#### SCIENTIFIC WORKS IN MATHEMATICS

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#### Introduction

This document represents basic guidelines concerning the nature of scientific works in mathematics. It has been compiled with feedback from members of the ETH Zürich Department of Mathematics, including in particular input from IFOR (Operations Research), SAM (Seminar für Angewandte Mathematik) and SfS (Seminar for Statistics).

The content of this text does not intend to be exhaustive. In particular, issues may arise that are not covered by the discussion. We recommend that students discuss any issue or question concerning ethics, citations, and similar topics, with a mentor (professor, advisor or postdoctoral mentor).

Comments, suggestions and other remarks should be sent to kowalski@math.ethz.ch

The reader may also consult the ETH research ethics guidelines, "Richtlinien für Integrität in der Forschung und gute wissenschaftliche Praxis an der ETH Zürich", Rechtssammlung, RS 414, available in German and English translation from www.share.ethz.ch/sites/rechtssammlung/Rechtssammlung

### 1. General features

Mathematical works in current practice are for the most part of the following types:

- Research papers;
- Research monographs or textbooks;
- PhD theses:
- Survey-type papers, including (most) master or bachelor theses;

Date: October 6, 2014.

• Software.

## More precisely:

- A research paper is a self-contained article presenting one or more **new** results in mathematics; these results must be proved completely according to the standards of mathematical rigor; in statistics, a paper can also deal with new software or applications of statistics;
- A research monograph is a book on a mathematical topic; it may contain new original research, but it can also be a presentation of known results and methods;
- A *PhD thesis* in mathematics contains one or more **new** results with complete proofs, often presented with more details and background than in a research article, and sometimes combined with surveys of known material;
- A *survey* is an article that presents mostly known results, either with proofs or in an informal way.

Software can also be of various types:

- Computer programs used to prove a result contained in a research paper ("computer-assisted proofs");
- Computer programs implementing a new algorithm or giving a new implementation of a known algorithm.

These mathematical works are made public in different ways:

- Research papers are often first made available as *preprints* on web sites such as http://arxiv.org; the preprint should be complete and fully checked by the author(s);
- Research papers are then usually submitted for publication, either to a specialist mathematical journal, or as a chapter of a proceedings volume for a conference;
- In principle, the results of a research paper are considered to have been checked and verified for correctness only after it is accepted for publication after full refereeing by one or more experts.

## 2. Special features: "pure" mathematics

In "pure" mathematics, the current standards concerning publication are the following. Note that they may differ significantly from other sciences.

- The most prestigious papers appear in generalist mathematical journals, or in journals specializing in some specific area of mathematics (e.g., analysis, combinatorics, number theory, etc); proceedings of conferences are, usually, not as important;
- If there is more than one author, they are listed in alphabetical order, with no implied ordering concerning the share of the work done by the various authors.
- The thesis advisor (for a PhD thesis) or mentor (for a postdoctoral researcher) or head of group or institute does not usually appear as an author, unless he or she has contributed scientifically at the same level as other authors.

# 3. Special features: applied mathematics, computational science and engineering

In Applied Mathematics, the following applies:

• Numerical experiments **must** be fully reproductible: any reader of the paper should be able to reproduce all the results from the paper the code and data available online. The computer code is part of the scientific work, hence it belong in an Appendix (if short enough) or in a repository that is publicly available and guaranteed of long life. The code is complete only with a fully documentation and with all instructions on how to install and run it, including dependencies and notes on used software versions. Each numerical experiment must have its own routine ready to be installed and run, and that produces exactly the published results.

# 4. Special features: statistics

- Prestigious papers on theory appear in mathematical journals focusing on statistics (e.g. *The Annals of Statistics*). However, prestigious papers involving a new method **and** applications thereof can also appear in prestigious journals outside of the mathematics community (e.g. *Nature Methods*).
- If there is more than one author, the listing of the names usually has some meaning. In particular, the first author contributed most and the last author is most senior and usually gave most strategic input (he or she is not listed if he or she did not contribute to the paper). The authors mentioned between first and last contributed less.
- Simulation studies must be archived in a way that a third person can reproduce them (for instance by having a commented script file with a fixed random seed available on your ETH account).

## 5. Special features: operations research

Prestigious papers may also appear in a highly competitive proceedings volume, such as IPCO ("Integer Programming and Combinatorial Optimization") SODA ("Symposium on Discrete Algorithms") or several others.

Scientific computations must be reproducible. Best practice is to make the computer code publicly available. If an essential part of the work involves parameter tuning, then the corresponding experiments should be well documented.

#### 6. Ethical issues

The most important ethical issues in mathematical publications are the following:

- One should not claim or announce a result without having a complete proof and having checked it (as far as possible, since mistakes are always possible); certain journals specialize in *research announcements*, where full proofs are not given, but when writing and publishing such an announcement, the authors should be in the process of preparing a full account, and should make all efforts to finalize this complete paper and to publish it:
- Priority for proving a result is not directly linked to publication; it may be established, for instance, by making available a (fully detailed) preprint, or by having a thesis manuscript; independent discoveries of the same or similar results are possible and they should be acknowledged as soon as possible;
- All authors of a research paper must have made a *significant scientific contribution* to the new results that it contains;

• All results that are used or other information or insights that have been involved in the research represented by the paper must be properly acknowledged.

# 7. ETHICAL ISSUES: CITATION GUIDELINES

The following guidelines apply to pure mathematics and statistics. For more details and examples, see the MathBIB Moodle module.

- Citations must have a sound scientific purpose, and in particular an author should not cite his or her own work, or that of friends or colleagues, without good reason.
- Any citation of a specific, precise, result, must be accompanied with a precise location in the paper or book that is referenced.
- On the other hand, if a book or paper is cited only to provide background information, context, or information related to what is being discussed, it may be cited without more precision.
- For a "standard" result, the citation need not belong to the original paper where the result is proved, but to a later account (for instance in a textbook). It is then usually clear to the reader that the authors of the work referenced are not the discoverers of the theorem.
- A theorem which is stated without specific attribution, and is not completely standard, is *supposed to have been proved by the author of the text*. If this is not the case, precise attribution is needed.
- It is acceptable in a research paper to follow closely the proof of an already published work to prove an analogue result, but this fact must be clearly indicated with proper reference.
- When proving an original result, a mathematical text should not cite only those works which contain statements which are used in the proofs, but should also cite and acknowledge works which have had an important influence in the search for the proof.
- The final advice is classical: "When in doubt, cite"; it is usually better to have too many citations than too few.

# Additional guidelines are:

• When publishing in a journal aimed at a non-mathematical audience, one should use the conventions of the journal (see e.g. the quotation style of *Journal of Chemical Physics*); usually, the journals have LaTeX-templates that correspond to the rules of the actual communities and that have to be used.

# 8. CITATION EXAMPLES

We illustrate some of the citation guidelines with examples.

(Citing a standard result) To cite the Banach-Steinhaus Theorem, supposing that one wishes to use Bourbaki's "Elements of Mathematics" as the reference, one should write:

By the Banach-Steinhaus Theorem [2, EVT, III,  $\S 4,$  Cor. 2], we have... and not

By the Banach-Steinhaus Theorem [2], we have...

(leaving to the reader the task of finding the theorem in the many volumes of Bourbaki's treatise).

(Background information) The following are examples of such citations:

Signs of Fourier coefficients of cusp forms have also been studied by Matomaki [8] and Ghosh-Sarnak [6].

or

For a general introduction to Hodge theory, see for instance the book of Voisin [10].

(Citing outside of the original source It is often useful to hint that one is making a citation to a later source by indicating with "e.g." that it is only one possible reference:

By the Hahn-Banach Theorem (see, e.g., [2, EVT, II, p. 24]), we have...

(Spelling out names) Write

It was proved by Fouvry [5] and Bombieri, Friedlander and Iwaniec [1], that certain arithmetic functions have exponent of distribution strictly larger than 1/2

instead of

It was proved in [5], [1] that certain arithmetic functions have exponent of distribution strictly larger than 1/2

(Attribution) Writing

**Theorem.** Let a be an integer and let  $q \ge 1$  be an integer such that a and q are coprime. Then there are infinitely many primes p congruent to a modulo q.

without additional precision (in a Bachelor or Master thesis) may mean that the writer claims that he or she has first proved Dirichlet's Theorem on primes in arithmetic progressions. One can instead either begin with

Dirichlet (see, e.g., [3, Chapter 4]) proved that...

or if, for instance, the text is a Bachelor thesis dedicated to an account, with proof, of the theorem, one may say:

We will prove in this text:

**Theorem** (Dirichlet). Let a be an integer and let  $q \ge 1$  be an integer such that a and q are coprime. Then there are infinitely many primes p congruent to a modulo q.

(Adapting a previous argument) One can use the following style to indicate that the proof follows closely a previous argument:

This lemma is a slight variant of a result of Helfgott [7, Lemma 2.2], and our proof follows his argument closely.

(Undergraduate theses) In a bachelor thesis, semester thesis or master thesis, a student who is showing that he or she understands well the proof and ideas of a known result should attempt as much as possible to write proofs of such results in his or her own words. Such accounts should, as discussed in these guidelines, always indicate clearly who proved the original result.

(Acknowledging the influence of previous work) The following are examples of such citations: The proof of this theorem was inspired by the analogy pointed out by Deligne [4] between Hodge theory and Galois representations.

or

The author learnt about the technique in this proof from the work of Venkatesh [9] on sparse equidistribution problems.

## References

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