

How to write a short scientific paper in L^AT_EX

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ABSTRACT

Aims. This paper explains how to write a short scientific paper using L^AT_EX.

Methods. The source file for this paper serves as an example and template, while the content should give useful information.

Results. The result is a short paper that can be used as a training for master students at the HAN University.

Conclusions. In your paper, don't forget to list the conclusions here!

Key words. paper: scientific – document: L^AT_EX – writing: grammar – writing: style – energy: sustainable

1. Introduction

This paper describes how to write a short scientific paper in L^AT_EX, for the fictitious scientific journal the HAN Journal of Sustainable Energy (HAN-JSE). This is meant as an introduction for students of the HAN University of Applied Sciences in Arnhem, the Netherlands into both scientific writing and L^AT_EX. The journal is not real, and your paper will not be published.

L^AT_EX is a document-preparation system that is widely used by scientists and engineers. Unlike many Office packages, L^AT_EX uses a plain-text source file¹ containing text and formatting code, which is then compiled to *e.g.* a PDF file. The main philosophy behind the L^AT_EX system is to separate the content from the style, which makes it easy for scientific journals to provide a style or class file so that the authors only need to be concerned with the contents.² L^AT_EX is well known (and was designed) for its equations. In addition, L^AT_EX can automatically generate section, figure, table and equation numbers and provide the correct internal references for them. L^AT_EX's bibliography system, known as B_BL_AT_EX, takes care of citations and the reference list, in the specified style.

This document is firstly intended to be *informative*. In Sections 2 and 3, I will give a short introduction on how to compile a L^AT_EX document, and then how to write one. Thick books have been written on the topic, but I shall necessarily restrict myself to the basics. Once you know these basics, it should be easier for you to find additional information online. Section 4 treats general writing *style*; it is based on comments I have regularly given on BSc, MSc and PhD theses of students. In discussing them now, I hope to save you and myself some time for this project, but also later on when writing or reading your thesis. Please pay special attention to Section 4.18, which contains a link to a web page with more information for you to read.

The second aim of this document is to serve as a *template* for this project. Whilst learning to use L^AT_EX, comparing the source documents to the final pdf should show you exactly how I created this “paper”. The somewhat confusing exceptions are the cases

¹ Typically ending in `.tex` like the file `paper.tex` for the current document.

² I once submitted a paper with an old journal style. Downloading the new style and recompiling took me about five minutes.

where I needed to put L^AT_EX source code in the document and had to escape especially backslashes in order to *print* the commands rather than *execute* them.

2. Compiling a L^AT_EX document

In order to create a PDF file from a L^AT_EX source file, you need a text editor (like emacs or Notepad++) to edit the source file and a L^AT_EX installation to run *e.g.* `pdflatex`. The combination of the two is available as an IDE, for example TexWorks or the combination of MikTeX and TexStudio. In addition, you can use a website like www.overleaf.com.³

You may have to run L^AT_EX twice to get the references and citations right after you have added a section, figure, etc. label. When you have added a reference to B_BL_AT_EX, you may have to run B_BL_AT_EX separately between L^AT_EX calls, or your IDE may do this for you.

Note that in order to create this document (`paper.pdf`), you will need to compile `paper.tex`, which will automatically include the other source files.

3. Writing in L^AT_EX

You can write most text as plain text. However, you will need special commands if a bit of text isn't normal. For example, the command `\section{Title}` generates a new section with the title *Title* and the correct number. Similar commands exist for (sub)subsections.⁴ **Boldface** and *italic* text can be generated using `\textbf{}` and `\textit{}`. Look in the file `paper.tex` for more examples.

3.1. Labels and references

After creating a (sub)section header, you can define a *label* using the `\label{}` command. This label can then be referred to elsewhere in the document using the `\ref{}` command, like

³ I wouldn't use it for top-secret stuff, but our current project isn't top secret.

⁴ Chapters can only be used in books and reports, not in articles.

I do here for Section 2. It is common to start the label name with `ch:`, `sec:`, `eq:`, `fig:` or `tab:` for respectively a chapter, (sub)section, equation, figure or table. Put an *unbreakable space* using a tilde (~) between ‘Section’ and the number, so that they cannot be split over different lines. When using the abbreviation Sect. 2, I use a shorter unbreakable space (\,) between the point and the number. After adding a new label you need to run \LaTeX *twice* in order for it to be generated and then used.

3.2. Math mode

Equations can be used *inline* by putting the math code between dollar signs. For example $\$x^2\$$ gives x^2 . In addition, you can use math code in *display mode*, where you put your math code between $\begin{equation}$ and $\end{equation}$ lines:

$$y = \lim_{a \rightarrow 0} \int_0^{\infty} \left(\frac{\sin x}{\sqrt{ax}} \right)^2 dx \quad (1)$$

For an equation, you must put the $\label{\}$ command *inside* the equation environment. Again, use a long unbreakable space with a tilde (~) between ‘Equation’ and the number and a short unbreakable space (\,) for the abbreviation Eq. 1.

In Eq. 1 I use curly brackets to *group* items (like $-\infty$), $\left($ and $\right)$ rather than simply $($ and $)$ to make the parentheses taller, $\frac{\text{num}}{\text{denom}}$ for the fraction and $\sin x$ rather than $\sin x$ (resulting in $\sin x$ rather than $\sin x$) for the function, since the latter indicates the product of the variables $s i n$ and x .

Note also that while *variables* should be in math mode, *units* should not. Hence $P = 16.5 \text{ kW}$, not $P = 16.5 \text{ kW}$. Use a short unbreakable space between value and unit, or a long one if you write the unit out. Units like % and °C have no space before them. Similarly, subscripts should be in math mode when they are variables themselves (A_i), but in *text mode* inside math mode if they are not: P_{mpp} .

Other useful things to do with math mode include CO_2 , ^{54}Fe , and symbols like $<$, $>$, \geq , \leq , \rightarrow , α , β , Γ , δ , ϵ , ε , \dots , ω . Many other symbols can be found online (see *e.g.* oeis.org 2019).

3.3. Figures

Figures are embedded in *floating environments* that start and end with \begin{figure} and \end{figure} . Floating means that \LaTeX decides where to place it. It is custom to put the figure in the *code* after the paragraph where it was first mentioned, but it will probably *not* be displayed there in the resulting PDF *file*.

Inside the environment, you must include the figure itself (*e.g.* with $\pgfimage{\text{path/to/image.png}}$) and define the caption (using $\caption{\}$). Note that a figure caption is much more than the name of the image. It should explain the figure in some detail, so that the reader can interpret it without referring to the main text. However, the interpretation of the figure is usually in the main text. You can add a label to the caption and reference the figure in the same way as you do for an equation. An example is shown in Figure 1 (a.k.a. Fig. 1).

See the source on how to set the width of the figure, in this case to the full columnwidth . If you want less, you could use *e.g.* 0.8columnwidth . In the current \LaTeX style, figures span a single column by default. The `figure*` environment (adding an asterisk to the `figure` environment) makes it span both columns. In that case, you will want to change the width to (a fraction of) textwidth .

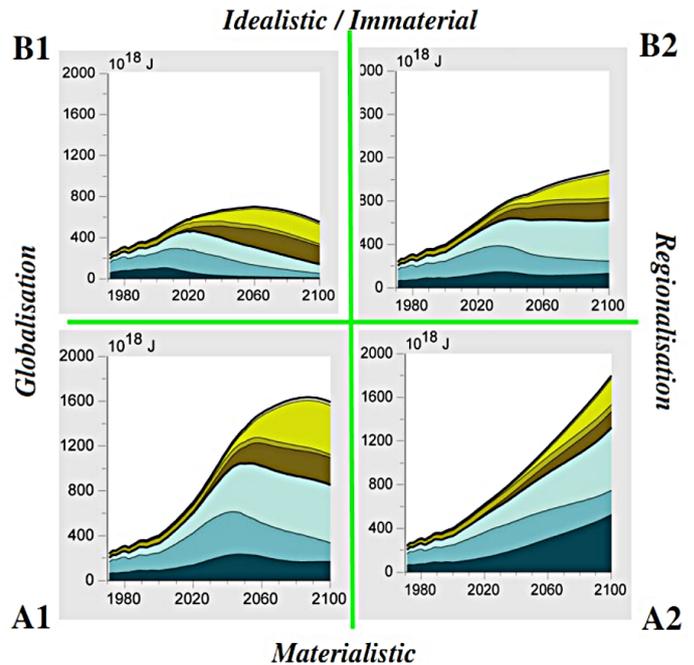


Fig. 1. An example figure, with the caption at the bottom. Note that this caption should explain the graphs above in quite some detail (unlike I do here): describe the different panels, axes, lines, symbols, etc.

Table 1. An example table, with the caption at the top. This caption should of course describe the contents of the table, *e.g.* its columns, from which model these are the results, etc.

x	y	z
1	1	1
2	4	8
3	9	27

3.4. Tables

Tables are floating environments like figures, but using the `table` environment. Inside this, you must create the table itself using the `tabular` environment. This takes a number of letters as an argument to represent the columns: `l`, `c` or `r` to align the column left, centre or right. In the content, values in a row are separated by an ampersand (&), the end of a row by two slashes ($\backslash\backslash$). A horizontal line can be created using \hline and should be used sparingly. The use of vertical lines is usually discouraged. The rules for a table caption are similar to those for an image caption (see Sect. 3.3), except that the former appears at the top of the table. See the \LaTeX source for the example in Table 1. Labels are also added to the caption for tables. Table 2 shows a simple example of a wide (two-column) table.

3.5. Lists

Lists are also an environment in \LaTeX (but not floating), either using `itemize` or `enumerate` (I’m ignoring description here):

- An itemised list has bullets, no numbers;
- the `\item` command starts a new item.
 - You can also nest lists.
 - Which bullets are used depends on the \LaTeX style.

1. An enumerated list has numbers, no bullets;

Table 2. An example of a wide table.

Variable	Value	E.use	CO ₂	Cost/hh.	E.imports	Blackouts
LED light	100%	-2.1%	+1.1%	€3955	94.4%	0 h/yr

2. the `\item` command starts a new item.
 - (a) You can also nest lists.
 - (b) Which “numbers” are used depends on the L^AT_EX style.

Note that the items in the two types of lists above are nearly identical, but that they use a different environment.

3.6. Using BibT_EX and citations

The bibliography information for L^AT_EX is stored in a BibT_EX file, ending in `.bib`. For this document, I used `references.bib`. In the main L^AT_EX file (`paper.tex`) I use the `\bibliography{file}` command. Each BibT_EX entry looks like

```
@ARTICLE{label,
  author = {{Lastname}, Firstname.},
  title = "{Title of the paper}",
  journal = {Journal the paper was published in},
  year = 2020,
}
```

but may contain more fields like `volume` and `page`. Note the use of curly brackets, quotation marks and commas.

You can usually find a the code for a BibT_EX entry on sites where you can find papers. Google Scholar⁵ (general) and ADS (physics) are useful places to go. You can copy the code for the BibT_EX entry and paste it into your BibT_EX file. See L^AT_EX Stack Exchange (2020) for a longer list of sites.

You can use the `\cite{label}` command to cite a paper with the label used in the BibT_EX file in a sentence: *e.g.* “Lastname (2020) have found that ...”. In addition, there is the `\citep{}` command that uses parentheses, *e.g.* “... was discovered recently (Lastname 2020)”. Check the code on how to use prefixes and affixes with `\citep{}` (*e.g.* Lastname 2020, or some other paper).

Once you have a BibT_EX entry in the `.bib` file, the file is included in your L^AT_EX file and you have made a citation in the text, you will need to run your L^AT_EX compiler, then your BibT_EX compiler and then your L^AT_EX compiler again (possibly twice).

In your paper, you may want to cite the Energy Transition Model (Quintel 2010). Here’s an example citation with BibT_EX entry to a Wikipedia article (Wikipedia 2021). Note (in the source) how the underscore in the url in the BibT_EX entry must be escaped.

3.7. Periods, quotes, accents, dashes and symbols

Periods (.) are used to close a sentence and for abbreviations. Since L^AT_EX cannot distinguish between the two cases, we need to indicate them. A period followed by a space implies the end of a sentence, for which a longer space is used. In order to indicate the last period in an abbreviation, we need to append a slash (/), like *e.g.* in `e.g.\`, to indicate that a normal space should follow.

⁵ After finding a publication in Google Scholar, click on the blue double quotes below the entry and click BibT_EX at the bottom of the popup.

The slash should not be used if the next character is not a space (but *e.g.* a comma).⁶

To create quotes, starting quotes ` are different from ending quotes ´. Double quotes actually consist of two single quotes. See the source for the use of ‘single’ and “double” quotes. The same symbols are used for accents.

A single dash is used to connect two words, *e.g.* a black-spotted dog. A range consists of two dashes: 2–3. Three dashes — if you want — can be used for subclauses.

Here’s a euro symbol: €.

3.8. Multiple source files

I have used multiple L^AT_EX source files to create this document (apart from the BibT_EX file). The main file is `paper.tex`. This is the file you should compile to generate `paper.pdf`. The secondary files `latex.tex` and `scientific_writing.tex` are included by `paper.tex` using the `\input{file}` command. This command includes the L^AT_EX code from `file.tex` as if it were provided at the position of the command itself. Using multiple input files is useful to separate content (L^AT_EX stuff separated from writing hints), to reuse parts in different documents (I can now use the L^AT_EX section elsewhere by including it there as well) and to make it easier for multiple authors to work on the same document at the same time without messing up each other’s content (the reason I introduce this here).

4. Scientific writing

This section contains some of my comments that I regularly provide as feedback to students who are writing (an early version of) their master thesis. Because I keep writing the same recommendations again and again, I have started to collect them. Some of these may be specific to the HAN University (like the way you write a project proposal, followed by a project plan and finally your thesis report), while others are much more universal.

The importance of clear and accurate writing are underestimated by many students. They think that because they know about their (research) topic and they can conduct a good conversation in English, writing a report is easy. Many of them make the mistake of not accurately and clearly writing down what they have to say. It’s one thing if you know or did something relevant, but it might be quite another thing to actually mention it in your report. While the supervisor of your minor project may still know what you mean if you write down your work in a clumsy way, a good supervisor will deduct points for it. And in your major-project thesis, the first examiner has *only* your thesis to assess whether you can defend it or not — if you know what you are doing but don’t show it in your thesis, your defence may be a NO GO.⁷

⁶ A slash should also be used if a space follows a special symbol, like L^AT_EX.

⁷ Compare it to a driver’s exam: you don’t only have to look in your mirrors; you have to clearly *show* that you are looking in your mirrors.

4.1. Write clearly from the start

At the HAN University, you have to write a project proposal, a project plan and then a thesis report. You can transform the earlier ones into the later ones, since they all have more or less the same structure. This means that you can transform the first into the second into the last. However, it also means that the proposal must already be good and clear. If a (textual) issue occurs five times in a two-page proposal, it could evolve into 100 occurrences of that issue in a 50-page report.

4.2. Design your document well

Design your paper/report/thesis properly at the start of your project. You can use it to organise your research project! At the start of your project, create the skeleton of your report with empty (sub)section headers, and perhaps a description of what you are supposed to do there from the project plan. This provides you with a structure for your project; all you have to do is follow it and fill in the missing bits. Of course your project may turn into a different direction during its course. That is no problem; just update your skeleton.

4.3. Be clear, concise, complete and unambiguous

Be clear, concise, complete and unambiguous.⁸ Use multiple short sentences instead of a long one with many clauses and sub-clauses. You're not Marcus Tullius Cicero who tries to impress the jury with his complex sentences. Instead, impress your reader with the quality of the content and the clarity of the text.

Define jargon and any important words or expressions that someone with a general background in your field might not know. Briefly reintroduce them as a reminder in the next section if necessary. You are not writing poetry (quite the opposite), so remove irrelevant text. Completeness means that the document should contain all the information that the reader needs to *reproduce* your work if they wanted. It does not suffice to just think, know or do something, you will also have to *write it down!*⁹ When rereading your text, make sure no other interpretation is possible than the indented one.

4.4. Use a spell checker

There are few better ways to annoy a reader than to provide typos that would clearly have been caught by a spell check.

4.5. Reread your text

Reread what you have written after two or three days. When you reread your text wight after writing it, everything is perfectly clear — because it is still in your head. When rereading, you start somewhat afresh. However, that is not enough. When you reread, pretend to be a reader with no background in your project. Would she understand everything without rereading sentences too much? If in doubt, fix it! Even better (or in addition): ask a friend with a similar background to read your text and give critical but honest and constructive feedback. The reason your text must be as clear as possible, is that at some point a reviewer,

⁸ The four c's, even though the fourth c is the wrong way up...

⁹ In particular, the first examiner at your HAN defence initially only has your thesis to form an opinion of your work. If you don't write something down, they can't judge whether you forgot to *do* it or forgot to *mention* it.

referee or even examiner is going to assess your text. You don't want to annoy them with the style or their having to reread every fifth sentence if they still have to judge the content. They might even consider an unreadable section as non-existing!

4.6. Punctuation

Punctuation is important! Use a comma when two parts of a sentence belong together and a full stop only to separate full sentences. Subclauses are separated from the main sentence using commas. Commas at the wrong location can change the meaning of the sentence. Borrowing from Dutch comedian Herman Finkers, compare *Hans said, Gretel shall I put on my skirt today?* to *Hans, said Gretel, shall I put on my skirt today?* A list of adjectives all applying to the same noun can best be separated by comma's, as in the huge, ferocious, white dog.

Note that there is usually no space before a period or comma, while there is usually a space after them. Likewise, there is typically a space before and no space after an opening bracket ((, [, et cetera), and no space before and a space (or comma, period, ...) after a closing bracket (like) or]).

4.7. Hyphenation

Hyphenation is important too. In English, compound *nouns* are usually separated by a space, not a hyphen, e.g. school bell. However, sometimes they are written as a single word compare front yard to backyard! Compound *adjectives* get a hyphen, for example a sustainable-energy project, where sustainable applies to the energy, not the project. Note that a black-spotted dog has black spots (and hence the dog itself isn't black), whereas a black spotted dog is a black dog with non-black spots (otherwise they wouldn't be spots). Hence, the addition or removal of a hyphen can turn a phrase into its opposite!

4.8. Use the active voice

Use the active voice! For example "Measurements were done, data were analysed and presented, and conclusions were drawn." uses the passive voice, which suggests that some mysterious people (or elves) did all this work, but you refuse to attribute them. So the first question a reader asks is "... by whom", so at least add "... by Jones et al. (2051)." And if you did it yourself, rather than using the passive voice and adding "by us", use the active voice. "In this section, we analyse..." "In Section 5, we present the conclusions of our study...". Usually, if the passive voice is used, a reader will assume that someone else did that work, and expect a reference to their work. Note that clarity should be one of the main characteristics of a report. It is fine to alternate between the active and passive voices, as long as it is clear who did what.

Most students seem to have heard somewhere that the passive voice is more neutral. I've no idea where that came from, but your *research* should be neutral (or objective), and your writing should be *clear* (and keep the reader awake). Prominent scientific journals like Nature ask their authors to use the active voice for clarity and directness (nature.com 2020). Don't add to the existing collection of papers where all kinds of mythical activities are reported but that never allude to what the authors did.

4.9. Clearly state and support your assumptions and choices

In your research project, you may have to make assumptions because not all data are available. This is fine, as long as they are good assumptions, and as long as you state these assumptions clearly in your report. In addition, it is a good idea to provide some *support* for your choice of assumptions. Remember that a reader should be able to understand and reproduce your work. They should however also be able to estimate the outcome if they would use their favourite assumptions instead of yours, or when later the data do become available and there is no more need for assumptions.

BTW, whenever you are making assumptions in a model, use a parameter for that assumption and state it clearly. If new data become available, you or others can simply update the parameter and rerun the model to see how the outcome changes. You can even loop over the value of that parameter to create a graph of an important output value as a function of the assumed value of the input parameter.

4.10. Citations and references

Use citations and references as much as possible. Whenever you state a fact, it should be clear whether this is a result of your work, or whether it came from an external source. If no reference is given, this implies that it is your own work. If that is not the case, it gets the smell of plagiarism. Hence, ample citations help to prevent plagiarism.

In your document, use numbered references to your figures, equations, tables, et cetera in the main text, at the point where the reader should shift her attention to it in order to understand the rest of the text. If you cannot find a good point for a reference, you should leave out the figure, equation or table.

4.11. Writing numbers

Write out counting numbers below 11 in the text when counting (not in tables and equations of course). For example: “Three data points were lost, but 21 are still available for analysis.” *Values* (as opposed to counting numbers) can be written numerically. Hence, “2 km”, but “two things”. When decimal numbers start with zero, write it out: “0.1” and “-0.6” instead of “.1” and “-.6”.

4.12. Number vs. amount

The term *number* is used for *countable* objects: a number of things, people, items, cars, trees, coins, *Amount* is used for *uncountable* materials: an amount of water, sand, air, money, energy, In the first case, you use *fewer* (fewer people), in the second *less* (less energy). Less people or fewer energy doesn't work.

4.13. High temperatures

I often read about “warm temperatures”. But a warm object indicates an object with a *high* temperature. Consequently, a “warm temperature” would be a temperature with a high temperature, which doesn't make sense because a temperature is just a number and numbers cannot have temperatures. The same of course applies to the adjective *cold*.

4.14. Use only useful abbreviations and define them

We're not sending a text message, but write full sentences. Hence, use “and” instead of &, “he or she” instead of “he/she”, et cetera. Write “is not” or “does not” instead of “isn't” or “doesn't”.

However, (long) terms that often occur can be abbreviated, but only after being defined at first use (even if you have a list of abbreviations). Example: “Photovoltaics (PV) are the default technology to . . .”. You may even redefine important abbreviations again in a new chapter to remind the reader or assist a reader who starts reading there.

4.15. Provide units

Whenever you provide a value, provided the physical unit — without it, the number is meaningless. Don't fall into traps like kW vs. kWh.

4.16. Make clear figures and tables

Ensure you include a figure or table caption with a number, so that it can be referenced. Always refer to your figure/table from the main text (at least once). If you find no possibility to do that, the figure or table is redundant, so you should remove it. Ensure your axes are labelled and use a readable font (rule of thumb: same font size as the caption). Add a legend if needed. The figure or table caption should explain what the figure or table is about without referring to the main text. A caption is not a title, but a short description consisting of one or multiple sentences.

4.17. HAN writing course

Many students think they don't need the writing course offered at the HAN. Many of them are wrong. Take it!

4.18. Further reading

Hints on scientific writing for every part of a scientific document can be found on scidev.net (scidev.net 2013).

5. Possible outline

Here's a possible outline for your short paper. Note that this is only a suggestion, so please feel free to deviate from it.

1. Introduction
2. Method
 - 2.1 Description of the Energy Transition Model
 - 2.2 Strategies
 - 2.3 Scenarios
3. Results
4. Discussion
5. Conclusions

Do not forget to write the abstract, including the main results and conclusions from your study!

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