Pet peeves, bêtes noires and just plain bad writing in journal papers, theses and dissertations©

by

Ben R. Hodges, Ph.D.

Department of Civil, Architectural and Environmental Engineering
The University of Texas at Austin

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Abstract
Writing is typically on par with getting a root canal for science and engineering students. The world of creative writing and English grammar is rarely enticing to the technical mind, so their writing style (or lack thereof) develops by imitating journal articles and textbooks. Unfortunately, they also learn to write dissertations and theses by following the rather dubious examples of prior students who “got by.” Furthermore, the lack of rigor in logic and argumentation in many first draft manuscripts is appalling (culminating in “it is important” merely because I assert it so). As my students’ (and my own) mistakes are likely universal, the present work is an attempt to provide some prophylaxis or (if nothing else) a means of reducing my commenting workload*. ©copyright Ben R. Hodges, 2012. All rights reserved. The author gives permission for this paper to be downloaded, copied and distributed freely to students without charge (especially if it causes pain). The author does not give permission for this work to be sold, bartered, or otherwise transferred for the pecuniary gain of other parties (as if!).

* DISCLAIMER: I have no authority or legitimacy as a critic of English grammar, syntax or usage. My main focus is on logic and clarity of communication. I do not claim to remember (or adhere to) all the arcane standards of written English. I do not recall the difference between a gerund and a participle (no doubt leaving the latter dangling). I have boldly split infinitives, and don’t really pay attention to the preposition that I end a sentence with. It follows (see the logic?) that you will no doubt find multiple English sins in the following pages. Furthermore, this paper contains merely my own prejudices and quirks, which I feel free to violate at my whim – as Emerson once wrote: “A foolish consistency is the hobgoblin of little minds, adored by little statesmen and philosophers and divines.” Note that Emerson didn’t follow the strictures of my son’s first grade teacher – see section B.1. The diligent student should really invest some time with Strunk and White and a class in elementary logic and argumentation. Another great place for insight into common mistakes is Prof. Paul Brians’ book and website http://www.wsu.edu/~brians/errors/.
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A. The relationship between your writing and your work

A.1. If it isn’t well written, it isn’t well done.
In the end, the amount of effort you put in doesn’t matter. If your writing is amateurish, sloppy and without rigor, then people will assume your science is the same.

A.2. Writing is science, not hand-waving:
Don’t separate science and writing – writing is an integral and critical piece of the scientific process. If you don’t write it down, it isn’t science. Remember how annoyed you get at professors who stand in front of the class and wave their hands about ideas rather than writing them down on the board? For your writing to be good science, each statement in your work should fit into one of several categories. Every sentence is typically about something that...

a. …someone else has definitively shown, which requires a citation;

b. …someone else has argued to be true based on evidence, that may be either supported or refuted by yours or other work, which again requires a citation;

c. …you are showing, which requires a clear linkage to evidence presented in tables, graphs and equations;

d. …you are claiming to be demonstrably true based on your notes and/or experiments, but is so trivial that it doesn’t need to be shown, which requires “(not shown)” after the statement – note that in general a dissertation should show everything that you have demonstrated to be true, if it is trivial it can go in an appendix;

e. …you are arguing to be true as a consequence of something that someone else has shown or something that you are showing; note that it should be clear that this is your argument, or that it supports or refutes someone’s argument – whenever you are showing by argument, you must make a clear and logical case that follows from some evidence;

f. …you hypothesize may be true and that you have some evidence for, but may not be able to definitely demonstrate;

g. …is pure speculation that provides an explanation for something observed, but cannot be considered to be irrefutable evidence; i.e. you may have evidence that supports your speculation, but other speculative explanations could readily be advanced that would also be supported by the same evidence. You need to be clear in letting the reader know how your evidence fits into others evidence, argument and speculation. Watch out for places where you assert something to be true without providing some form of evidence or argument to back it up.
A.3. **Big picture first, details second**

Give the reader an understanding of the big picture before you get to the details. That is, don’t start a section by building up descriptions of minutiae and then at the end of the section tell the readers what they should have figured out. Start an explanation by stating what you are going to show and the basic means of getting there, then give the details that back up what you want to show. Imagine if someone analyzed an elephant by giving you descriptions provided by the proverbial blind men, and then told you the result is an elephant. This approach is fine if the descriptions are short and you can keep them all in mind at the same time, but it is better to say that the creature is an elephant, a large four-legged beastie with a long trunk, leathery skin, a small tail and thick legs. Afterwards you provide the details of the toenails, the tusks, the big ears, etc. This concept is critical in doing mathematical derivations – just because you got to the end by struggling through a complicated path doesn’t mean your reader should also suffer. Tell them where you’re going then show them how to get there.

A.4. **Once upon a time... (don’t slip into a chronology)**

Avoid phrases such as “this ... then that” or “after that,” or “once this is done,” etc. Think of your research as an existing whole – your objective is to explain this whole, not the step-by-step process you took to get there. The only time a chronology is acceptable is when you are describing a precise series of steps that must be followed (e.g. a lab experiment). When you write a chronology there are two critical problems: first, you bore the reader to death, and second, you end up sounding whiny – “look at all the work I had to do.” The amount of time consumed by a task has no bearing on its scientific importance. Often we spend most of our time on things that later turn out to be unimportant.

A.5. **Research the literature**

A literature review needs to be both deep (in relevant works), and wide (in works which touch on the topic). Relatively few areas are so new that less than 30 or 40 relevant references can be found. For proposals on new research, I routinely include 50 or 100 citations to the literature to demonstrate the connections between my work and other work.

A.6. **A literature review is more than who did what when**

All theses and dissertations require some form of literature review. Sometimes this is called “Background” or is part of the introduction, but its location is really irrelevant – the key point is that the review must be coherent with the rest of your work. Too many literature reviews are simply a listing of “X did Y; whereas M did R. Later, W did Z.” When you first start researching the literature and you write up a literature review for yourself (or your professor), a simplified listing of who did what when might be OK. However, for your proposal, thesis or dissertation, your literature review should explain why work by others is related or not related to your work. Everything should tie back to your goals, objectives and methods in some form. Here’s a simple test: after each declarative statement citing prior work, say to yourself “so what?” Your next sentence should answer the question.
A.7. “The figure shows...”

...is an anthropomorphization (see B.6), that invites the reader to see data exactly as you do. Make sure your figure clearly reflects your claim rather than your bias or your particular expertise. Too many figures only “show” the claimed result when the reader has exactly the same knowledge and experience as the writer. Many figures “show” the result only when you squint real hard, hold it at a distance and turn it slightly sideways (I achieve the same effect by removing my glasses). Figures should: 1) illustrate concepts that are difficult to explain in the text, and 2) present data that supports your interpretation. The text accompanying the figure should help the reader get to the meaning of the figure.

A.8. “Comparing figure 1 and 2 indicates...”

Inviting readers to compare figures is inherently a qualitative exercise and is fraught with peril. If you say they are similar, be ready for a reviewer to point out all the dissimilarities. If you say they are different, make sure the differences are large and obvious. Generally, I prefer to invite comparisons only for differences – and then principally when it is difficult to make a meaningful quantitative analysis. If data is sufficiently similar, you should be able to make a quantitative computation of the difference (e.g. the RMS, or some error norm). Additionally, try not to have figures show things by forcing the reader to compare to figures from different pages; figures to be compared should be in separate frames of a single figure.

A.9. Did you graph the data, or your analysis?

Although you do need to graph your data, the more important graphs are your analysis. If you find yourself saying "The figure shows..." (A.7) or "Comparing Figure 1 and 2 indicates..." (A.8) it may be a symptom of a bigger problem: you may not be graphing your analysis. Instead of looking at your data and telling people what they should see, think about what you want them to take away from your paper and develop a graph that shows how your data is analyzed to support the conclusion.

A.10. Real science is black and white points and lines on an x-y axis.

Yes, I use color images as much as the next person, and I plead guilty to using color line graphs on occasion. But I try to only do so to add to understanding, or as a last resort when nothing else will work. If you can't break your analysis down to a set of black and white lines and points on an x-y axis, then either 1) the subject is really really complicated, or 2) you didn't finish your analysis. Color line graphs are a badge of failure – it means the analysis was less complex than the data. As a compromise, sometimes you can use color to make things clearer in a graph, but use line styles and markers that will still be unambiguous when copied in black and white.

A.11. The importance of being quantitative

Avoid words like important, significant, and critical. They generally indicate that you don't have enough information to quantitatively discuss the subject. Furthermore, if you must use one of these words, it should be as a qualitative assessment – so if something is important there must be something else that is unimportant. Thus, you may say that A is
important compared to B, but it is nonsense (from a scientific point of view) to simply assert that A is important (see also B.16, Primary implies a secondary).

A.12. What is your contribution?
Make sure you clearly separate what you have done from what others have done. This problem is often related to “What is the it?” in your sentences (see B.14) and the use of third person perspective. Beyond the grammatical aspects, you need to make sure that reader does not think either: 1) all the work you describe was done by others, so you made no contribution; or 2) you are claiming work that was actually done by others. In the first case, your thesis fails because you haven’t made a contribution, in the second case it fails because you have plagiarized. Thus, make sure to emphasize and distinguish your contribution from prior work.

A.13. Declaring facts is annoying
Phrases like, “the fact that...” or “in fact,” or “it is a known fact” are annoying as they are transitions where you are asserting the truth of something and claiming that you don’t require evidence. Sorry, I want evidence. To me, a fact is something that someone has definitively observed. That is, it is indeed a fact that Osbourne Reynolds observed dye streaks that remained essentially uniform or quickly mixed, depending on the speed of the flow. If you really want to be pedantic, it is a fact only that he reported these observations (while I do not have personal knowledge that extends beyond his paper, I do tend to give credence to the literature and considered the reported observations to be facts). However, the explanations given for observations cannot be considered facts. It is not a “fact” that Osbourne Reynolds observed the transition from laminar to turbulence. The words laminar and turbulent are products of continuum mechanics, which is a theory that describes everyday existence, but is (in fact) wrong. Best to avoid the use of the word “fact” unless it is critical to point out the difference between something observed (a fact) and an explanation (theory or hypothesis).

A.14. Don’t start from 1+1=2
You don’t have to explain the background as if your audience doesn’t know anything about it. You may presume a certain level of expertise. For example, even though you needed to derive the Navier-Stokes equations to understand the forces governing a fluid flow, you don’t need to re-derive it for your reader. Indeed, most derivations, unless they are really ground-breaking, belong in an appendix.

A.15. Avoid vague hand-waving
Don’t begin with really vague statements – get right to strong specific statements. Often your vagaries are simply hand-waving trying to explain things that the well-read reader may be expected to already know (see §A.14). On the other hand, sometimes its easy to begin writing by using vague statements and then refine them to get more specific. The secret to good writing is going back over you work and cutting out the vagaries, keeping only the good stuff.
A.16. Read what you cite and cite what you read

A.16.a. Read what you cite
It seems obvious, but make sure that when you cite another paper you are accurately conveying what the author found or argued. Make sure that your citation isn’t highly dependent on introductory material of the citation but is based on the actual science developed in the paper. Sometimes introductions/discussions/conclusions will present material that is arguable rather than factual.

A.16.b. Cite only what you read
NEVER cite works that you have not actually read. If someone else cites an author whose work you cannot obtain, then you should cite the authors whose work you can obtain. For example, if you have work by B that refers to A but you cannot get A, then you can write something like: “a similar result was developed by A (see attribution in B)” or perhaps “B attributed a similar result to A”. The key point is that it can be embarrassing to perpetuate someone’s mistake, so only cite what you have read. Note that when you refer to B who refers to A this is called a “secondary” source, and is considered less scientifically valid than a “primary” source. You should depend principally on primary sources.

A.17. Lazy citations
Let's say that you are trying to make some point that has been shown in the literature. You might write

"This idea follows previous demonstrations (Smith et al, 2001)."

The above is perfectly fine, assuming Smith et al (2001) is the only demonstration of the point. But here's the trap: if you've been lazy and forgot to mention that Jones (1999) also made the same point, you can bet that Jones is likely to be one of your manuscripts reviewers (editors are sort of nasty that way).

Another form of lazy citations occurs with the e.g. list. Don't get me wrong, it's good to use e.g. (see A.18 below). However, if your list of citations is mainly your own work the “e.g.” makes you look either lazy or self-important (see A.19 below). If you're using “e.g.” you better be sure that you have a list of at least 3 citations from different research groups that are not your own.

A.18. Tedious citations
If you could cite more than 3 or 4 papers on a particular idea: DON'T! If you really need to document a large number of papers that are relevant to an idea, then you probably need a table listing the papers and their different contributions. Otherwise, carefully choose the three or four papers that you think are most important and are from different research groups, and begin your list of citations with "e.g." Avoid having multiple papers from the same authors in your list.
A.19. Self-important citations

It's a good thing to cite your own work, but don't get carried away. Here's something I've seen in some published works:

In MyPaper (2012): “Yada yada yada has been proven (MyPaper, 2008).”

But when you look in MyPaper (2008) you find: “Yada yada yada was demonstrated by SomeoneElse (1999).”

Now from a strict logic point of view, the above indirect citation linkage isn’t a lie – however, it’s misleading and (in my opinion) a breach of scientific ethics. The end result is that MyPaper (2008) gets more citations whereas SomeoneElse (1999) gets fewer, and you have misled the reader on who actually demonstrated the truth of yada yada yada. This gamesmanship also shows a contempt for your reader – it only works if your reader isn’t diligent, so you are assuming a level of laziness. Anyone who reads your work and others closely is going to figure this out and consider you a charlatan.

A.20. Goals...

Your overall “goal” should be a big-picture statement of what you hope to achieve – you should be able to state this in a single sentence (and no, finishing this #*@&$* thesis is not a valid research goal).

A.21. ...objectives...

Your objectives should be a few clear statements of the individual milestones that will contribute to your goal. If you have more than five objectives, you probably need to pare things down. If you have two or fewer, then you probably need more. Three or four objectives are just about right. Note that an objective should have a clear and quantifiable finishing point; that is, an objective “to understand how X behaves” does not have a finish. There will always be more to understand, so how will you know when you are done? Your objectives should be measurable so that you can show your committee that you have achieved your objectives.

A.22. ...and hypotheses:

Hypotheses should be concrete statements associated with specific experiments or studies that you conduct for your objectives. Hypotheses are necessarily more focused and precise than objectives. Note that a good hypothesis should be associated with experiments that will lead to either affirmation or falsification. You should be able to explain how a hypothesis will be conclusively proven or disproven. It is relatively easy to write a hypothesis that can be proven; however, if your experiment fails, does this conclusively disprove the hypothesis? Or is failure of your experiment/approach merely an indication that the approach isn’t adequate to prove the hypothesis? Proving conclusive failure is much trickier than proving success. Spend some time thinking about how you can conclusively disprove your hypothesis.
A.23. Your dissertation goals and objectives.

When you’re writing your thesis/dissertation, the final research goals and objectives should be based on what was achieved, rather than what you planned to achieve (unless non-achievement is scientifically important – usually it’s just a time or resource issue). Very few science projects ever reach their original goals – we shoot for the stars and maybe hit the moon (or low-earth orbit – and sometimes only the roof of the house next door). Most projects reach some goal that, in retrospect, should have been the original, more achievable goal. Remember, you aren’t writing “how I got results and what mistakes I made along the way.” The goals and objectives should focus on what the final analysis/work achieved, not where you started or thought you’d go. Background on mistakes is only valuable if it provides scientific insight into why things are different than was originally expected – usually this only happens when your results contradict conventional wisdom.

A.24. Your proposal is your contract...

...with your committee. That is, if your dissertation committee approves the objectives in your proposal, your dissertation then hinges on meeting those objectives. If you meet the objectives to the satisfaction of the committee, your work should be done! So, it is in your interest to have clear, measurable and achievable objectives. Vague objectives that have multiple interpretations may get through the proposal stage, but can cause problems at your dissertation defense.

A.25. The scarecrow didn’t have a brain...

... so knocking down a straw man neither impresses the reader nor builds your intellectual muscles. A “straw man” argument is typically a weak argument that you can easily annihilate. A poor (but common) bit of argumentation is to set up a straw man that opposes your hypothesis so that knocking him down can be claimed to prove your hypothesis. Although the argument may seem logical, it is rarely convincing. A straw man argument usually shows either your hypothesis was trivial to start with, or you really didn’t look deeply at the opposing point of view. So whenever you prove something false, ask yourself whether anyone with a brain would have thought that it could be true to start with!

A.26. Self plagiarism

Not a bad joke, but a real issue. If you write a paper that is published and subsequently use that text in another paper or report – you must put the text in quotes and include a citation. That is, you must treat your own writing with the same respect as you would others. Professors have been fired over self-plagiarism.
A.27. **Analysis is your job, not the reader’s**

Telling the reader to “note X” or “compare Y and Z” are instructions on how the reader should think. Personally, I find this annoying. I want to see your arguments on how you think and analyze the data. I might think differently, so it’s up to you to convince me that your arguments hold up. You won’t do this by taking me on the torturous paths you used to reach your conclusions – you need to show me that the end result can be expressed cogently and logically.
B. Tips on style and grammar

B.1. And a good sentence has only one “and”
This rule improves the logic and clarity of your work. When you have more than one “and” in a sentence, it is generally unclear what items you are grouping together. Often, two “and” implies two different groupings, but this won’t be clear. Any sentence with more than one “and” should be reworked to form multiple sentences; you probably have more than one distinct thought you are trying to say. I learned this from a sign on the classroom wall of my son’s first grade teacher and I have found the idea useful and it is often abused and its violation makes for really long sentences and we could go on and on and I think you get the point.

B.2. Repetitive explanations
Repetition may be part of your writing process, but some culling will help. When I write, I often write a thought, and then I follow the thought with another way of explaining it. That is, I say something then I say it again in a different way. Another way to look at this is that I keep saying the same thing until I find a way to say it that makes sense. Moreover, I sometimes repeat myself. Enough already! Hopefully you get the point: a sentence that is well-written shouldn’t need amplification or further explanation. Naturally, there are exceptions – when an idea is difficult, it may be useful to present it in two different ways or give an example (see B.5, i.e. and e.g.). However, this is a rule that I don’t try to enforce when I’m writing – I go ahead and repeat myself because often the third or fourth sentence is the best one, and the others end up deleted later. If you write like I do, make sure you carefully edit your work for repetition before passing it on for review!

B.3. Repetitive transitions are repetitive
Watch for overusing transitions such as “therefore” or “since.” If every one of your sentences takes the form “Since A is true, B is also true” or “B happens since A occurred,” your writing will become tedious. Also, recognize that these transitions imply a logical causality between what comes before and what comes after. Make sure that “A therefore B” makes logical sense.

B.4. Repetitive sentence beginnings are boring
If two sentences in a row (or two headers!) begin similarly, the reader gets bored and easily loses focus. For example: “This section shows that A=B and C=D. This section is therefore really boring...” Note that it is OK (indeed desirable), to repeat key words that you want to stick with the reader – just don’t keep repeating the same filler and transitional words.

B.5. i.e. and e.g.
Check out the movie Get Shorty for a memorable discussion. The first is the equivalent of saying “that is” while the second is the equivalent of “for example.” These are useful (if not overused) to help tell the reader that the next sentence is not an additional thought, but is an amplification of the previous thought. Too many i.e.’s and e.g.’s sprinkled
throughout your writing indicate you are probably writing sentences that are overly complex (see also B.2, Repetitive explanations above).

**B.6. Don’t anthropomorphize**
It’s a good word, look it up. As an example, people can assume things whereas inanimate objects (such as research) cannot. From your data, you might infer a conclusion, but the data themselves cannot do so. Unfortunately, we usually do allow data to imply things (which is not quite as annoying as growing the economy, but it is getting close). The most common anthropomorphization is probably the least objectionable: “The figure shows...” is clearly an anthropomorphization, but can be used when the more correct alternatives seem too wordy. Alternatives are “As shown in figure...” or “As can be seen in...”. All these phrases have other implications discussed in “The figure shows...” (see A.7).

**B.7. Watch your assumptions**
Be careful with words like “assume”. Save the word “assume” for when you need it in its true technical sense – i.e. when you don’t have any data and you have to make an assumption to solve a problem. In which case, you need clear reasons why the assumption is valid. Don’t use “assume” when you really are saying that you are limiting your focus to a subset of cases or are making an approximation. You cannot assume the world is flat and that the sun revolves around the earth – however, if you limit your solution space to scales that are small compared to the earth’s rotation and curvature, you can neglect the effects of curvature and rotation and use Newton’s equations of motion for simple Euclidean geometry. This focus has the same effect as assuming the world is flat and motionless, but doesn’t make people think you’re stupid or your work trivial. Often the word “approximate” is much better than “assume” – i.e. Newton’s laws are a good approximation for continuum behavior, we don’t need to assume that they apply.

**B.8. In order to make your work concise**
Delete “in order” throughout your paper. The statement “in order to do something” can almost always be replaced by “to do something”.

**B.9. Limit new acronyms**
It can be annoying to readers if you create too many new acronyms. In the extreme, this can lead to sentences such as “When analyzing the results of an RBC test with the NFE methodology show that SFE can be FRE with the KDL but only when XKCD is true.” The key to deciding if you need to use an abbreviation is 1) if you will use it often, i.e. every page or so; 2) it is critical and central to the work – i.e. don’t coin new jargon for peripheral issues, and 3) the words you are abbreviating are long and annoying.

**B.10. This is indefinite.**
Whenever you use “this” or “these” it should be followed with a noun, not a verb – e.g. ‘this equation’, ‘this figure’, ‘these authors’ is correct. Avoid “this is”, “this shows” “this means,” or similar constructions, which leave the reader wondering “this what?”
B.11. Be tense about tense

Work that other researchers have completed should be referred to in past tense. The work you are presenting is present tense, unless you are specifically describing something that happened on a particular day during the course of the research. It is relatively easy to keep your research in the present tense if you keep in mind the problems of “Once upon a time” see (A.3). One way to consistently apply tense is to use past tense when discussing something that was observed or completed in the field or laboratory, but use present tense for what you are expecting the reader to see in your graphs, figures and equations; i.e. “The instrument was deployed such that...” is proper past tense, whereas “Equation (15) and figure (4) illustrate the connection between...” is proper present tense.

B.12. You must limit your imperatives (it is absolutely necessary)

Declaring something “must” occur or “must” be done or is “necessary” or “required” is setting up an imperative or an absolute. As a reader, I often get sidetracked by “must” or “it is necessary” as I start thinking about other options that prove the author wrong so that the statement should really only be “may.” You should be willing to bet your B.S., M.S. or Ph.D. degree on the absolute truth of any statement that includes “must” or any similar imperative.

B.13. Can, could, would v. may, might, should

The distinctions between may/can, might/could and should/would are subtle, but set the tone of your paragraph in ways you may not intend (see that? - if I’d said “ways that you could not intend,” I would be implying that you would never intentionally set the tone of your sentence). When you state something “may” happen, or “might” be done, the implication is that you don’t have direct evidence or experience, but are hypothesizing based on your work and understanding. When you state something “can” be done or “could” happen, you are implying that you have evidence or have experienced this. Can, could and would are weak imperatives (see B.12) - avoid them unless you really mean it (anybody want a peanut?). Note that here I am violating age-old traditions that “may” should only have to do with granting permission: “May I write a thesis?” asked the student; “Yes you have my permission” responded the professor. “Can I write a thesis?” asked the student; “I don’t know, are you capable of writing?” responded the professor. The permission rule on may/can is routinely violated in scientific writing where we use “may” to indicate our uncertainty in whether or not something “can” happen.

B.14. What is the it?

The word “it” can be troublesome. In particular, I’ve never really liked (although I admit to having used) the common scientific jargon that “It is shown that....” Who or what is the “it”? The alternative for “it” is usually a switch to the first person, “We show that...” which may not be appropriate (depending on the venue). Personally, I don’t mind the first person frame, as it helps separate what you have done from what others

† If you don’t get this reference - don’t bother. It’s not all that amusing if you didn’t see the movie - and perhaps not even if you did.
have done. “It is shown” is sometimes used for what someone else has done as well as for what you have done, so you tend to be downplaying your accomplishments by saying “it is shown” (see also A.12 What is your contribution?). We may be dispassionate observers (third person) for our work, but we are the ones doing the demonstrating and showing (not some mythical scientific ‘it’), so we might as well take credit!

B.15. Technical jargon – the good, the bad, and the ugly

Every discipline has its jargon. The ‘good’ is that jargon allows you to say something in a very precise way that will be clear to those familiar with the jargon. Thus, when I say “frequency” the jargon-knowledgeable reader should understand that I am referring to a system property defined as 1/T, where T is some time measure. The ‘bad’ is that much jargon is adapted from common words with ancillary meanings. Thus “frequency” can be used in a non-jargon (hand-waving) sense, such as “The frequency with which we see this result leads us to conclude....” which really isn’t about the 1/T value, but is really about the qualitative dominance of the particular result. The ‘ugly’ is when the jargon gets so thick that the meaning of sentences cannot be adequately deciphered. What should you do? Firstly, don’t avoid jargon, since it can considerably simplify your writing by making it more concise (i.e. you don’t repeat things the knowledgeable reader already knows). Secondly, don’t overuse jargon (i.e. don’t use it for its own sake, as obfuscation; use it to make your thoughts clear). Thirdly, don’t create new jargon if there is adequate old jargon used by other. Finally, only use jargon words in their precise jargon meaning. To continue the example above, if you use “frequency” in both the jargon and non-jargon meanings, you effectively make yourself more confusing. Some jargon words to watch for are: frequency, deviation, accuracy, error, precision, and system.

B.16. Primary implies a secondary

If something is primary, then something else must be secondary. The secondary items should be explicitly enumerated, unless it is easy for the reader to infer the secondary item (or items). Otherwise, you are simply using “primary” as a hand waving adjective to assert importance (see also A.11 The importance of being quantitative).

B.17. Between ‘a’ and ‘the’

English articles ‘a’ and ‘the’ are subtle signals to the reader as to whether the following item is general or specific. For example, the simple phrase “A velocity comparison method is used to...” is significantly different from the phrase “The velocity comparison method is used to...”. In the former, the reader is invited to consider the words “velocity comparison method” as a general description of the approach taken, implying that there may be multiple different velocity comparison methods. In the latter case, the word “the” implies a specific method, known as the “velocity comparison method” has been applied, so the reader needs some explanation of the method. For example, you might write that “The velocity comparison method (see section 4.2) is used to...”
B.18. Noun-ification
Noun-ification is a made-up word describing use of verbs as nouns in prepositional phrases (i.e. phrases beginning with prepositions such as of, with, for, to, in). This usage results in confusion of the reader. The previous seems like an OK sentence – at least grammatically. However, “confusion” is the noun form of a perfectly good verb that provides a clearer sentence: The previous usage confuses the reader. Both sentences are technically correct, but the latter is clearer. English speakers often formulate their speech and thoughts with lots of prepositional phrases, which creates passive sentences (no action verbs). Indeed, when I write informally (as in this document), I tend towards passive writing and noun-ification. My hypothesis is that prepositions give us more thinking time when we’re speaking, which carries over to our writing. I don’t try to solve this problem when writing; editing while writing slows me down. Instead, I generally look for prepositional phrases that can be simplified to active verbs (activated?) only after I have finished getting the basic structure of a paragraph onto paper.

B.19. Heaven above and hell below
Referring to arguments that can be found at some unspecified location in the text “above” or “below” do not win points with your reader. If the reader doesn’t have a photographic memory (with an excellent indexing system), then he/she must take you on faith (that heaven is above and hell is below), or as an atheist is forced to page through your paper to find the argument. All modern writing software have cross-referencing capabilities, so use a direct cross-reference to a section (e.g., “see section 4.7”) where the supporting argument/information is found.

B.20. As discussed above and mentioned previously...
Between heaven and hell is purgatory – which is where I am relegated when a student tries to get away from cross-indexing (see §B.19) or presenting logically-organized prose by repeating a prior discussion in slightly different words. If you discussed it above, do you need to repeat the discussion? Are you repeating it because you think your reader has a short memory (OK, mine is minimal, but that’s why we have cross-references). Often the use of “as discussed above” is used simply because the writer can’t think of a good way to start a paragraph and make a linkage to the prior paragraph. You should just get into the argument you are trying to make in a way that ties the disparate pieces together. The phrase “as discussed above” should be a flag that you haven’t written and organized your thoughts very clearly.

‡ Dare I claim that I made it up? There may be some truthiness involved (apologies to Stephen Colbert and the writers of The Colbert Report).

§ Thanks to Prof. Chris Rehmann of the Civil Engineering Department at Iowa State University for this example.
B.21. A lot of stuff is too informal
I know you ain't gonna use no slang (or text messaging shortcuts) in your writing, but you also need to watch out for words that are too informal or colloquial, e.g. “the results are all right” is not all right (indeed, it’s not even OK). But don’t go too far the other way, there is a fine line between being adequately “not informal” and being pompous, overwrought and turgid in the stately prose you pen. Here’s a short list of words and phrases that I consider too informal (I expect this list to grow with future editions).

Table of unacceptable informalities

<table>
<thead>
<tr>
<th>all right (alright)</th>
<th>OK</th>
<th>a lot (lots)</th>
<th>stuff</th>
</tr>
</thead>
<tbody>
<tr>
<td>ain’t (or any other contraction)</td>
<td>been done</td>
<td>other things</td>
<td>is no (are no)</td>
</tr>
<tr>
<td>sort of</td>
<td>of some sort</td>
<td>it turns out</td>
<td>if we look at</td>
</tr>
<tr>
<td>looking at</td>
<td>up to now</td>
<td>all the rest</td>
<td>I can’t get no (satisfaction)</td>
</tr>
</tbody>
</table>

B.22. Then there is the opposite problem...
One may, if not attentive or careful, become overly pompous, in so much as one’s writing becomes a collection of heavily-adjectived phrases, being of the long-winded variety, which may begin with repetitive or inventive prepositions, or may have many commas and/or many conjunctions, which leads inevitably to a turgid structure of sentence, of which no one in his or her right mind would want to read, much less understand.

Table of unacceptable formalities

<table>
<thead>
<tr>
<th>in as much as</th>
<th>in so much as</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B.23. The so-called “quote” problem
Be careful using “so-called” in a part of a description; e.g. referring to this manuscript as the “so-called tips on good writing” would be technically correct as I use the phrase “tips on good writing” in my web link for the document. However, keep in mind that if you use “so-called” you are implying that other people have so named it, but you disagree. By saying this is a “so-called” tips on good writing you are saying that it really isn’t, but other people, less informed than you, think that it is. In effect, “so-called” is subtly derogatory and makes you appear to be claiming you’re smarter than those other buffoons who came up with that “so-called” idea. If prior work is wrong, then you should state it more clearly and explain why. To continue the example, it would be better to say “Hodges characterizes his work as ‘tips on good writing,’ but it really fails in this goal as...”
A similar problem arises with a tendency to put “quotes” around words for emphasis, much as is sometimes done in speech (often for ironic effect). If you need to emphasize some words, you must use italics. Quotations marks should only be used for actual quotes and not for emphasis. Of course, you can find lots of quotes in this document that aren’t really quotations – I’m using quotes to set off words that are objects in a sentence rather than being used in their normal sense.

B.24. Hyphens for clarity
Consider the phrase “a temporally varying free surface.” Obviously, “free” is an adjective modifying “surface,” but what about “temporally” and “varying?” We want it to be clear that “temporally” modifies “varying,” describing how the free surface varies. When we have a string of adjectives we can use hyphens to connect the modifier to what it modifies: “a temporally-varying free surface” indicates that the combination “temporally-varying” modifies “surface,” as does “free.” Similarly, consider the phrase “the free surface equations.” As “free” modifies “surface” rather than “equations,” the appropriate phrase should be “free-surface equations.”

B.25. Whiling away the time
The word “while” implies simultaneous in time. Although dictionaries allow “while” as an alternate definition of “on the other hand,” a better construction is to simply use “although” or some other form of logical opposition instead of “while.” Restricting “while” to its temporal meaning simply keeps your writing clearer.

B.26. In addition, you may be just tacking things together
I usually search for the words “in addition”, “additionally”, and “also” when reviewing. These are good indicators that the writer is just tacking things together without making a cogent series of sentences that flow together. If you have to say “in addition,” you should question the point you are trying to make. If the idea is just an additional morsel of no consequence, then why include it? However, if it is important, then integrate it with the rest of the paragraph rather than just adding it on. Additionally, it just bugs me.

B.27. It is difficult to tell the very difficult from the merely difficult
... so you should avoid the use of “very” or similar modifiers (e.g. extremely) when making qualitative statements. Generally you can use difficult, simple, easy, etc. without any modifiers unless you are comparing several things – i.e. if A is difficult and B is very difficult, whereas C is easy and D is very easy, then you are OK. But simply to assert that A is very difficult doesn’t mean anything more than asserting that A is difficult. In addition (does it bug you?) see section A.11 above.
B.28. that which causes problems, with commas
A common sentence modification, which you might use and that might cause problems, is tacking on a clarifying phrase with either “which” or “that.” Here’s the simple rule -

Use “which” for a phrase that is useful but unnecessary and precede it with a comma. Use “that” for a phrase that is necessary for the sentence to carry the intended logic and don’t use a comma.

A good way to decide if you should use “which” or “that” is to write the sentence without the phrase - if it still has the same logical sense, then you should use “which”. If leaving out the phrase changes the sentence’s meaning you need to use “that”.

Let’s parse the first sentence of this subsection. We might have written it using two “which”...

A common sentence modification, which you might use, and which might cause problems, is tacking on a clarifying phrase with either “which” or “that.”

Or with two “that”...

A common sentence modification that you might use and that might cause problems is tacking on a clarifying phrase with either “which” or “that.”

Or by flipping the “which” and the “that”...

A common sentence modification that you might use, and which might cause problems, is tacking on a clarifying phrase with either “which” or “that.”

To determine what version is correct, let’s examine by leaving out the “you might use”...

A common sentence modification that might cause problems is tacking on a clarifying phrase with either “which” or “that.”

The above appears to express the same basic idea as the original sentence. Now leaving out the “that might cause problems”...

A common sentence modification, which you might use, is tacking on a clarifying phrase with either “which” or “that.”

Clearly, this last form doesn’t present the idea that “which” or “that” causes problems. Instead the sentence expresses the idea that these are merely two forms that you might apply. Thus, leaving out the “might cause problems” phrase changes the idea in the sentence, so it must be preceded by “that” without a comma.
B.29. When things are included, something must be left out
Whenever you use an “include” construction, you are saying that you are just giving a few examples, rather than an exhaustive list. If something is included in your list, there must be something excluded, or the word “include” should be replaced by “are.” As an example of what not to do: “the primary colors include red, blue and yellow.” The only primary colors are red, blue and yellow, so the proper statement is “the primary colors are red, blue and yellow.” It is OK to say, “the primary colors include red and blue,” which properly implies there are other colors that are primary but are not included in your list.

B.30. Numeri Non Verba**
Don’t unnecessarily use words when you can use numbers and equations. Don’t write, “we take the difference between A and B”, when you could more easily write “A-B”. Yes, it is a pain to make equations look good in a thesis, but if you didn’t want to write equations you should have been an English major. We always prefer equations because they are concise and have a standard interpretation. When you say you take the difference of A and B, it isn’t actually clear whether you take A-B or B-A; both are valid differences, but don’t produce the same result.

B.31. Oranges exist, thus bananas exist.
I probably over-use the word “thus.” It’s not a habit you should follow. However, if you use it, please use it correctly. The word “thus” implies that the following statement is either logically deducible from the preceding statement, or provides an example of the preceding statement. Thus, the subtitle above is grammatically correct but logically nonsense.

** My undergraduate alma mater has the motto Acta Non Verba.
C. Formatting and layout

C.1. Reference figures now, not later
Don’t put the figure reference at the end of a long discussion. Let the reader know at the start of a discussion that there is an accompanying figure. There is nothing more annoying than puzzling through a complex explanation and finding “as shown in Figure 2” at the paragraph’s end. This issue is absolutely critical when the figure ends up on the next page.

C.2. Refer to the figure before the figure, not after
You don’t want to make the reader page both backwards and forwards. So figures should appear either on the same page that they are first referred to, or on the following page. It is annoying to encounter a figure before its discussion in the text, because then the reader has to back up a page (or more). In particular, readers of dissertations may want to simply throw a page into a pile after they have reviewed it, so they don’t want to have to pick in up again. Important point – always organize your writing so as not to annoy the reader!

C.3. Define your acronyms once
And don’t switch back and forth between the acronym and the full text. I can think of only two exceptions to this: 1) in a long dissertation it is OK to restate the definition of an acronym (especially a non-standard acronym) when it is first used in each chapter; 2) it is sometimes useful to use the full text rather than the acronym in a concluding paragraph to make it more readable to people (like me) who start reading with the conclusions.

C.4. Learn to use the Word Style functions
Do this now, and save yourself many headaches later. Instead of formatting a paragraph or word, you should develop and use a style that is consistent through the text. You should define a ‘Body’ or ‘normal’ style for all paragraphs that includes the appropriate indentation and line spacing etc. You should be able to change the line spacing through the entire document by simply changing one style setting. Look at the Format – Styles and Formatting menu to see what styles you are using. Also, use the Word features for headings and numbering based on headings. These tools allow automatic creation of table of contents etc. All your equation number references should be automatic cross-references that change when the equation number changes.

C.5. Equation symbol definitions
Where possible, use standard symbol definitions for your subject (e.g. in fluid mechanics \( \rho \) is density, ‘\( u \)’ is the x-direction velocity). The first time a particular symbol is used in an equation, it should be explained below the equation. Such definitions may not be necessary in a short report that uses standard terms defined in a table of nomenclature at the start of the report. However, in long reports, it can break the reader’s concentration to continually refer to the table of nomenclature for obscure symbols. When there is a single term on the left-hand side of an equation, it is sometimes useful to define that term
in the sentence before the equation. Within a particular section of a thesis or dissertation, you do not need to keep defining terms that were defined in prior equations. However, you should use some judgment. In general, it is not a bad idea to provide the definitions of obscure symbols anew in each chapter of a dissertation or thesis, but it gets annoying when common ones are provided for every equation. On the other hand, if the last use of a previous non-standard symbol was 10 pages prior, then a repeated definition of an obscure symbol may not a bad idea if it keeps the reader in the flow of the text.

C.6. Equation consistency
Make sure you include a table of nomenclature in a thesis, dissertation or technical report. The table should have all the symbols used in your paper. No symbol should have multiple definitions. Symbols used in an equation must be consistent in typeface. That is ‘A’ is not the same as ‘A’ or ‘a’ or $A$ or $A$. However, this doesn’t mean you should have 5 different ‘A’ definitions using slightly different typefaces. For journal papers, make sure you know what the editor requires – some want nomenclature tables, others do not.

C.7. Equation format
Take a look at equations in textbooks and use these as your patterns. In general, you will not see either ‘*’ or ‘x’ used for multiplication, so don’t write $a \times b$ where $ab$ can be used. Modern word processing gives you the tools to make your equations clear, professional and unambiguous.

C.8. Equation symbols
Use single character symbols (e.g. $a$ or $b$) with subscripts, overbars, etc. as necessary. Don’t name variables with two letters (e.g. $AB$) as it may be interpreted as $a \times b$.

C.9. Equation parentheses
Always use the automatic sizing brackets and parenthesis in equation editor; i.e. use

\[ a = bx + c \left( \frac{z^2}{2\alpha} - 4 \right) \quad \text{not} \quad a = bx + c\left(\frac{z^2}{2\alpha} - 4\right) \]

C.10. Equations numbering
Never use equation numbers for equations that haven’t yet appeared. For example, if the last equation was eq. (2), then do not write “We develop eq. (3) by substituting eq. (2) into eq. (1), resulting in...” and then have eq. (3) on the next line. Instead, simply write “Substituting eq. (1) into eq. (2) results in...”

C.11. Subsection organization

C.11.a. Subsections get lonely
They just cannot stand alone. For example, we are presently in section C.11.a, which means that there must be a C.11.b. Otherwise, there is no logical justification for putting this paragraph in a subsection.
C.11.b. “Three shalt be the number thou shalt count, and the number of the counting shalt be three... Five is right out” ‡‡
Some people get a little carried away with organizing by section headers. Subsections are generally OK at about three levels. I can keep in mind that I’m in the second subpoint of the 11th idea in the 3rd section of this paper. This is still somewhat meaningful. However, once you start into the 4th level...

C.11.b.1 Sub-sub-subsections

Or into the 5th level...

C.11.b.2.1 Drowned sections

... you are creating something with about the same organization of the IRS tax code, and about the same readability. Anyone that can look at a set of five subsection labels and can accurately recall all the higher level subjects is obviously not an absent-minded professor (and is therefore probably not on your reading committee). Furthermore, if you need 5 levels, you’ve probably got problems in your argument structure. It may be that some subsections are irrelevant to your main point and can be relegated to an appendix.

C.11.c. Introductions are also subsections

You shouldn’t have a “zeroth” paragraph. That is, consider the following bad example:

1. Section Title
   Here is some introductory text explaining this section. blah blah blah and yada yada yada or anything else you want to say
   1.1 Subsection one title
   Here is the start of the first subsection, again its more of the same blah blah blah and yada yada yada or anything else you want to say
   1.2 Subsection two title
   Here is the start of the second subsection, again its more of the same blah blah blah and yada yada yada or anything else you want to say

The problem with the above is that if you wanted to provide a cross-reference to something in the introductory paragraph, what would you do? If you say Section 1, it refers to all of Section 1, not just to the introductory paragraph. So the better approach is

1. Section Title
   1.1 Introduction
   Here is some introductory text explaining this section. blah blah blah and yada yada yada or anything else you want to say
   1.2 Subsection two title

‡‡ with apologies to Monty Python. For the more demented, the full quote (from The Holy Grail) is: “And the Lord spake, saying, ‘First shalt thou take out the Holy Pin, then, shalt thou count to three, no more, no less. Three shalt be the number thou shalt count, and the number of the counting shalt be three. Four shalt thou not count, nor either count thou two, excepting that thou then proceed to three. Five is right out. Once the number three, being the third number, be reached, then lobbest thou thy Holy Hand Grenade of Antioch towards thou foe, who being naughty in my sight, shall snuff it.’ ”
Here is the start of the first subsection of real stuff (as opposed to introductory stuff), again its more of the same blah blah blah and yada yada yada or anything else you want to say

1.3 Subsection three title
Here is the start of the second subsection, again its more of the same blah blah blah and yada yada yada or anything else you want to say

C.12. Tables with numbers...

... belong in an appendix (unless short): Before you put in a table with numbers, ask yourself what use the reader will make of the numbers. If the numbers are necessary for archival purposes, then they belong in an appendix.

... or should have two significant digits: If the reader actually needs the numbers, they shouldn’t have more than two (or three at a stretch) significant digits and the table shouldn’t be more than a half-dozen entries. A table with 14 numbers at 4 or 5 significant digits is just too much information for anyone to comprehend in a simple manner.

... or better yet, should be a bar graph: If the reason you are putting in the numbers is to show their interrelationships, then they belong in a bar graph. It’s easy to do in Excel, so there isn’t any good reason not to.

C.13. Figures, labels, captions and in-text descriptions

Figures are critical to any paper, but can lead to more confusion if you don’t provide good labels, captions and descriptions.

Labels: Labels are required for all lines, symbols and axes in a graph. Ideally, keep to a single font size throughout the graph. Make sure the font is readable! Check with the journal on what size standard figures should be so that you know whether the figure will be shrunk and the font reduced. All values that have dimensions should be noted; i.e. if your x-axis is a length in meters, it should be labeled something like: “L (m)”.

Captions v. in-text descriptions: Figure captions should not repeat what is in the text, nor should they be so brief that the reader must search through the text to understand the figure. In general, a figure and its caption should provide enough information for the reader to understand the importance of the figure without having to read all the text. If you’ll pardon a politically incorrect observation: subscribers to Playboy and scientists have a lot in common – they claim to read the articles, but mostly look at the pictures!

Font size: Make sure your figure has readable fonts. For a thesis or dissertation, the equivalent of 10 point is my minimum (~11 pt), but I prefer 11 or 12. Journal papers often can go as small as 8 pt. Keep in mind that when you shrink the figure to fit the page, you also shrink the font. I write a separate Matlab script for each figure in a paper; if I need to change the font size or figure size it usually requires only changing a single line of code.
C.14. **Figures should be more than one line**

If you have a figure that has only one line against an x-y axis, you should try to figure out if you could combine it with some other figures and or lines. A single line is rarely as informative or useful as a series of lines on a single axis. In particular, you should not have a whole page of figures where each contains a single line!

C.15. **The origin is (0,0)**

Any x-y figure should have axes that begin at (0,0) unless the axis uses a logarithmic scale. If you think you have to begin somewhere else in order to show the variability in the data, you probably haven’t thought through the data very well. Usually - at least in Fluid Mechanics - we can find a way to non-dimensionalize the data so that the range of variability either lies between 0 and 1, or we can present the data on a log scale. So if your graph doesn’t look good with a (0,0) origin the answer isn’t changing the origin – rework the data!

C.16. **Paragraphs**

Paragraphs should be more than one sentence.
D. Pet peeves in environmental fluid mechanics and modeling

D.1. Motivation
Most of the prior sections are fairly general and may be applicable to any area of engineering or science. However, in the course of reviewing theses and dissertations I encounter a number of discipline-specific problems that aren’t of general interest. So once more to reduce my workload, I’m providing these comments for my students to internalize and (hopefully) correct in their writing.

D.2. Comparators high/low, large/small, many/few, coarse/fine
Qualitative comparators are often misused. High and low are best reserved for referring to heights (vertical measurements). Larger or smaller are good for physical sizes (including the size of numbers). Many/few are used for counts of object quantity. Coarse/fine are used for describing model grid meshes. This pet peeve arises from the problems in describing the grid meshes used in numerical modeling. In particular, a fine grid mesh is one with small grid cells, which means it has many grid cells compared to a coarse mesh. Sometimes this is referred to as a high resolution grid, but we casually think of “high” as (erroneously) synonymous with “large.” To confound things, we often discuss grid resolution in terms of the grid spacing, so it becomes somewhat confusing to discuss model behavior as the grid spacing gets smaller - i.e. decreasing the grid spacing causes the resolution to get “higher” or “larger.” It’s much easier to think of making the grid resolution “finer” which is consistent with smaller grid cells.

D.3. Capitalization

D.3.a. Names of non-dimensional numbers
The Froude number, Reynolds number, Strouhal number, etc. are all proper names, so they must be capitalized. Some numbers have descriptive names (e.g. the Brunt-Väisälä frequency is sometimes called the Buoyancy Frequency), which arguably should not be capitalized. However, I’m on the fence on this issue - buoyancy frequency is not obviously a name for a specific equation. For example, if asked to define the frequency at which a floating object will oscillate when displaced vertically from its equilibrium, one might derive an object-based buoyancy frequency that would not be equivalent to the Brunt-Väisälä frequency of a stratified fluid. In contrast, Buoyancy Frequency clearly denotes a named quantity that therefore should have one and only one definition. I tend to lean towards capitalizing Buoyancy Frequency (or other named equations) - to make the meaning very clear. After all, the purpose of writing is clarity, and considering Buoyancy Frequency to be the proper name for a particular equation is clearer than using the more generic term buoyancy frequency.

D.3.b. TKE not tke (upper case abbreviations preferred)
I know that you would use "turbulent kinetic energy" rather than "Turbulent Kinetic Energy" in a paper, but the abbreviation (at least to my way of thinking) should be TKE rather than tke. The problem with the tke is... did you catch it? "the" and "tke" are so similar that the reader has to pause to get it right. It's tough to speed-read when you hit abbreviations like "tke". So, generally use upper case abbreviations.
D.4. Convergence

“Convergence” has a couple of meanings. The first is in an approximate series solution - whether or not the series converges. The second is in solution of a linear algebra problem, where a non-converged solution is one that may either have diverged or simply has had its iterative solution stopped at some point. The third is in analysis of numerical error as the model grid or time scale is reduced. My students are usually dealing with the latter point, but this is not commonly understood outside of small community. It’s generally better to leave the word “convergence” to the true mathematical meanings, and discuss numerical error using order of accuracy rather than convergence.