TEN SIMPLE RULES FOR MATHEMATICAL WRITING

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ON WRITING

- **“Easy reading is damn hard writing” (Hawthorne)**
- **“Word-smithing is a much greater percentage of what I am supposed to be doing in life than I would ever have thought” (Knuth)**
- **“I think I can tell someone how to write but I can’t think who would want to listen” (Halmos)**

WHAT IS MATH WRITING?

- **Writing where mathematics is used as a primary means for expression, deduction, or problem solving.**
- **Examples that are:**
  - **Math papers and textbooks**
  - **Analysis of mathematical models in engineering, physics, economics, finance, etc**
- **Examples that are not:**
  - **Novels, essays, letters, etc**
  - **Experimental/nonmathematical papers and reports**

WHAT IS DIFFERENT ABOUT MATH WRITING?

- **Math writing blends two languages (natural and math)**
  - **Natural language is rich and allows for ambiguity**
  - **Math language is concise and must be unambiguous**

- **Math writing requires slow reading**
  - **Often expresses complex ideas**
  - **Often must be read and pondered several times**
  - **Often is used as reference**
  - **Usually must be read selectively and in pieces**

WHY THIS TALK?

- Experience is something you get only after you need it …
- One current model: The conversational style
  - "Mathematics should be written so that it reads like a conversation between two mathematicians on a walk in the woods" (Halmos)
  - "Talk to your readers as you write" (Strang)
  - Very hard to teach to others ("Effective exposition is not a teachable art. There is no useful recipe …" Halmos)
  - Controversial (where do proofs start and end? … I am not sure what the assumptions are … I can't find what I need … etc)
- Instead we will advocate a structured style
  - Offers specific verifiable rules that students can follow and thesis advisors can check
  - Allows room to develop and improve over time

SOURCES

- General style books
  - Strunk and White, “The Elements of Style” (www)
  - Fowler and Aaron, “The Little Brown Handbook”
  - Venolia, “Write Right!”
- Halmos, “How to Write Mathematics”
- Knuth, et al, “Mathematical Writing” (www)
- Kleiman, “Writing a Math Phase Two Paper,” MIT (www)
- Krantz, “A Primer of Mathematical Writing”
- Higham, “Handbook of Writing for the Mathematical Sciences”
- Alley, “The Craft of Scientific Writing”
- Thomson, “A Guide for the Young Economist”

RULES OF THE GAME

- **Small rules:**
  - Apply to a single sentence (e.g., sentence structure rules, mathspeak rules, comma rules, etc)
- **Broad rules:**
  - Apply to the entire document
  - General style and writing strategy rules
  - Are non-verifiable (e.g., organize, be clear and concise, etc)
- **Composition rules (our focus in this talk):**
  - Relate to how parts of the document connect
  - Apply to multiple sentences
  - Are verifiable

EXAMPLES OF SMALL RULES I

- **Break up long sentences into simple ones**
- **Mathspeak should be "readable"**
  - **BAD: Let k>0 be an integer.**
  - **GOOD: Let k be a positive integer.**
  - **BAD: Let $x \in R^n$ be a vector.**
  - **GOOD: Let x be a vector in R^n.**
- **Don't start a sentence with mathspeak**
  - **BAD: Proposition: f is continuous.**
  - **GOOD: Proposition: The function f is continuous.**

EXAMPLES OF SMALL RULES II

- Use active voice (“we” is better than “one”)
- Minimize “strange” symbols within text
- Make proper use of “very,” “trivial,” “easy,” “nice,” “fundamental,” etc
- Use abbreviations correctly (e.g., cf., i.e., etc.)
- Comma rules
- “Which” and “that” rules
- … ETC

EXAMPLES OF BROAD RULES

- **Language rules/goals: precision, clarity, familiarity, forthrightness, conciseness, fluidity, rhythm**
- **Organizational rules (how to structure your work, how to edit, rewrite, proofread, etc)**
- **“Down with the irrelevant and the trivial” (Halmos)**
- **“Honesty is the best policy” (Halmos)**
- **“Defend your style” (against copyeditors - Halmos)**
- **… ETC**

TEN COMPOSITION RULES

- **Structure rules (break it into digestible pieces)**
  - Organize in segments
  - Write segments linearly
  - Consider a hierarchical development
- **Consistency rules (be boring creatively)**
  - Use consistent notation and nomenclature
  - State results consistently
  - Don’t underexplain - don’t overexplain
- **Readability (make it easy for the reader)**
  - Tell them what you’ll tell them
  - Use suggestive references
  - Consider examples and counterexamples
  - Use visualization when possible

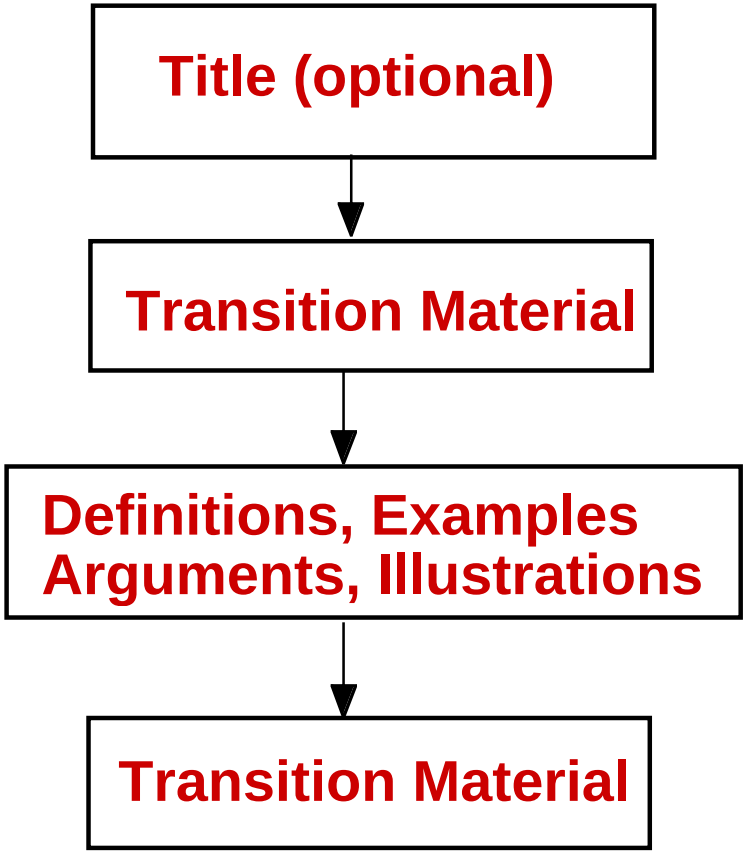
1. ORGANIZE IN SEGMENTS

- "Composition is the strongest way of seeing" (Weston)
- Extended forms of composition have a fundamental unit:
  - Novel — Paragraph
  - Film — Scene
  - Slide presentation — Slide
  - Evening news program — News report
- Key Question: What is the fundamental unit of composition in math documents?
- Segment: An entity intended to be read comfortably from beginning to end
- Not too long to be tiring, not too short to lack content and unity

SEGMENTATION PROCESS

- **Examples of segments:**
  - **A mathematical result and its proof**
  - **An example**
  - **Several related results/examples with discussion**
  - **An appendix**
  - **An abstract**
  - **A conclusions section**
- **A segment should "stand alone" (identifiable start and end, transition material)**
- **Length: 1/2 page to 2-3 pages**

SEGMENT STRUCTURE



EXAMPLE OF SEGMENTATION: A SECTION ON PROB. MODELS

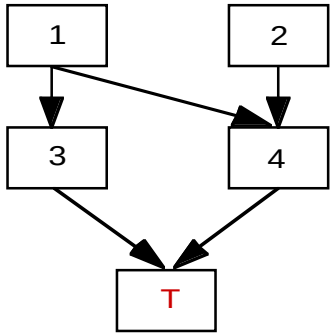
- Sample space - Events (1 page)
- Choosing a sample space (0.5 page)
- Sequential models (0.75 page)
- Probability laws - Axioms (1.25 page)
- Discrete models (2 pages)
- Continuous models (1 page)
- Properties of probability laws (2 pages)
- Models and reality (1.25 page)
- History of probability (1page)

2. WRITE SEGMENTS LINEARLY

- Question: What is a good way to order the flow of deduction and dependency?
- General rule: Arguments should be placed close to where they are used (minimize thinking strain)
- Similarly, definitions, lemmas, etc, should be placed close to where they are used
- View ordering as an optimization problem

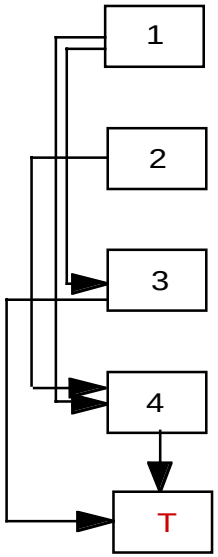
EXAMPLE

Dependency Graph of Arguments



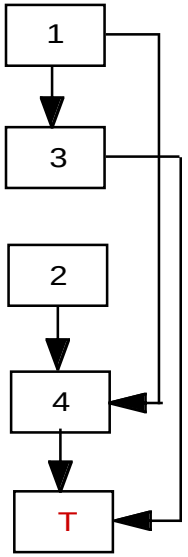
Level 1 Arguments

Level 2 Arguments



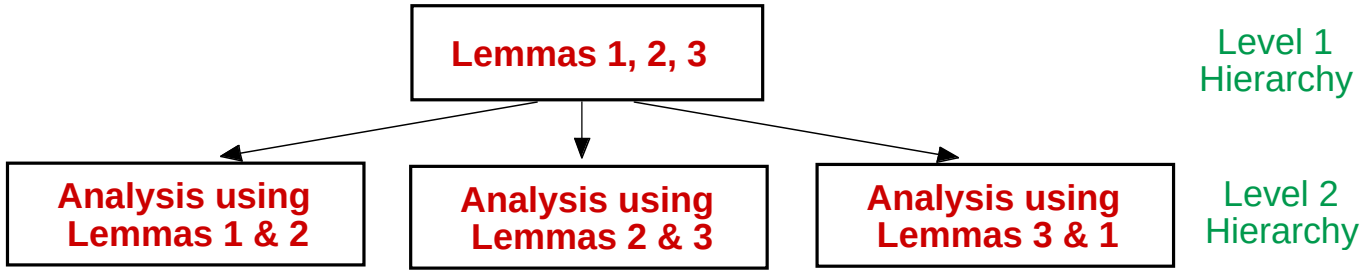
Nonlinear

Linear



3. CONSIDER A HIERARCHICAL DEVELOPMENT

- **Arguments/results used repeatedly may be placed in special segments for efficiency**



- **Possibly create special segments for special material (e.g., math background, notation, etc)**
- **Analogy to subroutines in computer programs**

4. USE CONSISTENT NOTATION

- Choose a notational style and stick with it
- Examples:
  - Use capitals for random variables, lower case for values
  - Use subscripts for sequences, superscripts for components
- Use suggestive/mnemonic notation. Examples: S for set, f for function, B for ball, etc
- Use simple notation. Example: Try to avoid parenthesized indexes: $x(m,n)$ vs x_{mn}
- Avoid unnecessary notation:
  - BAD: Let X be a compact subset of a space Y. If f is a continuous real-valued function over X, it attains a minimum over X.
  - GOOD: A continuous real-valued function attains a minimum over a compact set.

5. STATE RESULTS CONSISTENTLY

- Keep your language/format simple and consistent (even boring)
- Keep distractions to a minimum; make the interesting content stand out
- Use similar format in similar situations
- Bad example:
  - Proposition 1: If A and B hold, then C and D hold.
  - Proposition 2: C' and D' hold, assuming that A' and B' are true.
- Good example:
  - Proposition 1: If A and B hold, then C and D hold.
  - Proposition 2: If A' and B' hold, then C' and D' hold.

6. DON'T OVEREXPLAIN - DON'T UNDEREXPLAIN

- Choose a target audience level of expertise/background (e.g., undergraduate, 1st year graduate, research specialist, etc)
- Aim your math to that level; don't go much over or under
- Explain potentially unfamiliar material in separate segment(s)
- Consider the use of appendixes for background or difficult/specialized material

7. TELL THEM WHAT YOU'LL TELL THEM

- **Keep the reader informed about where you are and where you are going**
- **Start each segment with a short introduction and perhaps a road map**
- **Don't string together seemingly aimless statements and surprise the reader with "we have thus proved so and so"**
- **Announce your intentions/results, e.g., "It turns out that so-and-so is true. To see this, note …"**
- **Tell them what you told them**

8. USE SUGGESTIVE REFERENCES

- Frequent numbered equation/proposition references are a cardinal sin
- Page flipping wastes the reader's time and breaks concentration
- Refer to equations/results/assumptions by content/name (in addition to number)
- Repeat simple math expressions
- Remind the reader of unusual notation, and earlier analysis
- Dare to be repetitive (but don't overdo it)

9. CONSIDER EXAMPLES AND COUNTEREXAMPLES

- **“Even a simple example will get three-quarters of an idea across” (Ullman)**
- **Examples should have some spark, i.e., aim at something the reader may have missed**
- **Illustrate definitions/results with examples that clarify the boundaries of applicability**
- **Use counterexamples to clarify the limitations of the analysis, and the need for the assumptions**

10. USE VISUALIZATION WHEN POSSIBLE

- "A picture is worth a thousand words"
- Keep figures simple and uncluttered
- Use substantial captions
- Captions should reinforce and augment the text, not repeat it
- Use a figure to illustrate the main idea of a proof/argument with no constraint of math formality
- Prefer graphs over tables

THE END

“Bad thinking never produces good writing”

(Lamport)

Good writing promotes good thinking …