information and current updates.

zbMATH Open, https://zbmath.org. This long-running indexing service began as "Zentralblatt für Mathematik und ihre Grenzgebiete" in the nineteenth century. Now known as "Zentralblatt MATH," it is an online database with about four million records, indexing over 3,000 journals and 180,000 books. Similar to MathSciNet, it uses the Mathematics Subject Classification (MSC) scheme, links to full text and citation information, and provides summaries of each article. It should be noted that because the two databases use MSC independently, search results may vary in some cases. The summaries in zbMATH tend to be a discussion of the article rather than a review of the mathematics. Although summary contributors are international, the summaries and metadata are in English.

Web of Science, http://wokinfo.com. Web of Science is considered an authoritative source for measuring research impact and determining citation information, though it is not used in the mathematics community as often as in other fields. Since Web of Science only indexes a core set of "premier" journals, it may exclude journals that mathematicians would want to include in a literature search (such as *Annals of Mathematical Logic*). However, if graduate students or math researchers are looking for the top papers in the highest-ranking journals in math, this database is very useful.

Scopus, http://www.scopus.com. One of the newest citation databases, Elsevier's Scopus database can also be used to search journal articles (and some conference papers) by title, author, citation count, or the citation network of recent articles and foundational papers. Scopus has some advantages over Web of Science for mathematics, since it indexes many more sources. However, since Scopus is a newer system, the majority of journal data is from the past decade or two. Elsevier is continually adding historic coverage of journal issues but this varies by title; some math journal coverage starts in the 1970s while the majority start in the mid-1990s. Few libraries can afford both Scopus and Web of Science, so many may have one or the other. It would be important to distinguish if a local math department has a preference.

Google Scholar, http://scholar.google.com. Google Scholar is Google's index of what is referred to as "scholarly literature." It has become increasingly useful in mathematics since it indexes many articles through arXiv. It also indexes books from the Google Books project, particularly older materials, so mathematicians benefit more than many other disciplines from the mix of scholarly literature included here. Citation information from Google Scholar can be very beneficial, since it includes talks and proceedings from mathematics conferences as well as books and journals. Some mathematicians have set up Google Scholar profiles to highlight their work, but author searching can be difficult with common names. For collection development, Google Scholar can help you find books and journals that have poor citations, give you multiple paths for locating full-text resources online, and provide links to libraries and vendors that own or sell a particular resource.

ERIC, https://eric.ed.gov. The Education Resources Information Center (ERIC) database is often a part of the library's database collection for education majors and teachers. Mathematics students researching teaching and pedagogy and faculty searching for information on effective teaching methods and best practices may also find ERIC useful. The database contains other education-related topics and publications, for example magazines published by the National Council of Teachers of Mathematics.

PREPRINTS AND OTHER GREY LITERATURE

A preprint as defined here is an author's early version of a research paper prior to submission for peer review to a scholarly journal. Even before the prevalence of online preprint repositories, math faculty have practiced the sharing of early manuscripts. Mathematicians often loaded their articles onto their own personal or departmental websites, sharing drafts and finished papers and even publishing preprint series of their own, such as the University of Reading *Applied Mathematics Reports* (https://www.reading.ac.uk/maths-and-stats/research/maths-appliedrpts.aspx). Now many institutional repositories (IRs) and disciplinary repositories (such as arXiv) host preprint articles. Mathematicians are often willing to share their research findings as early as possible to establish primacy for an idea, proof, or theory. This can result in multiple versions of a paper existing in some form, whether that be a blog, preprint, or published article. The final journal article is still considered the publication of record, but the preprint may already have achieved high recognition. Preprints are often shared widely, often via Wikipedia, online science news outlets, or Google Scholar.

It is possible that a popular preprint may be significantly rewritten for journal review, or not at all. One example of the latter is Perelman's proof of the Poincare conjecture. As mentioned in Chapter 3 it was only ever published in preprint form, but was reviewed and cited by multiple papers published in journals, including corrections to a number of trivial errors.

Publishers are also increasingly cautious about duplicate submissions in order to avoid deliberate or inadvertent self-plagiarism. Each publisher or journal may have a different policy related to the author's dissemination of copies or preprints. Publisher policies may only allow the preprint to be shared on certain websites, like an IR that the author's home institution has set up to store faculty works. Other policies may only allow this after a certain period of time has passed. Faculty may consult with librarians before sharing an article to determine what their copyright agreement allows. A good resource to determine publisher and journal policies for most English language materials is the SHERPA/RoMEO database (http://www.sherpa.ac.uk/romeo.php).

arXiv, https://arxiv.org. Second only to physics in volume of articles, mathematics is the fastest-growing subject in the arXiv preprint repository. Since the site launched in 1991 authors have been submitting articles to arXiv prior to journal review, though many are eventually published in peer-reviewed journals. arXiv strongly appeals to mathematicians because they value early public sharing of their discoveries and have few reasons to keep discoveries secret (for example, the proof of the Poincare conjecture mentioned previously). ArXiv provides the benefit of immediate publication, while a paper may take months or years to make it through the peer-review cycle. ArXiv is free to use but is supported by Cornell University Libraries and annual contributions from many other libraries. There are some questions about the sustainability of this funding model, but it has worked so far. The results of the arXiv@25 survey suggest further enhancement of the platform is needed for stability and improved search functionality (Rieger 2016).

JOURNALS

The number of peer-reviewed journals in mathematics has been growing for centuries. Despite not growing as rapidly as some STEM fields like chemistry, the number of articles and journals in math doubles every decade (Larsen and Ins 2010). This explosion has increased the number of possible publication options for research, but also presents new challenges. It is hard for busy mathematicians to track new journals and determine their quality and editorial oversight. One emerging role for math librarians is to vet journals that invite faculty as potential authors or editors. Journals with little editorial oversight that exist primarily to collect author fees are sometimes called "predatory" journals. Some services and websites with information on journal reputation exist, such as *Ulrich's Periodicals Directory* (http://www.ulrichsweb.com/ulrichsweb/faqs.asp), Cabells' *Journalytics* and *Predatory Reports* (https://www2.cabells.com), and the ThinkCheckSubmit project (https://thinkchecksubmit.org). The Retraction Watch project (http://retractionwatch.com) can also help authors spot systematic problems with a publisher or journal.

Mathematicians can also proactively protect their reputations by scanning for their names on the editorial boards of journals—some librarians have discovered instances where faculty did not realize their name had been associated with a journal without their permission. Plagiarism has also become an issue, particularly with international journals where the language difference can make copying difficult to detect. There are many other nuances of math journal publishing; for more detail see the excellent review from a workshop on the topic in 2011 at the University of California-Berkeley (Crowley et al. 2011).

New faculty in mathematics will often ask which journals are the most prestigious in the field, since promotion and tenure criteria still take into account the reputation of the journals in which their research is published. Some may also ask about the impact factor, which can be found on the journal website or from *Journal Citation Reports*, or the acceptance rate, available either from the journal website or by contacting an editor. Another new role for librarians is helping math faculty launch journals. Either the library or university itself may be a journal publisher or, more likely, the library may help faculty find either funding or software, such as Open Journal Systems (https://pkp.sfu.ca/ojs), to support a new journal.

Magazines for Libraries, mentioned in Chapter 4, provides an overview of the core research and general interest journals and magazines in mathematics. Published annually as both a large single volume work and an online database, it covers many of the titles listed in this chapter in greater detail and provides information on the topics they cover and their appropriateness for local math departments. Another way to find information about journals is the AMS Digital Mathematics Registry (http://www.ams.org/dmr), which lists electronic journals and series. It provides the years available by journal title or publisher and uses a symbol to indicate whether a resource is open access, subscription access, or a hybrid of both. Librarians can use it for quick reference in making decisions about format type when selecting journals or for considering what to do when weeding or storing older journals. A similar source for digitized books is the Bielefeld DML: Digital Mathematics Library (https://www.math.uni-bielefeld.de/~rehmann/DML/dml_links.html).

Only the major publishers in mathematics are listed here, but there are many smaller publishers in the field including small societies and university presses. Project Euclid (http://projecteuclid.org) is a platform for small publishers in mathematics and statistics that is jointly supported by the Cornell Library and Duke University Press. Some Project Euclid partner publishers require a print subscription to gain online access. There are also a few smaller publishers and societies in mathematics that do not yet make their journals available online. In addition to mathematics-focused publishers, many of the large aggregators like ProQuest and EBSCO include a core set of mathematics magazines and journals. If you are at a library with a small budget or no set budget for math, explore which aggregators provide the most access to journals that fit into the teaching and research areas of the local math department. Every librarian should focus on a few key journal subscriptions to balance out the content in the general article databases leased by the entire library.

Math journals can be classified into two major types: general "flagship" journals that publish from all areas of mathematics, and specific journals that focus on one field. Below are examples of some of the best flagship journals, as well as important journals in some of the major fields of mathematics. With mathematicians there is not much consensus about which journals are essential, since they focus on very specific fields. In a recent survey of faculty at one institution, a librarian found that many respondents held similar views regarding which prestigious journals are most essential; however, between faculty in different research groups there was little agreement about the most crucial journals. In other words, while there is consensus on important journals for mathematics in general, the most important journals for any individual mathematician are based on his or her research focus. Citation studies within a single institution show that the top-cited journals by faculty include flagship journals as well as some journals focused on a specific field, mostly due to the focus of the mathematics department on a certain field.

Bibliographic studies have also indicated a wide reading selection by mathematicians. For example, a large math faculty at a research university will cite hundreds of different journals. The list below is by no means comprehensive, but is included to give readers a sense of the diversity of journals, both general and specialized, that are useful to mathematicians and students.

General Science Journals Core to Mathematics

The preeminent journals listed below are desirable venues for mathematicians to publish their research results when the theories or methods discussed could have an impact beyond mathematics. These general science titles are also read and cited by mathematicians more than any other non-math journals.

- *Nature* (Springer)
- *Proceedings of the National Academy of Sciences* (US National Academy of Sciences)
- *Science* (American Association for the Advancement of Science)

Flagship Journals in Mathematics

These journals are core to any mathematics collection, as they are used by almost every branch of math. Each has a broad scope and general readership, though any given article may fit in a small niche area of mathematics or only be understood within a particular branch. Most mathematicians will read these journals and many want to have their research published within them. The *Bulletin of the American Mathematical Society* is very useful for undergraduate students looking for topics in math.

- *Advances in Mathematics* (Elsevier)
- *Annals of Mathematics* (MSP)
- *Bulletin of the American Mathematical Society* (AMS)
- *Communications on Pure and Applied Mathematics* (Wiley)
- *Duke Mathematical Journal* (Duke University Press / Project Euclid)
- *Inventiones Mathematicae* (Springer)
- *Journal of the American Mathematical Society* (AMS)

Top Ten Math Journal Publishers

The following are publishers that produce the largest number of math journals annually (listed alphabetically).

1. AMS
2. Cambridge University Press
3. Elsevier
4. International Press of Boston
5. MAA
6. Mathematical Sciences Publishers (MSP)
7. SIAM
8. Springer
9. Wiley
10. World Scientific

- *Proceedings of the American Mathematical Society* (AMS)
- *Transactions of the American Mathematical Society* (AMS)

Journals Particular to Certain Areas of Mathematics

Librarians should consider these journals only if faculty or students are doing research in these specific areas. Only a few areas of mathematics are covered here, though there are dozens of journals for each specialized area of study. Within each area, the titles were chosen to represent the diversity of publishers and platforms.

APPLIED MATHEMATICS

There are many titles not in this list that are published by SIAM, notably *SIAM Review* which broadly covers the field and provides some digest summaries of articles from other SIAM journals.

- *Advances in Applied Mathematics* (Elsevier)
- *IMA Journal of Applied Mathematics* (Oxford)
- *Journal of Applied Mathematics* (Hindawi)
- *SIAM Journal on Applied Mathematics* (SIAM)

COMPUTATIONAL MATHEMATICS

Also useful for computer scientists and some engineers, these journals publish papers dealing with computer algorithms, computer optimization, and even statistics.

- *Applied Mathematics and Computation* (Elsevier)
- *Foundations of Computational Mathematics* (Springer)
- *Mathematics of Computation* (AMS)
- *SIAM Journal on Computing* (SIAM)

DIFFERENTIAL EQUATIONS

Journals in this area cover fields such as dynamical systems, mathematical physics, and other applied mathematics, but may also include pure mathematical papers.

- *Dynamics of Partial Differential Equations* (International Press)
- *Journal of Differential Equations* (Elsevier)
- *Journal of Differential Geometry* (International Press)

LOGIC

Similar to the discipline of philosophy within the humanities, mathematical logic is one of the purest divisions of mathematics. It also has applications in computer science and many other mathematical fields. One of the major professional societies in this area is the Association for Symbolic Logic.

- *Annals of Pure and Applied Logic* (Elsevier)
- *Bulletin of Symbolic Logic* (Cambridge University Press)
- *Journal of Symbolic Logic* (Cambridge University Press)
- *Journal of Mathematical Logic* (World Scientific)

MATHEMATICAL ANALYSIS

Advanced uses of calculus comprise the field of mathematical analysis, which is considered a subfield of pure mathematics but may have some practical applications as well.

- *Geometric and Functional Analysis* (Springer)
- *Journal of Functional Analysis* (Elsevier)

MATHEMATICAL PHYSICS

These titles primarily focus on the applied mathematics subfield of mathematical physics. They are often published by commercial publishers or professional societies in physics, such as the American Physical Society (APS). For additional titles, consult *The Sudden Selector's Guide to Physics Resources* (Fosmire 2013).

- *Communications in Mathematical Physics* (Springer)
- *Journal of Computational Physics* (Elsevier)
- *Physical Review Letters* (APS)
- *Proceedings of the Royal Society A: Mathematical, Physical, and Engineering Sciences* (Royal Society)

TOPOLOGY

This is a field of pure mathematics that studies the properties of space when it is deformed or transformed.

- *Annals of K-Theory* (MSP)
- *Journal of Topology* (London Mathematical Society)

Other Institutional Memberships

As mentioned in Chapter 3, it is possible for a library or math department to become an institutional member of a mathematical professional society. Benefits can include discounts on publications, access to databases, and memberships for math faculty and students. Librarians should inquire if the math department is an institutional member of any societies, and who pays the membership fees. Details the library and department may wish to negotiate include which organization pays for the membership, who acts as the official contact to the professional society, and who receives copies of print journal issues. In some cases, the library may be able to receive complementary journal subscriptions through a math department membership. Be aware though that in the case of electronic journals, the terms of membership may limit online access only to members of the math department.

One great icebreaker when meeting new faculty is to ask about their professional memberships in societies. In small professional societies, even international ones, it is likely that these faculty know how these "publishers" really operate and the history behind the associations. They may even be involved in the publishing activities of the society or be a current or prior editor, leader, or officer. In one example, when a librarian asked a faculty member why electronic access was not available for a certain professional society's publications, it was revealed that the three journals were published by a single person from their home.

Math faculty and students may also have membership benefits that could save the library money. For example, if there is only one logician on campus who is already a member of a society in mathematical logic that publishes a journal, they may receive a free copy and online access. The library does not need to subscribe to that journal if there are no other users who need it. For multiple faculty, graduate students, or even undergraduates who are studying in a particular field, it makes more sense for the library to provide access to the publications of relevant societies either through subscription or institutional membership. In some cases, an institutional membership will include free memberships for students or faculty. Investigate if this is the case and work with a contact in the department to help determine who benefits from the complimentary memberships, because it could be for the department alone rather than the entire institution.

Journal Exchanges

There are sometimes standing agreements between libraries at different universities, known as "journal exchanges." These usually involve a library sending extra issues of a print journal, obtained through multiple subscriptions, to an international university in exchange for issues of an international journal from that country. These arrangements were important when it was difficult to obtain international journals or subscribe to foreign journals, but may no longer be necessary as journals have gone online and political barriers have changed significantly, removing prior postage and shipping difficulties. Math librarians should regularly review such exchanges to determine whether they should continue. One reason to continue an exchange would be logistics; for example, there may be journals that are still difficult to obtain through a subscription with a publisher or journal aggregator.

GENERAL SOFTWARE

Occasionally the cost of mathematics software licenses may be assigned to library collections or operating budgets, though they can be expensive. In some cases central library or campus-wide software funds are available, and these are worth investigating. The math department or central IT may provide the software in their labs or give students and faculty a discount on purchasing it. The following programs are used by mathematicians in various fields and might be useful to have available to patrons.

LaTeX, http://www.latex-project.org. LaTeX is a markup language and document creation software system that makes it easy to type mathematical symbols as text for constructing papers in math. Similar to XML and HTML, markup tags are used to indicate formatting, metadata, and interpretations of codes representing mathematical symbols. LaTeX was developed in the early 1980s when postscript files were required by printers and typewriters were still in use. Based on the TeX typesetting system, documents are compiled from multiple files including "libraries" of additional information such as BibTeX (see below). While LaTeX was historically difficult to learn there are now web and graphical user interface (GUI)-based clients for LaTeX, though many mathematicians and other scientists still use the open source version of the software. The open source version of LaTeX is available for Linux, Windows, and Mac OS.

Though originally developed for the fields of computer science and mathematics, many other sciences and engineering researchers use LaTeX for document preparation. Many journals require submission of articles in LaTeX format (Olver 2011). It is an acceptable file format for submission of scientific papers to ArXiv and an increasing number of journals, including those of the AMS. As an underlying programming language, TeX has a large user base and many online communities such as the Comprehensive TEX Archive Network (http://www.ctan.org).

BibTeX, http://www.bibtex.org. BibTeX is a companion software to LaTeX for bibliographic management. It uses the ubiquitous ".bib" format for files, which contain a bibliography that can be linked to a ".tex" file. It has both platform-independent software interfaces (JabRef, http://jabref.sourceforge.net) and platform-specific programs (Mac OS BibDesk, http://bibdesk.sourceforge.net). Many citation managers and databases export or import to the BibTeX standard. Other bibliographic management tools (i.e. RefWorks, EndNote, Mendeley, Zotero, and Papers) can synchronize with and import or export to BibTeX. It is worth understanding that once again mathematicians will be outliers, as they tend to rely on BibTeX instead of those other products.

One noteworthy collaborative project based on this open platform is Overleaf (https://www.overleaf.com). It allows for planning, working, and online publishing in real-time using LaTeX. The local math department or institution may have a membership, which would make it free to all users. Similarly, Collaborative Calculation in the Cloud (https://cocalc.com) works with LaTeX and is great for collaboration. There are also LaTeX templates available for theses and dissertations. It is often used for teaching courses using Jupyter Notebooks (https://jupyter.org), a free, open-source platform for creating and sharing code.

MATHEMATICS COMPUTATIONAL SOFTWARE

Libraries can provide their users with a number of licensed computational software packages for math, which engineers and mathematicians often use for their work. Campus IT departments may support these, or the library may need to buy licenses separately. Since each science or engineering user may have a need for any of these tools, the library should communicate with multiple academic departments on campus as well.

Mathematica, https://www.wolfram.com/mathematica/. Mathematica is a powerful math platform available as a desktop client or cloud-based interface. It focuses on computation and has both a simple interface and the ability to create programs. It has been used in computation of data from basic geometry to complex neural network modeling. It can be very difficult for libraries to install Mathematica on multiple computers, as the cost per license is high. The entire campus, engineering department, or math department may have separate contracts from the library. The vendor, Wolfram Research, requires different licenses based on number of users, which may be prohibitively expensive for some units. Wolfram Research also operates Wolfram|Alpha, mentioned earlier.

Maple, http://www.maplesoft.com. Maple is a simple programming environment where users can either enter problems using simple mathematical notation or program user interfaces and graphics for computation. While it has less functionality than Mathematica, Maple also has a simple user interface mode where students can simply build programs by clicking buttons. It can also visualize problems and compute large-scale algorithms.

MATLAB, https://www.mathworks.com/. Another computational software option is MATLAB, created by Mathworks. This software is based on matrix computations and has added a more visual interface, "Simulink," to its traditional scripting window, where programming commands are typed and executed. MATLAB can be used in signal processing, medicine, and even aerospace applications.

STATISTICAL SOFTWARE

Statistical software tools are developed by statisticians and can be applied in many fields. There is also growth in the use of predictive modeling in industry, so there is high demand in multiple academic departments on campus for the software and books that support it. Occasionally, user manuals are freely distributed by the software company as e-books, CDs, or promotional print materials. Investigate the software vendor's website to see if you can purchase these materials. Though adding them to the collection may not be the ultimate goal, doing so will put them directly in the hands of users. Be aware that there can be dramatic variations in functionality between different releases of software versions, so these books may become outdated more quickly than many mathematics books.

R, https://www.r-project.org. R is an open source system for statistical computing and visualization. Free to download and install on UNIX, Windows, or Mac operating systems, it is used pervasively in statistics and frequently in other STEM fields. Many textbooks and research monographs will include R code or examples and often include "R" in the title. It is essential that libraries collect titles that support this language, either as print monographs or e-books. Be aware that those books may be classified in computer software or computer science. Older R books can be useful for a long time since R code has not changed much over time, and new releases are developed with backward compatibility in mind.

SAS, https://www.sas.com/en_us/software/analytics/stat.html. Licensed software solutions for statistics such as SAS (Statistical Analysis System) often provide more of a GUI-based experience than their open-source counterparts. It is more important to update these books and manuals to the most recent edition, since the interfaces for these programs change more often than low-level programming interfaces such as R. SAS has a web- and Windows-based tool for analysis and visualization of data.

SPSS Statistics from IBM, http://www.ibm.com/analytics/us/en/technology/spss. Social scientists frequently use SPSS (Software Package for the Social Sciences) for population analysis, and it can even be useful for librarians performing user studies. The complexity of the GUI interface is customizable based on the expertise of the user. It is possible for the novice user to simply load files and perform tests, but the software also allows advanced users to manipulate the data directly in more complex ways.

Minitab, http://www.minitab.com. Minitab is frequently used in engineering and computing for analysis of data. The range of tests and analysis available within this one software platform is wide–it can go from simple classroom exercises to predictive analytics on big data.

MULTIMEDIA

Videos can make excellent additions to a mathematics collection. Depending on the library's patron base, this could include popular fiction movies such as *A Beautiful Mind* or nonfiction documentaries such as *The Story of 1*. Some of these videos may be purchased with public performance rights, so the library can show them at a movie night and lend them for classroom use. Streaming video versions of these films may also be available, and there may be videos in streaming video collections that include math topics.

There are also many online sources for free videos, some of which are created and hosted by libraries. One example is the Banff International Research Station for Mathematical Innovation and Discovery (https://www

.birs.ca/videos), which digitally preserves thousands of mathematics lectures from famous mathematicians. It has almost 3,000 items in the archive and each has a DOI (digital object identifier) and other metadata associated with the video.

Patents in Mathematics

Under US patent law, pure mathematical expressions such as a formula have been ruled unpatentable since they may be considered abstract ideas or laws of nature. However, applications of formula can be patented, such as software or processes based on algorithms. Depending on recent US case law, the line between pure mathematical algorithms and patentable inventions has shifted over time, so it is important to examine recent US patent law and court cases when doing background research in this area. A majority of mathematicians use copyright to protect their ideas by self-publishing them as early as possible, thereby establishing priority as the first person to solve a proof.

But there are mathematicians and statisticians with patents to their names. For example, James Z. Wang and others have a patent for an image-based CAPTCHA generation system, US Patent # US 7929805 B2. However, since software is one of the ways in which mathematics can be patented, the students and researchers most interested in patents will be those developing code. Most information sources on patents are freely accessible, since they are government documents. Google Patents (https://patents.google.com/), as well as the US Patent and Trademark Office, have free search engines that can be used to find mathematics patents and software (http://patft.uspto.gov/). The library can invest in the limited number of books on searching and applying for patents, which will benefit researchers in all fields, but otherwise librarians would do well to know how to do this, as there are not very many reference materials available.

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TOP TEN JOURNALS FOR MATH LIBRARIANS TO READ

1. *Issues in Science and Technology Librarianship* (http://istl.org)
2. *Science and Technology Libraries* (https://www.tandfonline.com/loi/wstl20)
3. *Notices of the American Mathematical Society* (https://www.ams.org/notices)
4. *Scientific American* (https://www.scientificamerican.com)
5. *CHANCE: Using Data to Advance Science, Education, and Society* (https://chance.amstat.org)
6. *College Mathematics Journal* (https://www.maa.org/press/periodicals/college-mathematics-journal/the-college-mathematics-journal)
7. *American Mathematical Monthly* (https://www.maa.org/press/periodicals/american-mathematical-monthly)
8. *Mathematics Magazine* (https://www.maa.org/press/periodicals/mathematics-magazine)
9. *College and Research Libraries* (https://crl.acrl.org)
10. *Online Information Review* (https://www.emeraldinsight.com/loi/oir)

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