WRITING MATHEMATICS EFFECTIVELY

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This is a collection of advice on writing mathematical papers and presentations. Like much of mathematics itself, most of it is common sense once you've thought about it for long enough, and the purpose of writing it out is so that others don't have to discover it from scratch.

Section 1 talks about serving the reader. Section 2 addresses differences between electronic and traditional paper publication. Section 3 gives some style guidelines. Advice specific to talks appears in Section 4. And finally in Section 5 I list a few other sources of advice to check out.

1. Serving the reader

When you write, you provide a service to the reader. The level of service you provide is up to you. You can choose to provide low-grade service or premium service or somewhere in between. In any case, it's your responsibility as an author to successfully communicate your ideas to the extent that you want them understood.

As I see it, there are three main components of good service in mathematics: how well ideas are conveyed, how well mathematical objects are named and notated, and the level of guidance the reader receives.

1.1. Conveying ideas.

The technical nature of mathematics makes most mathematical writing inherently difficult to read. Go far out of your way to make it as easy as possible for the reader to understand your writing. Strive for both mathematical and linguistic clarity.

- Choose every word. The slight difference between two similar words is enough to put the emphasis of a sentence where you want it, and a whole paragraph of correctly-chosen words becomes a force of nature. As you write, briefly consider each word as it comes out of your hands and whether it's the best one for the job. If you can't think of the right word immediately, use the closest word you can think of but put it in brackets as a note to come back to it. Often after writing another sentence or two you'll be able to think of the word you wanted.
- When discussing a class of objects, it's usually clearer to refer to a single representative object rather than the entire class in plural.

  CUMBERSOME: All integers have unique prime factorizations.

  CLEAR: Each integer has a unique prime factorization.
- Don't use 'this' or 'these' often, as in 'the remaining terms in this equation' or 'under these assumptions'. Write the explicit object, or use unique identifiers such as 'Equation 7'. It's better to be over-specific than ambiguous.

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- Make sure that mathematical statements are precise and unambiguous. Each theorem (and lemma and proposition and so on) should be self-contained; it should state all its hypotheses rather than rely on surrounding discussion to qualify variables.

  AMBIGUOUS:

  Theorem. *The floperator G_n is always bitwise cogent.*

  UNAMBIGUOUS:

  Theorem. *For every $n \geq -2$, the floperator G_n is bitwise cogent.*

  EVEN MORE UNAMBIGUOUS:

  Theorem. *For every integer $n \geq -2$, the floperator G_n is bitwise cogent.*

- Include illustrations where relevant. A good intuitive picture can take time to create, but it conveys information much more efficiently than text. Consider using graphics especially if you are routinely discussing objects that are cumbersome to represent in text, for example graphs or trees. There are many ways to create high-quality graphics; take the time to learn one.
- Never write anything that you don't completely understand. This is a corollary of being precise. For example, don't write 'There are deep connections to Schubert varieties [2, 3, 4].' just because every other paper in your field says something similar. At best the reader won't understand it either, and at worst it won't actually make sense in context and the reader will realize that. There is an important difference between 'There are deep connections to Schubert varieties [2, 3, 4].' and 'Hampersand [2] has found connections to Schubert varieties.' The latter doesn't imply any advocacy on your part of Hampersand's historic achievements, and of course you can't advocate what you don't understand.
- For the same reason, you shouldn't reference a paper you haven't looked at. At the very least, check that the page numbers are correct, because in surprisingly many citations they aren't; while you're at it, skim through to find out what the author was actually interested in, so that when you cite the paper you know the context. Sometimes it's impossible to obtain a copy of an old paper; in this case it may be better to instead cite a more obtainable work that cites the original. (In number theory this is often Dickson's *History of the Theory of Numbers*.) If the reference is not written in the language of your paper and there is a translation available, provide the reference for the translation too.
- Write consistently, in every aspect from tense to notation. Don't use two wordings for the same concept, for example 'final letter' in one place and 'last letter' in another. Similarly, don't write $p+r$ in one place and $r+p$ in another. Whenever two parallel ideas are not written in a parallel way, the reader spends effort to determine that the superficial differences are only superficial. Don't leave anything to chance; whenever there is a choice, determine a convention and stick to it.
- On the other hand, never copy full sentences. If Case 1 in a proof takes a paragraph to explain and Case 2 is nearly identical, it is tempting to

copy/paste and tweak it. But the reader doesn't need to read the same material twice. Instead, do what you would do if you were explaining orally; say that the second case is similar to the first and only point out the differences.

- Don't copy introductory text from your previous paper (or someone else's!); the context is different, so background material and previous results should be described differently for the current context. For example, if your paper is more of a "here are some more results about this well-known object" paper than a "this is a brand new research topic" paper, it doesn't make any sense to restate all the motivation and connections to other areas that was originally given in the "this is a brand new research topic" paper for that topic; the new motivation is the previous paper.

Redundancy is key in conveying ideas. A healthy amount of redundancy gives the reader a few options to understand what is being said, and it lets the reader confirm their understanding once they think they have it.

- You can always say 'That is, . . . ' to restate a sentence in a different way. It's generally easy to do this without sounding repetitive.
- If a definition or theorem is not completely transparent, state it three times — once intuitively, once by example, and once formally, in whatever order is most revelatory. People generally don't synthesize concepts from single instances; we build them from repeated experience. If you are defining 'continuous function', state that we can think of a continuous function as a function that can be drawn without lifting the pencil and that $f(x) = (\sin x)^2$ is an example.
- There seems to be a sentiment that examples belong in talks but not in papers because papers are more formal. But this is completely wrong. Although of course they are important in talks, examples are *more* important in papers. For one thing, written text does not carry all the inflection and emphasis that spoken text does. And for another, a talk is always followed by a Q&A session where audience members can ask the speaker questions; when someone reads your paper alone in their office all they have is what's written. So a paper should have more examples than a talk, to compensate for the lack of live communication.
- Be on the lookout for anything that the reader might misunderstand, and add redundancy to correct for it. In particular, there are situations where the reader may suspect a typo although what you've written is actually correct. For example, in the equation

$$s(kn+i) = \begin{cases} s(i) & \text{if } 0 \le i \le k-2 \\ s(n)+1 & \text{if } i = k-1 \end{cases}$$

one might suspect that $s(i)$ should actually be $s(n)$ even though perhaps it's correct as is.

1.2. **Naming and notation.** Much of mathematics is removed from the everyday world of natural language, so when you write about new mathematical objects you end up having to name them. There are two kinds of naming that we do — assigning words (borrowed from natural language) and assigning notation. Both are important to get right.

Assigning a word or phrase to a new concept can be difficult when you don't know much about it yet, so try to avoid fixing a name until you've worked with it for a while. When you do choose a name, invest some thought. Generate several possibilities and evaluate their strengths and weaknesses. A name should be intuitive, and it should bear resemblance to names of related concepts. Choose descriptive names rather than non-descriptive names (like 'serial comma' instead of 'Oxford comma').

Don't give fancy names to simple concepts. Let me pick on the name 'Parikh vector'. The Parikh vector of a finite word simply tallies the occurrences of each letter. A simple concept like this probably doesn't warrant a name that, while honoring Parikh, doesn't convey any information to the uninitiated. What should we call it instead? The name 'letter tallies vector' is descriptive but awkward. After more consideration we might conclude that there is no good name, and what this would suggest is that the concept is not really a core notion. Perhaps a function that counts the occurrences of a single letter is a more natural primitive, or perhaps the set of Parikh vectors of a language is more natural to name. The point is that good names have a funny way of corresponding to good concepts.

Assigning notation can be even more problematic than assigning a name, because in the end notation is just scribbles on a page. Just as with a new name, don't introduce new notation when you can get by without it. A new function or symbol may clarify your thoughts for a moment, but ingesting notation when you have no choice in the matter (as a reader) is far less pleasant than inventing it. In particular, if you only use a piece of notation in one or two sentences, you certainly can get by without introducing it at all. As an extreme example, do not introduce $m = n + 1$ just to make the expression $f(n+1) - n\,g(n+1)$ a few characters shorter. A good notation system is like a basis for a vector space; it lets you represent everything you want without any extra clutter.

When you do introduce notation, be meticulous about deciding what it is. Choose suggestive symbols and variable names. Make sure that the connotations of a variable, both internal to the paper and generally in your field, agree with how you use it. A common alphabet (as shared by the letters α, μ, σ), proximity in an alphabet (r, s, t), font $(\mathbf{a}, \mathbf{m}, \mathbf{s})$, and phonetic sound ($n$, N, ν) all indicate potential relationships between variables. Be on the lookout for misleading connotations. If you use the same symbol twice in one work, even if the uses are separated by forty pages, the two uses should represent the same type of object (for example, a length or a group or a prime).

For notation other than variable names, remember that traditional mathematics notation is hugely overloaded as it is; there are books whose indices of notation look like this:

$K[x]$	ring of blah blah of K
$K(x)$	field of blah blah of K
$K[[x]]$	ring of formal blah blah of K
$K((x))$	field of formal blah blah of K
$K\langle x\rangle$	algebra of blah blah of K

You can only use brackets for so many things. And you can only use superscripts and subscripts for so many things. Add to this a few binary operators $(+, -, \times)$, fifty or so letters, a few decorators like $\bar{a}$, $\hat{a}$, and a' and you have almost all of our mathematical notation. Let's branch out a little! Unintuitive, overloaded notation, even though we have all managed to memorize a number of conventions, is not beneficial in any way except to write quickly, which evidently is not the point of communicating mathematics.

So what else can we use? An undergraduate once told me he had to use ϖ for a function he was defining because all the other letters were taken. We shouldn't be so obsessed with one-letter notation. It's much better to have longer notation that's natural rather than shorter, cryptic notation. For example, some authors use $\{x\}$ to denote the fractional part of x, which of course can be confused with the set containing the element x. Other terse notations are also potentially ambiguous. Why not just use $\mathrm{frac}(x)$ or the notation used by your favorite programming language?

Programming languages do not have the luxury of supporting ambiguous notation, and the solution is of course to use multiple-letter function names. Maybe $\mathrm{FractionalPart}(x)$ is just a bit too long for your taste. But in a larger context, $\mathrm{RationalFunctions}(K, x)$ and $\mathrm{LaurentPolynomials}(K, x)$ more than make up in clarity what they lack in brevity. With the right notation you don't need an index of notation because the notation is self-explanatory. So next time you can't find a combination of brackets, superscripts, and subscripts that you like, or if you run out of letters, consider that there are n^ℓ words of length ℓ on an alphabet of size n. No, I take that back; the number of words is

$$(\text{size of the alphabet})^{\text{word length}}.$$

Just please don't use acronyms!

Here are some other suggestions regarding notation.

- When submitting an abstract or title to be published on a web page or printed without being processed by TEX (such as on the arXiv), remove all TEX code! It's not meant to be read! Write math in plain text (or in html if for a web page). Leaving dollar signs and slashes everywhere is really ugly and only rarely provides necessary information.

  REALLY UGLY:

  ```
  We introduce a family of $n$ meta-filtrations for each
  $0 \leq n \leq \infty$ and use it to construct a counterexample
  to Hampersand's conjecture for continuous compact
  $\frac{\alpha}{2}$-manifold extensions of $\text{SL}_2(\mathbb{Z})$.
  ```

  MUCH MORE READABLE:

  ```
  We introduce a family of n meta-filtrations for each
  0 <= n <= infinity and use it to construct a counterexample
  to Hampersand's conjecture for continuous compact
  alpha/2-manifold extensions of SL_2(Z).
  ```

- Don't name an object using a variable that carries no information. For example, 'q-analog' is a bad name, because q is an arbitrary symbol that is used only for historical reasons. I can't imagine anyone thinking this a good name on a first hearing. A term like 'k-automatic sequence', on the other hand, is fine, since k is a symbolic integer that can be replaced by an integer (so that one can speak of 2-automatic sequences and 5-automatic sequences and so on). But no one ever talks about the '2-analog'.
- Don't skimp on notation by, for example, writing 'iff' or omitting subscripts.

- Write $\arcsin x$ instead of $\sin^{-1} x$, and write $(\sin x)^2$ instead of $\sin^2 x$, *especially* when writing for non-mathematicians (for example, calculus students). There is absolutely no need to use ambiguous notation. Reserve $f^n(x)$ for function composition.

1.3. **Guidance.** While a paper is ultimately a linear narrative with a beginning and an ending, no one actually reads a paper that way. At least not at first. Readers extract what they are interested in and skip the rest. So in addition to writing a paper that flows well from beginning to end, you also have to write a paper that is easily navigable, so that a reader can skim and still have an idea of what's going on. Here are some ways to guide the reader.

- Use the introduction to orient the reader early on in the paper. Mention the big ideas, and state the main theorems if appropriate. If you begin with an impenetrable wall of technical definitions then readers won't make it to the actual results. At the end of the introduction, describe the outline of the paper in as non-technical terms as possible. After reading the introduction and paging through the rest of the paper, any researcher in the general area should be able to write a few-paragraph summary that correctly captures the main ideas and results of the paper.
- Orient the reader frequently throughout the paper. Sections and Theorem/Proof environments of course help out greatly by partitioning material into blocks. Within each block, be a narrator. It is easy to forget that while technical details of proofs may take the *most* time to write, they will be read *least*. Most readers are far more interested in higher-level information. Describe what you are about to do and why. It's cliche, but beginning each section with 'In this section, we ...' can provide much-needed direction. The longer the paper, the more critical this is, because it's easy to get lost in lemmas without guideposts. Similarly, throughout a long proof it is courteous to recap what has been accomplished and what remains to be shown.
- Establish the scope of each definition, lemma, and piece of notation, and make the scope clear by where it appears. Notation and definitions that are used throughout the paper should generally be stated in the introduction or shortly after, whereas a definition that isn't used until Section 5 should not be stated until Section 5. You should decide whether it makes sense for the sections of your paper to be largely self-contained, notationally speaking, or whether they should be cumulative. In particular, if Sections 2–4 are three self-contained variants of a problem, put the common definitions and notation in Section 1 rather than at the beginning of Section 2.
- It's usually dangerous to rely on the reader's memory, since they may not have read what came before. Refer to a section, theorem, or equation by its number if it doesn't appear within the reader's current field of vision. Similarly, if a theorem follows immediately from the previous three propositions, say so either immediately before or immediately after the theorem rather than before the first proposition, since someone reading for only the big results will otherwise wonder where the proof is.
- Number theorems (and lemmas and so on) in such a way that each theorem is easy to find. It's really hard to find Theorem 5 if it occurs between

Lemma 10 and Proposition 2, especially when the theorems are sparse. Either number all results consecutively, or (if the sections are short enough) include the section number as in '**Theorem 3.5**'.

1.4. **Editing.** Often when we write mathematics we are focused on the accuracy and details of the mathematics, and rightly so. But as a consequence, first drafts are rarely readable and almost never publication-worthy. Once a paragraph or proof is correct, then go through not at the microscopic level but at the level of a first reading by someone who has never read it before. Smooth out the narrative so that the reader doesn't realize he or she is reading. In most cases there is really only one way to say something so that the appropriate words are emphasized and it fits well in context. If you detect any clumsiness, try rewriting a sentence or paragraph from scratch in a different order. Every sentence should somewhat inevitably follow from the previous. When you get it right, the reader will be able to access the intended meaning, with the intended implications, with minimal effort.

Edit locally but think globally. When you make a small change, briefly consider what's in the rest of the paper. Don't unintentionally duplicate something you've already said elsewhere. Don't launch into motivation if you give the motivation (or a different motivation) somewhere else. Don't introduce a variable clash. And so on. After you've done your local editing, read through the paper in its entirety to check that each part of the paper is still aware of all the other parts. And then read it through again to proofread, returning to the microscopic level.

While you're editing, you can ask yourself these questions:

Basic question. Does the paper make consistent sense?

- Does the definition of each term appear before its first use?
- Similarly, does each lemma appear before the proofs that depend on it?
- Is the paper self-sufficient? Does it supply the reader with everything they need to read it (background, motivation, definitions, references)?

Intermediate question. Does the paper make pedagogical sense?

- Is the paper ordered for purposes of assimilation? Or do some definitions appear long before they're used, for example?
- Do you introduce more notation or machinery than you need?
- Do you have a big paragraph that would function better as a bulleted list? Or a bulleted list that should be a paragraph?
- Does each section title accurately summarize the material of the section (as opposed to what you expected the material to be when you chose the title)?

Harder question. Is the presentation optimal?

- Is the important information in an important place (usually first)?
- Is there clear large-scale guidance for the reader?
- Is there adequate motivation and discussion to keep a someone in the general subfield but not in the specific subsubfield (such as a potential referee) engaged?

It goes without saying, but I'll say it anyway: Do *whatever you have to do* to run a spell checker on your document before submitting or posting anywhere.

Polishing the first draft to the point of readability can take more time than the first draft, and polishing the second draft to the point of distribution quality, where the entire text flows effortlessly, can take as much time again. But editing doesn't have to be drudgery. It can be pretty fun! It's great when you realize that changing the order of a few words in a sentence makes it click perfectly into its place in the paragraph. Or when restructuring large parts of a paper produces a substantially clearer exposition. And it will be clearer in your mind too. Refining the presentation is really part of the research process — it's the stage where you see the paper as a whole and in the context of the larger field rather than as a collection of theorems.

2. Electronic publication

The biggest change in academic publishing in recent decades has been the surge in electronic distribution. Electronic publication already is the primary means of publication in many fields, and soon enough it will be the only means of publication. Of course, a lot of journals and authors have not caught up, but there are some incredibly basic features of the electronic medium that everyone should take advantage of.

2.1. **Links.** Foremost, when referencing another document (a paper or web site, for example), include an electronic link if it's reasonable to do so. In LaTeX this can be done by using `\href` as in

```
\href{http://www.wolframalpha.com}{where I spend most of my day}
```

(by including `\usepackage{hyperref}`) or by using `\url` as in

```
\url{http://www.wolframalpha.com}
```

(by including `\usepackage{hyperref,url}`) if you want the link to display the url. In fact it's a great idea to include `hyperref` even if you aren't linking outside your paper, because doing so will create links within your paper to sections, equations, and references when you compile to pdf.

For each paper listed in the bibliography, if there is an electronic version available (on the arXiv or on the author's web site or on the journal's web site), link the title of the paper to the digital version.

On the other hand, try to avoid links that will likely break in the next few years. In particular, don't include links to your web site if its location is temporary (if your current affiliation is temporary, for example).

2.2. **Color.** Another freedom that electronic publication affords is the use of color. Probably you want the main text to appear in black, but there are many ways to use color in an effective (and tasteful) way. For example, you can gray parentheses to mute them a little, both in text and math.

2.3. **Keywords.** Don't bother with keywords. Listing a few keywords is rarely enough to give an accurate picture of your paper; besides, this is what the abstract is for. Electronic searching tools have made keywords obsolete for indexing.

In the event that the journal you're dealing with has not caught up with the modern world and requires you to include keywords, don't include words like 'special' which refer to specific concepts used in the paper but are completely meaningless in any larger context. Also, don't list words like 'intractable' whose scope is so broad that anyone searching for it will be interested in a survey or overview and not in your particular specialized paper (unless it's a survey or overview).

2.4. **Abbreviations.** In general, don't use abbreviations. Abbreviations tend to look bad and suggest laziness, and in a digital document there is little need to conserve space.

Primarily I'm thinking of abbreviations of journal names. Write out the full names of journals in the bibliography. Using an abbreviation is just not worth making someone look up what journal the abbreviation corresponds to. Besides, it's quite luxurious to write (and read!)

Series on Analysis, Applications, and Computation

as opposed to '*Ser. Anal. Appl. Comput.*', which, by the way, only reduces the character count by a factor of 2.

Here are some other abbreviations you can delight in avoiding.

- When available, write out first names of authors in the bibliography. It's usually easy to find an author's first name, even if it doesn't appear in the paper, and being able to identify people contributes significantly to the recorded history of the field. (You can even systematically include middle names, following Donald Knuth.)
- Write out an author's name for each paper in the bibliography rather than using a dash (—) as 'ditto'.
- Don't invent acronyms. Use existing acronyms only when it is uncommon to write out the full name of the entity (for example, 'NSF').
- Avoid 'p.', 'pp.', 'Eq.', and 'Sec.'.
- Use Latin abbreviations ('e.g.', 'i.e.', 'etc.', and so on) sparingly.

I don't consider contractions such as *don't* to be abbreviations, since they reflect how we speak, and text is easier to read when it is written in a verbal way.

3. Style guidelines

This section concerns mechanics of writing. Generally the suggestions aren't deep, but on the plus side they are really easy to implement.

3.1. **Style.** First, a few remarks about style.

- Don't go out of your way to speak in the third person. Traditionally this is one way to make mathematics sound unmarred by mortal hands, but when done wrong it sounds awful.
- Don't complete a sentence with a Theorem header. The dangling unfinished sentence doesn't look nice, and doing so once implies that all headers are to be treated as part of the text, which means that 'Therefore we have Theorem 5 (Euler).' is grammatical, which is false. The period in '**Theorem 1.**' makes the theorem header stand out; it doesn't mark the end of a sentence.

  INCORRECT: We are now ready to prove

  Theorem 1. *English units are more natural than metric units.*

  CORRECT: We are now ready to prove the following theorem.

  Theorem 1. *Metric units are more natural than English units.*

- Generally avoid Latin phrases such as '*reductio ad absurdum*' that can be expressed perfectly well in whatever language you're writing in (unless of course you're writing in Latin). Repeated use comes across as pretentious.

3.2. **Punctuation.** The sole purpose of punctuation is to allow a reader to read fluidly without having to re-read phrases to figure out their syntax. Anything you can do to reduce ambiguity on a first read is helpful.

- Use the serial comma. For one thing, it removes ambiguity in some situations. But the main reason to use the serial comma is so that the reader can parse phrases correctly the first time, without having to backtrack.

  UNFORTUNATE: A, B and C are the bigwigs in the field. Motivated by work of A, B and C showed that . . .

  When you get to 'showed' you have to change the parse. As another example, consider 'Homeopology has connections to analysis, combinatorics and discrete math, algebra, . . . '. If the reader is accustomed to seeing the serial comma, he or she knows that 'combinatorics and discrete math' is one unit without having to re-read anything. This becomes particularly important in sentences with phrases embedded inside others.

- Use hyphens (-) and dashes (— and –) correctly. The most common uses are as follows.

  (1) A hyphen is used in a compound word where the first modifies the second, as in 'self-contained', 'time-consuming', and 'publication-worthy'.

  (2) A long dash ("em dash") is used for a mid-sentence interruption. I personally think text looks too smashed together when a long dash is used without space on either side — but often you see it without such space.

  (3) A short dash ("en dash") has a few uses. It is used between the first and last element in range (of pages or dates, for example). It is also used to join the names of coauthors. It is also used to join two terms that do not modify each other but contrast with each other, as in 'left–right reflection' and 'hybrid automated–manual search'.

  CORRECT: The illustrations on pages 77–81 show a regular 17-gon — with diagonals drawn in — constructed using the Euclid–Gauss algorithm.

  With these conventions, you can unambiguously write a phrase such as 'the Birch–Swinnerton-Dyer conjecture' and it is understood that this a conjecture of two people — Birch and Swinnerton-Dyer. The Wikipedia article on dashes has other examples. In LaTeX, type `--` for a short dash and `---` for a long dash.

- Distinguish between the use of single quotes ('') and double quotes (""). Use single quotes when the quoted text is the object under discussion, and use double quotes when the quoted text is someone else's wording. A good rule of thumb is that removing double quotes leaves the sentence grammatical; removing single quotes does not.

  CORRECT: The only three-letter word I could think of was 'ran'.

  ALSO CORRECT: We "ran" around the track at about 3 kph.

  ALSO CORRECT: The definition of 'floperator' used by Gauss [6] differs slightly from the modern definition.

- Avoid putting a complete sentence in parentheses inside another sentence, especially when the parenthesized sentence is longer than four or five words.

If you must put a parenthesized sentence inside another sentence, capitalize and punctuate the parenthesized sentence as you would any other sentence.

- Don't treat a citation as a noun; like a footnote, it provides a "link" to more information about a noun (hence the term 'references'). It's a minor annoyance to have to flip back to the References list to get any information about a reference besides the order it appears in your reference list. Plus, people like seeing their names in print.

  NO INFORMATION: Theorem 4 was proved in [6].

  A LOT OF INFORMATION: Theorem 4 was proved by Gauss [6].

- Do not punctuate cases or conditions in piecewise expressions. The spacing suffices to convey the syntax. Further, there is no way to punctuate the end of each line that allows consistent punctuation when embedded in an arbitrary sentence; just punctuate the last line, when appropriate, with whatever you would use following the expression.

  CLUTTERED: From experimental data one guesses that

$$f(x) = \begin{cases} -1, & \text{if } x = 23; \\ 1, & \text{if } x \geq 25; \\ 0, & \text{otherwise}; \end{cases},$$

  and this is what we now prove.

  CLEAN: From experimental data one guesses that

$$f(x) = \begin{cases} -1 & \text{if } x = 23 \\ 1 & \text{if } x \geq 25 \\ 0 & \text{otherwise}, \end{cases}$$

  and this is what we now prove.

4. Talks

All of the preceding comments apply to presentations as well as purely written communication. However, giving decent talks is particularly critical because the audience is captive. Most people think they give great talks, but everyone seems to agree that most talks are terrible. By the pigeonhole principle, there exist a lot of people who think their terrible talks are great. What can we do about this?

First of all, don't tell someone how great their talk was if it wasn't actually a great talk. This can be hard, because we all want to be supportive. But hopefully you can thank someone for a talk and point out features of the talk that you did appreciate without lying. And if you can give a little constructive criticism, the community will be grateful.

Secondly, try to give better talks (even if someone told you that your last talk was great!). Here are a few suggestions.

- Never begin your talk by apologizing, whether it is for how much smarter everyone else is than you, that everything you will say is trivial, or anything else. The main reason to avoid this is that it's boring to listen to. But if you don't give yourself some credit, no one else is likely to, and it taints your presentation with negativity. If there are members of the audience who have heard you give this talk before, you can acknowledge that, but be positive about it or make a joke: "For those of you who have heard this talk before, I expect you to solve the open problems by the end."

- Talks should contain *nothing* but intuition. Any material that isn't directly supporting intuition will not be absorbed in the short time you have.
- Don't be afraid of making the talk too simple! People who are not familiar with the particular topic you're discussing will only be able to follow when you explain everything as simply as you possibly can — and sometimes not even then.
- Don't include words on slides that you don't intend the audience to read (or pictures that you don't intend the audience to look at).
- Run a spell checker! Spelling mistakes scream for attention when projected onto a huge screen.
- Do not talk longer than your allotted time. Doing so is inconsiderate to the audience, and if you are presenting at a conference it is inconsiderate to even people who did not attend your talk since it throws off the schedule.
- It is common for presenters to abbreviate their names to a single letter on slides or on the blackboard. Presumably they are trying to show modesty, or perhaps they are ensuring that even members of the audience who don't remember the speaker's name can still identify the speaker's results. But it just looks silly next to unabbreviated names. No one is offended to see your name on your result in your talk.

SILLY:

Theorem (Brouwer–R–Weyl)**.** *Infinity doesn't exist.*

SENSIBLE:

Theorem (Brouwer–Rowland–Weyl)**.** *Infinity doesn't exist.*

ACCEPTABLE when handwritten quickly on a board:

Theorem (B–R–W)**.** *Infinity doesn't exist.*

If the result is not joint work, then you can leave out the attribution entirely, and this implies that the result is yours.

SILLY:

Theorem (R)**.** *With probability* 1*, infinity doesn't exist.*

SENSIBLE:

Theorem. *With probability* 1*, infinity doesn't exist.*

STILL PERFECTLY FINE:

Theorem (Rowland)**.** *With probability* 1*, infinity doesn't exist.*

5. Other resources

Other people have great advice about writing mathematics. Here are two sources:

- David Goss has written Some Hints on Mathematical Style.
- The style guide for the *Journal of Integer Sequences* contains a lot of good LaTeX advice and common mistakes to avoid.