Introduction to Mathematical Literature and Resources
UIUC Department of Mathematics
REU/REG0 Programs, Summer 2009

A.J. Hildebrand
hildebr@math.uiuc.edu

Version 7/16/09

1 Introduction

The first stage in any research project is to familiarize oneself with the "state of the art" of the problem one plans to investigate. This requires searching the mathematical literature for articles and books on the subject. There are hundreds of mathematical journals, and the number of mathematical papers that have been published is in the millions. Locating relevant articles in this maze of published research is a skill that has be learned and which requires a lot of experience. Fortunately, a number of resources, both printed and online, are available to facilitate literature search.

This lecture introduces some of these resources. Of course, there are also human resources that you should take advantage of: faculty advisors and others who are familiar with the area. For students working on a thesis, most of the pointers to the literature will probably be provided by their advisor, but anyone planning on a research career should learn how to do literature search on their own.

2 MathSciNet

By far the most important and most useful research tool for mathematicians is MathSciNet (`http://www.ams.org/mathscinet`), the online version of **Mathematical Reviews** (MR), a monthly publication containing reviews (summaries) of virtually every mathematical article of interest to research mathematicians and published in the past 60 years.

MathSciNet is a subscription-based service, but most universities have site licenses, and you should be able to access MathSciNet from your university account. The computers in UIUC Math Library have a direct link to MathSciNet from their homepages.

Some tips on using MathSciNet

- **Use full search mode:** The basic search mode has very limited functionality; full search is easy to use, and doesn't seem to be any slower than basic search.
- **Searches are case insensitive.** For example, you need not capitalize proper names.
- **Start out by specifying only one or two search terms.** If you get too many hits, you can always go back and add terms to narrow the search. If you are too specific, you may miss some relevant papers.
- **Use wild cards.** For example, to find papers dealing with digital sums, you might want to search with "digit* sums" in the "Anywhere" field so as to match both "digital sums" and "digit sums".
- **Use the "Anywhere" field for searches on particular topics or keywords.** This is the broadest type of search, and while it may yield too many hits, it is easy to narrow the search by specifying additional search terms in a second field. (To get a second "Anywhere" field, simply click on one of the other fields to pull up a menu of possible fields.)
- **Displaying a review.** Unless a search yields exactly one hit, the results of the search will be not the reviews themselves, but a list of citations to matching articles. To view the full review for a given article, just click on the MR number (a number like MR1419093 at the

beginning of the citation). To view the reviews of multiple articles among those cited, check the corresponding boxes, then click on "Retrieve marked" near the top of the screen. Alternatively, clicking on "Retrieve all" or "Retrieve first 50" will give you the reviews of all (resp. the first 50) cited articles.

- **Changing the display format.** By default, the review text is provided as TeX source. Thus, mathematical expressions are encoded in TeX, but with a modicum of TeX knowledge you should be able to figure out enough to determine whether the item is relevant and therefore worth pursuing further.

  If you find something that may be relevant and worthy of pursuing further, then select "pdf" in the "Choose alternative format" menu near the top of the screen, and click on "Go". This downloads the review in pdf format (you can change that to other formats, such as ps or dvi, but pdf is the most convenient), and (depending on your browser settings) will probably display it in Acrobat. You can then print the review from the File menu in Acrobat.

- **Access to original article.** Perhaps the most useful feature is direct access to the original article if the article is available electronically. If a citation has a link "Original article", clicking there usually takes you directly to an electronic version (pdf or ps) of the original article. In order for this to work, you have to access the article from a site that is authorized to do so. Fortunately, the UIUC, like most universities, has site license agreements with most major publishers to allow such access from any host in the uiuc.edu domain.

- **Review citations.** If a review of paper X cites paper Y, clicking on the MR number for Y takes you to the review of paper Y. Conversely, each review has a link "Review citations" that takes to an index of all reviews (if any) that cite the particular paper being reviewed. This is a great way to locate follow-up work: if the result of paper X is extended, or improved upon, in paper Y, there is a good chance (though no guarantee) that the review of Y will point out that Y's result generalizes that in paper X, and will reference X in the review.

- **Reference citations.** A related, but different concept is that of "reference citations." Some (but by no means all) of the more recent reviews

contain a complete list of references cited in the paper, along with links to reviews of those references if available. The idea is to have eventually the entire mathematical literature connected through a gigantic (directed) graph, in which the nodes represent papers and the edges represent citations. Such a graph structure would allow one to locate all papers that cite a particular paper, thus substantially reducing the chances to overlook relevant literature. Unfortunately, the program is in its very early stages, and only a tiny fraction of all reviews have such a list of references. (There is another database of citations of scientific journals, the "Science Citation Index", but its coverage in mathematics is small compared to that of MathSciNet, and it has a rather clumsy, and difficult to use, interface.)

- **Mathematics Subject Classification.** Each paper listed in MathSciNet comes with one or more codes such as 11A55 or 05E30. These codes classify the paper by subject according to a rather elaborate classification scheme, known as the Mathematics Subject Classification (MSC). The classification numbers are of a form such as 11A55, where the first two digits (11) denote the main area (in this case, number theory), and the remaining part is a subclassification within that area (in the example, A is elementary number theory, and 55 is continued fractions). To see the subject corresponding to a given classification number, just click on the classification number in the MathSciNet listing.

3 Zentralblatt

Another database of reviews and bibliographic information is Zentralblatt (`http://www.zentralblatt-math.org/zmath/en`). Its functionality largely duplicates that of MathSciNet, so I rarely use it. However, its coverage goes quite a bit further back than MathSciNet, so if one looks for articles published before 1950, Zentralblatt is a good alternative to MathSciNet.

4 JSTOR

JSTOR (`http://www.jstor.org`) is a fantastic resource, containing archived issues of some selected journals in a variety of fields. In mathematics, about

a dozen journals are covered, including most journals of the American Mathematical Society and the American Math. Monthly. The archive contains the full text of these journals, dating back to the 1800s in some cases, and, most importantly, it is searchable by full text. In this respect, JSTOR is quite different from, and far superior to, MathSciNet. While both JSTOR and MathSciNet contain the usual bibliographical information (author, title, key words, etc.), JSTOR contains, in addition, the original, full text of articles, whereas the MathSciNet database only contains reviews of those articles.

The main drawbacks of JSTOR are that (1) the archive covers only a small fraction of the several hundred mathematics journals covered by MathSciNet, and (2) the archive doesn't cover the most recent issues of a journal (usually, those published within the past five years). (The reason for the latter restriction is to discourage institutions subscribing to JSTOR from cancelling journal subscriptions.) JSTOR is subscription based, but most universities have access to JSTOR.

5 ArXiv

The ArXiv (`http://front.ucdavis.edu/`) is a "preprint server" and the standard place for posting "preprints". Preprints are unpublished papers and thus have not undergone any kind of review, in contrast to papers that listed in MathSciNet, nearly all of which are published in reputable journals. While the vast majority of preprints posted there are good quality research papers that will eventually get published, the ArXiv has its share of crackpot papers (these are usually classified as "GM").

6 Hints on locating relevant articles

Think of the mathematical literature as a (huge) graph, with nodes representing articles, and an edge between two articles meaning that one article cites the other. The tools mentioned above provide entry points. Here are some methods to proceed from there.

- **Search backwards.** After you have located a paper (e.g., through a MathSciNet search), go to the library and look at the actual article. In some cases, it might turn out not to be relevant, but if it is, you can

use it to locate further references from among the papers cited in the article.

- **Search forward.** Another strategy is to search for papers whose reviews cite a given paper, using the "Review Citations" and "Reference Citations" features mentioned above. (An alternative, though more limited and much more difficult to use, tool for such reference tracking is the "Web of Science" database, which can be accessed from the "Online Resources" section of the UIUC Library Website, `http://www.library.uiuc.edu/orr`.)

- **Read introductions.** A well-written paper should have an introduction describing the history and background of the problem investigated in the paper, and providing relevant references.

- **Find and read survey papers.** Survey papers, by definition, present a readable exposition of a given topic and usually include a comprehensive (if not exhaustive) bibliography. If there exists a (good) survey paper on the topic of your research, you are in luck, as someone has already done most of the work for you. If the survey is not recent, you will still need to search for any relevant literature that has been published since the survey was written.

7 Book catalogs

- **UIUC Library catalog**, `http://www.library.uiuc.edu/catalog` (linked from the main web page of the UIUC Math Library). The obvious place to search for books that we might have in our library. The type of search I have found most useful and which I use almost all the time is the "key word" search, since you can use it to search both by author and title words (in no particular order), or a combination of author/title words.

- **Library of Congress Catalog** (`http://catalog.loc.gov`). The Library of Congress (LOC) is the Mother of all Libraries, and their catalog is the biggest single library catalog. Nearly every book published in the U.S. has an entry in the Library of Congress catalog. The Library of Congress catalog is part of the WorldCat database, so if you do a

search on WorldCat you will find books that are in the LOC catalog. (The interfaces, though, are different; I find the LOC interface more flexible and easier to use.)

- **WorldCat**, accessible from the UIUC Library Main Page, `http://www.library.uiuc.edu`, under "Online Research Resources". (The easiest way to get at this catalog is to just type "WorldCat" in the search box.) WorldCat is the Mother of all Library Catalogs; it is a combined catalog of hundreds of libraries in the U.S. and abroad. It is particularly useful when trying to locate books that only one (or a few) libraries may have in their collection, as is often the case with dissertations, institutional publications, self-published books, and other oddities. For example, a title search for "Fermat last theorem" pulls up well known books by Simon Singh, Amir Aczel, and others, but also a few items that appear to be the works of crackpots. (Exercise: Try to find some in the latter category.) Note that WordCat is not a free resource; the University of Illinois has a site license (as do most universities), so if you connect from a uiuc.edu site, you should have no problems getting in.

- **Amazon.com** (`http://www.amazon.com`). Has nearly every book that is currently in print in the U.S., as well as many out-of-print books. If you are considering buying a book, this is an obvious place to go (and in many, though not all, cases you get a discount, plus you save sales tax), but I have also found amazon.com to be a good place to search for books on a particular subject, or to locate bibliographic information on a particular book. Also useful are the reviews that amazon has for many books. Of course, you have to take these reviews with a grain of salt, but they are still helpful in deciding which book to purchase if there are dozens of books on a particular subject on the market (as is the case with many subjects in computer programming).

8 Other databases

Many commercial databases are available at the "Online Resources" section of the UIUC Library website, `http://www.library.uiuc.edu/orr`. If you know the name of a particular database, just type that into the search box (e.g., "Nexis" for the Nexis/Lexis database). For mathematical literature,

most of these databases are of little or no value (other than the ones already mentioned, MathSciNet and JSTOR), but the databases are useful for general literature search. For example, Lexis/Nexis is a well-known database offering full text access to articles in major newspapers and magazines. To find newspaper and magazine articles about the mathematician Paul Erdos (one of the few mathematicians who have been written up in mainstream media), you can do a Lexis/Nexis search on "Paul Erdos" . It will generate several dozen hits during the past ten years.

9 Some Interesting Mathematical Websites

- **MathWorld**.
  `http://mathworld.wolfram.com`
  A gigantic online encyclopedia. (A 3200 (!) page print version, "CRC Concise Encyclopedia of Mathematics" by Eric Weisstein, is also available.) MathWorld is a fantastic resource, with high-quality, well-researched articles, written by experts, on virtually any topic in mathematics. If you want to know more about a particular mathematical topic, this is the place I'd recommend as a starting point. (For example, try to look up the "W function", or "palindromes", or "riffle shuffles".)

- **Wikipedia**.
  `http://www.wikipedia.com`
  Has excellent coverage of many mathematical topics, often comparable to, and sometimes better than, that of MathWorld.

- **Online encyclopedia of integer sequences**.
  `http://www.research.att.com/~njas/sequences/`
  An absolutely amazing resource. For example, if you want to know how the sequence $1, 3, 4, 5, 7, 9, 11, 12, 13, 15, \ldots$ is generated, this website will tell you. (Try to find the rule on your own first; it's not too hard!)

- **Inverse symbolic calculator (real number lookup)**.
  `http://oldweb.cecm.sfu.ca/projects/ISC/ISCmain.html`
  Another remarkable tool that does for real numbers what the above site does for sequences. Type in a real number that represents the result of sone numerical calculation, and it tries to come up with the

mathematical expression that evaluates to this real number, up to the given accuracy. For example, try this with 1.7724538.

- **Math Genealogy Database**.
  `http://www.genealogy.ams.org/`
  Tracks mathematical descendents (PhD students) and ancestors (PhD advisors, etc.). For example, a search for Gauss (1777–1855) shows that he had 7 students and a total of 46707 mathematical descendants.

- **Math History Archive**.
  `http://www-history.mcs.st-andrews.ac.uk`
  Biographical and other information about more than 1300 mathematicians. By far the best of its kind. For example, the entry for Gauss includes an extensive biography, a list of 67 books/articles about Gauss, 27 quotations, and links to other websites.

- **Mathematics Information Servers (Penn State)**.
  `http://www.math.psu.edu/MathLists`
  A large collection of mathematical web sites from around the world. Of particular interest is an extensive listing of Mathematics Department web sites.