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Engineering and Scientific Documentation

Support material

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Preface

The strength of the material presented here lies not in the PDF document alone. It is the fact that the complete directory structure, LaTeXdocuments and all other material required to produce this PDF are made available. This enable the reader to identify a desire functionality in the PDF document and to perform cut and paste for the corresponding TEX document.

I have defined a *getPackages.tex* file that includes all packages required to generate this file and a *olearyDefinitions.tex* file that make all definitions so that you can format formulæ according to ISO-80 000.

Additionally, I make a set of MATLAB tools available to simplify the transfer of structured numerical data to LaTeX. In particular, the tools *matrix2latex* and *table2latex* alleviate the difficulties with defining tables and matrices.

This text is not a replacement for a good LaTeXreference document, I still prefer books as reference; however, the online possibilities to find support make finding missing details significantly easier.

You may wish to refer to the on-line document *The Not So Short Introduction to LaTeX 2ε*, available at: `https://tobi.oetiker.ch/lshort/lshort.pdf`, which is considered to be a good introduction to LaTeX 2ε.

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Document History

Abstract This gives a brief history of the document and the changes made over time

History

Date	Comment
26 January 2017	First issue of Version 1.0.

Contents

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Part I
General issues

Chapter 1
Writing

Abstract This chapter give a collection of possible helpful approaches to writing. It is not definitive since each person must find his own approach. Nevertheless, there are general aspects which should be addressed in good scientific writing style.

1.1 Structuring the content of your introduction

It may be helpful to approach to structuring he content of each paper, or chapter in a thesis, to start by addressing the following five aspects:

1. Write a concise statement on the problem or issue being addressed;
2. State why it is important;
3. What are the challenges involved;
4. How has it been solved (or not) in the past;
5. What is your contribution.

Once you can write these issues in a concise manner you will be in the position to start writing the paper or chapter as a whole. Clarity and conciseness are important at this point in writing.

1.2 Writing that writes

The French philosopher (15. Oktober 1926 in Poitiers – 25. Juni 1984 in Paris) Michel Foucault wrote:

> "There is a writing that writes the writing and it has its own intelligence".

My personal experience is that this is very true. If you are having difficulties writing you may find it is revealing the difference between you unformulated thinking and understanding of an issue and the inadequacy of the explicit discursive

formulation as words in sentences. This discrepancy is a source of knowledge and better understanding of what you are working on. Finding precise formulations which adequately express your unformulated thinking also makes out thinking more precise.

When you encounter difficulties writing it may be important just to write and let the process of writing inform you of what you need to reflect on more thoroughly. Putting the inner understanding into external words may be an iterative process. In the first writing[1] on a difficult issue, my first text will commonly focus on expressing the gist or essence in a manner so that I can say "yes the main idea is there". At this point is may not be perfect and I may not be 100 % happy with the text, but it is a very good entry point. Writing in this manner lets the writing write the next writing and things improve and if they don't you can always return to the original text.

If you are having difficulties writing then *just write* and let your difficulties inform you about the nature of your difficulties. Its the difficulty we need to solve, so the best thing you can do is simply address them. We then discover what we need to do to alleviate the difficulties. They may be because the structure of the content is not appropriate or it may simply be that you not fully in clarity about what you wish to say, or your understanding is not sufficient. Thinking about writing has a different intelligence to the writing itself.

It may be helpful to consider writing a document which forms the basis for writing the paper or chapter. The aim is to take the expectation for perfection and achieving a final result the first time you write. The topics which you find easy to write may not need so much attention at this point. However, the document should be as complete as possible. You can always us cup-and-paste into the final document.

1.3 Styles of text

1. Descriptive
2. Definitive
3. Discursive

1.4 Some basic inner positioning of a text

Academic writing should provide a solution to the reader's problem of understanding.
It does **not** show how you think, it changes how the reader thinks.
Better: It provides an improvement to the state before.

[1] Yes the *first writing* seldom is it done with writing just once. I commonly rewrite the large sections of my work until I am satisfied.

1.5 Information, knowledge and understanding

We how (or can describe) **how** something works but not **why**.

Fit for purpose if our model permits us to describe and predict behaviour this may be called *understanding*.

The model is the suitable *representation* for understanding, since it is fit for purpose, i.e., it permits us to perform the required computation to enable prediction or to yield facts about an observation.

1.5.1 Cumulative knowledge model

An accumulation of all past knowledge

1.5.2 Permeable knowledge model

1. What is considered knowledge changes over time
2. What is considered knowledge is determined by the (a) community
3. Previously considered knowledge is discarded

But also knowledge can transform to something *taken for granted* (selbstverständlich).

1.5.3 Instability

Costs

Benefits

1.5.4 Define your terms

1.5.5 Emphasis and exaggeration

One of the explanations for *emphasis* is: ti to be deserving of attention.

Exaggeration (literally to pile up) is to overstate.

1.6 Wording

1. Get to know your readers.
   To do this it is helpful to read articles from the venue of journal you are submitting to. In this manner you become familiar with the style of that community.
2. Start with instability.
   Identify parts of present solution which may cause instability, or results with poor reliability.
3. Show them (don't tell them) why they should care about the instability, by identifying costs and possible benefits of addressing the issue.
4. Provide a solution
   It may be preferable to present work incrementally, this is easier for editors to agree to publish. Ironically, a paper that solves all the known problems with an issue may not get cited often, since there is no further reason to work in this area.
5. Identify further avenues for investigation, this will attract others to wok on the issues and they will tend to cite your papers for this reason.

1.6.1 Example text

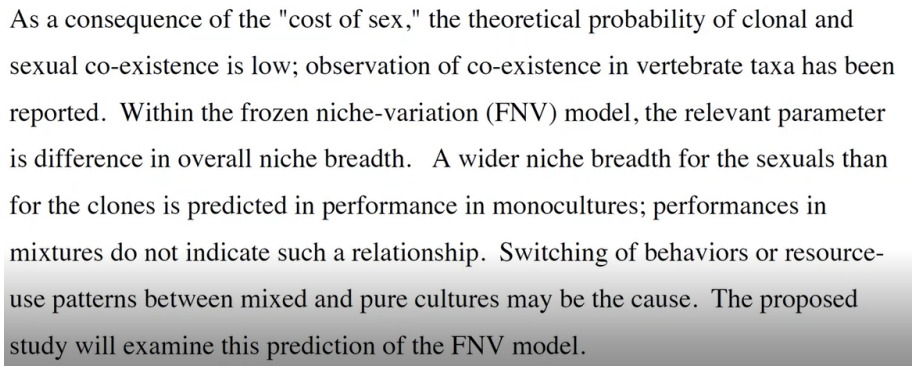

Fig. 1.1: Example of a complex text. This text is difficult to read and requires a high degree of concentration and is low on tension.

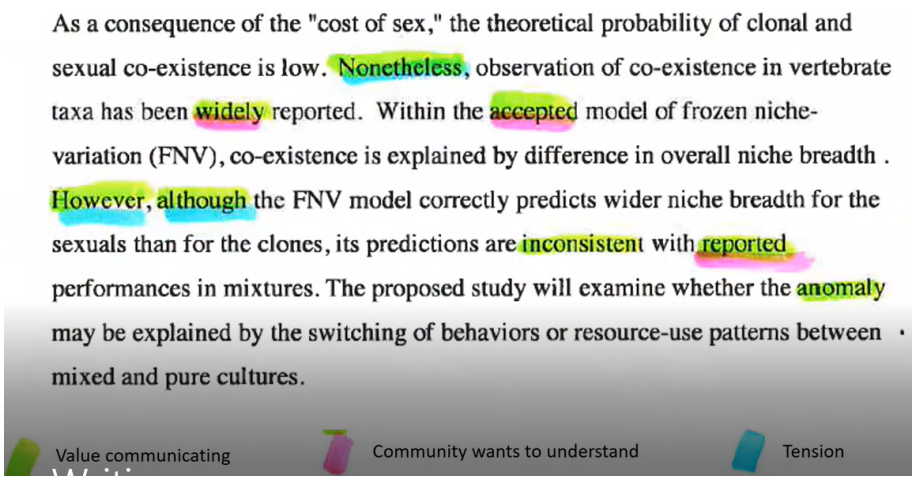

Fig. 1.2: The same content reformulates in a more readable text (thanks to Jakob König for this figure.

1.7 Formatting a juxtaposing

Here I present exactly the same information but in a different format. My goal is to juxtapose (to place side-by-side for the purpose of comparison) the two texts and strengthen the comparison.

As a consequence of the "cost of sex," the theoretical probability of clonal and sexual co-existence is low; observation of co-existence in vertebrate taxa has been reported. Within the frozen niche-variation (FNV) model, the relevant parameter is difference in overall niche breadth. A wider niche breadth for the sexuals than for the clones is predicted in performance in monocultures; performances in mixtures do not indicate such a relationship. Switching of behaviors or resource-use patterns between mixed and pure cultures may be the cause. The proposed study will examine this prediction of the FNV model.

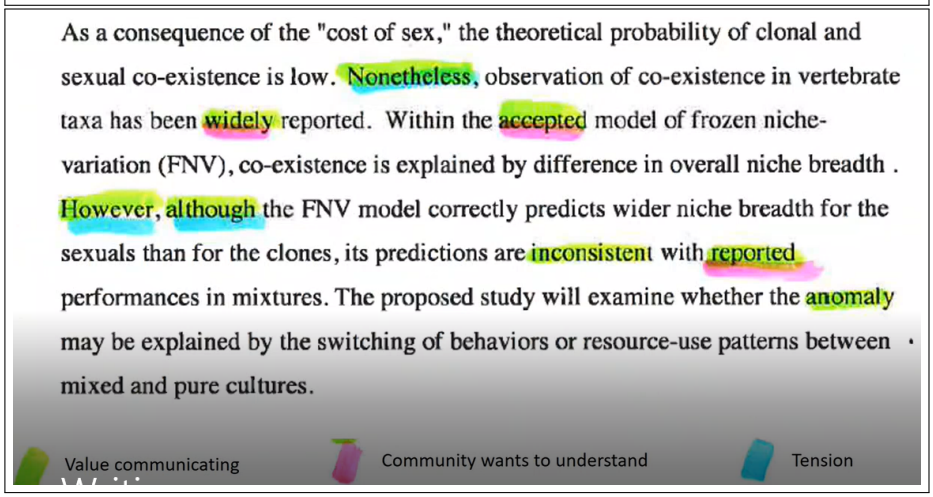

Fig. 1.3: (Top) Example of a complex text. This text is difficult to read and requires a high degree of concentration and is low on tension. (Bottom) The same content reformulates in a more readable text (thanks to Jakob König for this figure.

Chapter 2
English Punctuation

Abstract This chapter provides an introduction to English punctuation and possessive forms. The focus is on issues which Scientists and Engineers require when writing.

2.1 Introduction

Punctuation makes a difference, e.g.:

> "A woman, without her man, is nothing."
> "A woman: without her, man is nothing."

It can help support a reader to understanding the information that should be transported by a text and it can change the meaning of a sentence totally!

I hope this short introduction will improve our writing skills and with that the quality of our publications. This text is an extract from the book "Eats, shoots & leaves" by Lynn Truss [1] It should help you to get a basic understanding of English punctuation. I can strongly recommend reading her book.

2.2 Possessive apostrophe

2.2.1 Singular

The possessive apostrophe indicates a genitive in a singular noun: e.g.: *The boy's hat*.

2.2.2 Plural

When the possessor is plural, but does not end in an "s", the apostrophe similarly precedes the "s", e.g. *The children's playground.*

however, when the possessor is a regular plural the apostrophe follows the "s", e.g., *The boys' hats (more than one boy)*, *The babies' bibs*.

2.2.3 Indicating time or quantities

The apostrophe is also used to indicate time and quantities, e.g. *In one week's time*, *Two weeks' notice*.

2.2.4 Indicating omission of digits in dates

The omission of digits in a data is indicated using the apostrophe, e.g., *the summer of '68.*

2.2.5 Indicating the omission of letters

e.g. *It's your turn (it is your turn)*, *It's got very cold (it has got very cold)*

The confusion of the possessive "its" (no apostrophe) with the contractive "it's" (with apostrophe) is an unequivocal signal of illiteracy and sets off a simple Pavlovian "kill" response in the average stickler[1]. The rule is: the word "it's" (with apostrophe) stands for "it is" or "it has". If the word does not stand for "it is" or "it has" then what you require is "its".

[1] Being dyslexic myself, I have often been the recipient of this pavlovian behaviour

2.2.6 Indicating plurals of letters

For example; *how many y's are there in O'Leary?*

2.2.7 Indicating plurals of words

E.g., *What are the do's and don't's?*, *If if's and and's were pots and pans there'd be no place for tinkers.*

2.2.8 Dangling expectations caused by incorrect pluralisation

E.g., *Cyclist's only (his only what?)*, *Please replace the trolley's (replace the trolley's what?)*

2.3 Possessive-determiners and -pronouns

Non of these require apostrophes

Determiners	
my	our
your	your
his	their
her	their
its	their

Pronouns	
mine	ours
yours	yours
his	theirs
hers	theirs
its	theirs

2.4 Commas

2.4.1 Commas for lists

This is probably the first thing you ever learn about commas, that they divide items in lists, but are not required before the *and* on the end. In a list of adjectives, again the rule is that you use a comma where an and would be appropriate – where the modifying words are all modifying the same thing to the same degree: e.g.,

It was a dark, stormy night. (The night was dark AND stormy)
He was a tall, bearded man.

2.4.2 Where not to use

It was an endangered white rhino.
Australian red wines are better than Australian white ones.

This is because, in each of these cases, the adjectives do their jobs in joyful combination; they are not intended as a list.

2.4.3 Commas to join sentences

Commas are used when two complete sentences are joined together, using such conjunctions as *and*, *or*, *but*, *while* and *yet*: e.g.,

The boys wanted to stay up until midnight, but they grew tired and fell asleep.

Meanwhile, words that must not be used to join two sentences together with a comma are *however* and *nevertheless*, as in, *It was the Queen's birthday on Saturday, nevertheless, she had no post whatever*, *Jim woke up in his own bed, however, he felt great.*. Again, the requirement is for either a new sentence or one of those unpopular semicolons, e.g. *It was the Queen's birthday on Saturday; nevertheless, she had no post whatever.*

2.4.4 Commas to fill gaps

Anyway, this one is quite simple, involving missing words cunningly implied by a comma: e.g., *Annie had dark hair; Sally, fair.*

2.4.5 Before direct speech

The rector said, *"Doesn't anyone know it's my birthday?"*.

2.4.6 Commas setting off interjections

Blimey, what would we do without it? Stop, or I'll scream.

2.4.7 Commas that come in pairs

This is where comma usage all starts getting tricky. The first rule of *bracketing commas* is that you use them to mark both ends of a "weak interruption" to a sentence – or a piece of "additional information". The commas mark the places where the reader can – as it were – place an elegant two-pronged fork and cleanly lift out a section of the sentence, leaving no obvious damage to the whole, *I am, of course, going steadily nuts.*

The people in the queue who managed to get tickets were very satisfied.
and:
The people in the queue, who managed to get tickets, were very satisfied.

In the first case, the reader infers from the absence of commas that not everyone in the queue was fortunate. Some people did not get tickets. (The ones who did were, naturally, cock-a-hoop.) In the second version everyone in the queue gets tickets, hurrah, and I just hope it turned out to be for something nice. The issue here is whether the bit between the commas is *defining* or not. If the clause is *defining*, you don't need to present it with a pair of commas.

1. Leonora walked on her head, a little higher than usual.
2. The driver managed to escape from the vehicle before it sank and swam to the river-bank.
3. Don't guess, use a timer or watch.
4. The convict said the judge is mad.

In the first example, of course, the comma has been misplaced and belongs after *on*. The second example suggests that the vehicle swam to the riverbank, rather than the passenger. It requires a comma after *sank*. The third is pretty interesting, since it actually conveys the opposite of its intended meaning. What it appears to say is, *Don't guess, or use a timer or a watch*, when in fact it only wants to tell you not to guess. It therefore requires a semicolon or even a full stop after *guess*, rather than a comma. The fourth makes perfect sense, of course – unless what's intended is: *The convict, said the judge, is mad.*

2.5 The colon

"placed baldly in dramatic apposition", he said, use a colon. Thus, "Luruns could not speak: he was drunk." Shaw explains to Lawrence that when the second statement reaffirms, explains or illustrates the first, you use a colon; also when you desire an abrupt *pull-up*: "Luruns was congenitally literary: that is, a liar."

Tom has only one rule in life: never eat anything bigger than your head. (*Tom had only one rule in life – yes! Never eat anything bigger than your head.*)

But the *annunciatory* colon is only one variety. As well as the *Yes!* type colon, there is the *Ah* type, when the colon reminds us there is probably more to the initial statement than has met the eye: e.g., *You can do it: and you will do it. (You can do it – ah, and you will do it.)*

A classic use of the colon is as a kind fulcrum between two antithetical or oppositional statements: e.g., *Man proposes: God disposes.*

And as Shaw put it so well, the colon can simply pull up the reader for a nice surprise: *I find fault with only three things in this story of yours, Jenkins: the beginning, the middle and the end.*

They start lists (especially lists using semicolons): They set off book and film sub-titles from the main titles: e.g., *Gandhi II: The Mahatma Strikes Back*

Conventionally, they separate dramatic characters from dialogue: e.g.

PHILIP: Kerry-Anne! Hold still! You've got some gunk on your face!

2.6 The semicolon

The main place for putting a semicolon is between two related sentences where there is no conjunction such as *and* or *but*, and where a comma would be ungrammatical:

Whereas the semicolon suggests a connection between the two halves of each of these sentences, the dash ought to be preserved for occasions when the connections is a lot less direct, when it can act as a bridge between bits of fractured sense:

True, its use is never obligatory, because a full stop ought always to be an alternative.

2.7 The exclamation mark

The exclamation mark is almost an expletive, traditionally used in the following types of case:

1. in involuntary ejaculations: *Phew! Lord love a duck!*
2. to salute or invoke: *O mistress mine! Where are you roaming?*
3. to exclaim (or admire): *How many goodly creatures are there here!*

4. for drama: *That's not the Northern Lights, that's Manderley!*
5. to make a commonplace sentence more emphatic: *I could really do with some Opal Fruits!*
6. to deflect potential misunderstanding of irony: *I don't mean it!*

2.8 the question mark

Question marks are used when the question is direct: e.g., *What is the capital of Belgium?*, *Have you been there?*, *Did you find the people very strange?*

When the question is inside quotation marks, again it is required: *"Did you try the moules and chips?"* he asked. But when the question is indirect, the sentence manages without it: *What was the point of all this sudden interest in Brussels, he wondered. I asked if she had something in particular against the Belgian national character.*

2.9 Italic

Italics are the print equivalent of underlining:

1. emphasis of certain words;
2. foreign words and phrases;
3. examples when writing about language.

In technical articles or theses I recommend you put terms in italics the first time you use them and add a reference in the index to this location. This draws the attention of the reader to the introduction of a new term.

2.10 The hyphen

The hyphen is used, most commonly, to connect two words to form a compound noun: e.g., the *stream-of-coconsciousness*.

2.11 Parenthesis

Double dashes are another matter. These are a bracketing device, and the only issue is when to use brackets, when dashes. The differences can be quite subtle, but compare these two:

He was (I still can't believe this!) trying to climb in the window.

He was – I still can't believe this! – trying to climb in the window.

The brackets half-remove the intruding aside, half-suppress it; while the dashes warmly welcome it in.

1. round brackets (which are also called parentheses)
2. square brackets [for example]
3. braces {normally used in mathematical equations}
4. angle brackets ¡used in palaeography, linguistics and other technical specialisms¿

There are plenty of legitimate uses of brackets. First, to add information, to clarify, to explain, to illustrate: e.g., *Tom Jones (1749) was considered such a lewd*, *Starburst (formerly known as Opal Fruits) are available in all corner shops.*

Second, brackets are perfect for authorial asides of various kinds: e.g., *Tom Jones was blamed for some earthquakes (isn't that interesting?).*

Square brackets are quite another thing. They are an editor's way of clarifying the meaning of a direct quote without actually changing any of the words: *She had used it [Tom Jones] for quite a number of examples now.* Square brackets are most commonly used around the word sic (from the Latin sicut, meaning "just as"), to explain the status of an apparent mistake. Generally, sic means the foregoing mistake (or apparent mistake) was made by the writer/speaker I am quoting; I am but the faithful messenger;

However, there are distinctions within sic: it can signify two different things:

1. This isn't a mistake, actually; it just looks like one to the casual eye. I am grateful to Mrs Bollock [sic] for the following examples.
2. *Tee hee, what a dreadful error! But it would be dishonest of me to correct it. "Please send a copy of The Time's [sic]," he wrote.*

Square brackets also (sometimes) enclose the ellipsis, when words are left out. Thus: *But a more lucky circumstance happened to poor Sophia: another noise broke forth, which almost drowned her cries [. . .] the door flew open, and in came Squire Western, with his parson, and a set of myrmidons at his heels.*

2.12 Ellipsis

Ellipses are used to:

1. To indicate words missing . . . from a quoted passage
2. To trail off in an intriguing manner . . .

2.13 Hyphens

If it's not extra-marital sex (with a hyphen), it is perhaps extra marital sex, which is quite a different bunch of coconuts.

Thus the pickled-herring merchant can hold his head high, and the coat-tail doesn't look like an unpronounceable single word.

There are many legitimate uses for the hyphen:

1. Many words require hyphens to avoid ambiguity: words such as *co-respondent*, *re-formed*, *re-mark*. A re-formed rock band is quite different from a reformed one. Likewise, a long-standing friend is different from a long standing one. A cross-section of the public is quite different from a cross section of the public.
2. It is still necessary to use hyphens when spelling out numbers, such as thirty-two, forty-nine.
3. When linking nouns with nouns, such as the London-Brighton train; also adjectives with adjectives: American-French relations. Typesetters and publishers use a short dash, known as an en-rule, for this function.
4. Though it is less rigorously applied than it used to be, there is a rule that when a noun phrase such as "stainless steel" is used to qualify another noun, it is hyphenated, as "stainless-steel kitchen". Thus you have corrugated iron, but a corrugated-iron roof. The match has a second half, but lots of second-half excitement.
5. Certain prefixes traditionally require hyphens: un-American, anti-Apartheid, pro-hyphens, quasi-grammatical.
6. When certain words are to be spelled out, it is customary to use hyphens to indicate that you want the letters enunciated (or pictured) separately: "K-E-Y-N-S-H-A-M".
7. Purely for expediency, the hyphen is used to avoid an unpleasant linguistic condition called "letter collision". However much you might want to create compound words, there will always be some ghastly results, such as "deice" (de-ice) or "shelllike" (shell-like).
8. One of the main uses of the hyphen, of course, is to indicate that a word is unfinished and continues on the next line.
9. When a hyphenated phrase is coming up, and you are qualifying it beforehand, it is necessary to write, *"He was a two- or three-year-old."*
10. 9. Hesitation and stammering are indicated by hyphens: *"I reached for the w-w-w-watering can."*

References

[1] Truss L (2003) Eats, Shoots & Leaves: The Zero Tolerance Approach to Punctuation. Gotham Books

Chapter 3
SI Units

Abstract The aim of this chapter is to introduce the SI system of units and their correct use in reporting scientific results. Additionally, the relevant portions of the ISO 80000 part 2 are presented.

3.1 Introduction

The SI system defines units for seven fundamental physical quantities and rules for the generation of coherent derives units for other quantities. Additionally there are 22 coherent derived units with special names and symbols for commonly used quantities. It is considered essential to use this system of unity when reporting results. All quantities reported should have the appropriate units associated with them; this should be the case in all forms of presentation, e.g., text, tables, figures etc.

The principles laid down in ISO 80000-1:2009 are intended for general use within the various fields of science and technology. In particular Part 2 defines *Mathematical signs and symbols to be used in the natural sciences and technology*. Consequently, any document which should conform with international standards must use the defined symbols[1].

[1] For LaTeX users we provide a set of macros to support the generation of documentation which conforms to ISO-80000.

3.2 Quantities and the SI Base Units

All measurement results should be expressed in terms of physical quantities or dimensionless values. A physical quantity should be expressed as a *quantity symbol*, a *numeric value* and the appropriate *unit symbol*, e.g. the rod length, $l_r = 213.5\,\mathrm{m}$. The SI system[2] lays down a consistent set of units with rules on how these are to be used. Above and beyond the SI system the ISO 80000 defines how variables are to be represented and formatted in documentation. It is important to have a consistent use in your reporting.

Base quantity	Unit	Symbol	Definition
Length	metre	m	The metre is the length of the path travelled by light in vacuum during a time interval of $1/299\,792\,458$ of a second.
Mass	kilogram	kg	The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.
Time	second	s	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.
Thermodynamic temperature	kelvin	K	The kelvin, unit of thermodynamic temperature, is the fraction $1/273.16$ of the thermodynamic temperature of the triple point of water.
Electric current	ampere	A	The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to $2.0 \times 10^{-7}\,\mathrm{N/m}$ (of length).
Amount of substance	mole	mol	The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kg of carbon 12. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.
Luminous intensity	candela	cd	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency $540 \times 1012\,\mathrm{Hz}$ and that has a radiant intensity in that direction of $1/683$ watt per steradian.

Table 3.1: The seven SI base units. All other units are derived from these fundamental physical quantities.

[2] For those using LaTeXto generate their documentation the package siunitx is available; it is a comprehensive implementation of the SI units system: It can be highly recommended.

3.3 Coherent derived units expressed in terms of SI base units

Derived units are expressed algebraically in terms of base units or other derived units. The symbols for derived units are obtained by means of the mathematical operations of multiplication and division, e.g., density has the unity $\mathrm{kg\,m^{-3}}$.

Derived quantity	Name	Unit	Unit
area	square meter	$\mathrm{m^2}$	
volume	cubic meter	$\mathrm{m^3}$	
speed, velocity	meter per second	$\mathrm{m\,s^{-1}}$	$\mathrm{m/s}$
acceleration	meter per second squared	$\mathrm{m\,s^{-2}}$	$\mathrm{m/s^2}$
density, mass density	kilogram per cubic meter	$\mathrm{kg\,m^{-3}}$	$\mathrm{kg/m^3}$
specific volume	cubic meter per kilogram	$\mathrm{m^3\,kg^{-1}}$	$\mathrm{m^3/kg}$
current density	ampere per square meter	$\mathrm{A\,m^{-2}}$	$\mathrm{A/m^2}$
magnetic field strength	ampere per meter	$\mathrm{A\,m^{-1}}$	$\mathrm{A/m}$
luminance	candela per square meter	$\mathrm{cd\,m^{-2}}$	$\mathrm{cd/m^2}$
substance concentration	mole per cubic meter	$\mathrm{mol\,m^{-3}}$	$\mathrm{mol/m^3}$

Table 3.2: Examples of SI coherent derived units expressed in terms of SI base units. Two alternative formats are provided for the units.

3.4 Derived units with special names and symbols

The SI system defines 22 derived units with special names and symbols. These are for quantities which are commonly used. A derived unit can often be expressed in a number different ways, e.g. through the use of base units or derived units with special names. In practice, with certain quantities, preference is given to using certain units with special names, or combinations of units, to facilitate the distinction between quantities whose values have identical expressions in terms of SI base units. For example, the SI unit of frequency is specified as the hertz (Hz) rather than the reciprocal second ($\mathrm{s^{-1}}$), and the SI unit of torque (moment of force) is specified as the Newton-meter ($\mathrm{N\,m}$) rather than the joule (J).

Quantity	Special Name	Symbol	Combined	Base Si
plane angle	radian	rad	1	$\mathrm{m\,m^{-1}}$
solid angle	steradian	sr	1	$\mathrm{m^2\,m^{-2}}$
force	Newton	N		$\mathrm{m\,kg\,s^{-2}}$
frequency	Hertz	Hz		$\mathrm{s^{-1}}$
pressure, stress	Pascal	Pa	$\mathrm{N\,m^{-2}}$	$\mathrm{kg\,m^{-1}\,s^{-2}}$
energy	Joule	J	N m	$\mathrm{m^2\,kg\,s^{-2}}$
power, work	Watt	W	$\mathrm{J\,s^{-1}}$	$\mathrm{m^2\,kg\,s^{-3}}$
electric charge	Coulomb	C		A s
electric potential	Volt	V	$\mathrm{W\,A^{-1}}$	$\mathrm{m^2\,kg\,s^{-3}\,A^{-1}}$
capacitance	Farad	F	$\mathrm{C\,V^{-1}}$	$\mathrm{m^{-2}\,kg^{-1}\,s^4\,A^2}$
electric resistance	Ohm	Ω	V A	$\mathrm{kg\,s^{-3}\,A^{-2}}$
electric conductance	Siemens	S	$\mathrm{A\,V^{-1}}$	$\mathrm{m^{-2}\,kg^{-1}\,s^3\,A^2}$
magnetic flux	Weber	Wb	V s	$\mathrm{m^2\,kg\,s^{-2}\,A^{-1}}$
magnetic flux density	Tesla	T	$\mathrm{Wb\,m^{-2}}$	$\mathrm{kg\,s^{-2}\,A^{-1}}$
inductance	Henry	H	$\mathrm{Wb\,A^{-1}}$	$\mathrm{m^2\,kg\,s^{-2}\,A^{-2}}$
Celsius temperature	degree Celsius	°C		K
luminous flux	lumen	lm	cd sr	cd
illuminance	lux	lx	$\mathrm{lm\,m^2}$	$\mathrm{cd\,m^{-2}}$
activity referred to a radionuclide	Becquerel	Bq		$\mathrm{s^{-1}}$
absorbed dose	Gray	Gy	J kg	$\mathrm{m^2\,s^2}$
dose equivalent	Sievert	Sv	J kg	$\mathrm{m^2\,s^2}$
catalytic activity	katal	kat		$\mathrm{s^{-1}\,mol}$

Table 3.3: The 22 SI coherent derived units with special names and symbols

3.4.1 Additional Units without special Symbols

There are many additional commonly used quantities which have special names but do not have special symbols, a short list is given in Table 3.4.

Quantity	Special Name	Symbol	Base Si
moment of force, torque	newton meter	N m	$\mathrm{m^2\,kg\,s^{-2}}$
surface tension	newton per meter	$\mathrm{N\,m^{-1}}$	$\mathrm{kg\,s^{-2}}$
angular velocity	radian per second	$\mathrm{rad\,s^{-1}}$	/ sec
angular acceleration	radian per second squared	$\mathrm{rad\,s^{-2}}$	$/\,\mathrm{sec^2}$

Table 3.4: Examples of SI derived units with special names

3.5 Non-SI Units

There are *NON-SI-Units* which are accepted for use in conjunction with the SI system. The most prominent members are listed in Table 3.5

Quantity	Special Name	Symbol	Value in base SI units
Time	minute	min	$1\,\mathrm{min} = 60\,\mathrm{s}$
	hour	h	$1\,\mathrm{h} = 60\,\mathrm{min} = 3600\,\mathrm{s}$
	day	d	$1\,\mathrm{d} = 24\,\mathrm{h} = 1440\,\mathrm{min} = 86\,400\,\mathrm{s}$
Angle	degree	$^\circ$	$1^\circ = \pi/180\,\mathrm{rad}$
	minute	$'$	$1' = 1/60^\circ = \pi/10\,800\,\mathrm{rad}$
	second	$''$	$1'' = 1/60' = \pi/648\,000\,\mathrm{rad}$
			Example: $\phi = 13^\circ 4' 14''$
Area	hectar	ha	$10^4\,\mathrm{m}^2$
Volume	Liter	l	$1\,\mathrm{l} = 10^{-3}\,\mathrm{m}^3$
	Liter	L	$1\,\mathrm{L} = 10^{-3}\,\mathrm{m}^3$ (recomended in the US)
Mass	metric ton, tonne	t	$1\,\mathrm{t} = 10^3\,\mathrm{kg}$

Table 3.5: Non SI units accepted for use with the SI

3.6 Scaling prefixes for decimal numbers

The SI system defines a set of prefixes to denote scaling of variable in multiples of 1×10^3, see Table 3.6. It is important to observe the correst use of upper- and lower-case letters.

Factor	Name	Symbol
10^{24}	yotta	Y
10^{21}	zetta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da

Factor	Name	Symbol
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

Table 3.6: SI system of prefixes for decimal scaling factors.

3.7 Scaling prefixes for binary numbers

Binary data is expressed in units of bits (symbol bit) and bytes (symbol B). The binary scaling prefixed are shown in Table 3.7, e.g., 30 Kibit or 30×2^{10} bit.

Name	Symbol	n power of 2	Value
kibi	Ki	10	1024^1
mebi	Mi	20	1024^2
gibi	Gi	30	1024^3
tebi	Ti	40	1024^4
pebi	Pi	50	1024^5
exbi	Ei	60	1024^6
zebi	Zi	70	1024^7
yobi	Yi	80	1024^8

Table 3.7: Binary prefixes for scaling in powers of 2. These are used in conjunction with bits and bytes.

3.8 Logarithmic quantities and units: neper, bel

This section briefly introduces logarithmic quantities and units. It is based on Ref. ??: IEC 60027-3, which should be consulted for further details. Two of the most common logarithmic quantities are level-of-a-field-quantity, symbol L_F, and level-of-a-power-quantity, symbol L_F; and two of the most common logarithmic units are the units in which the values of these quantities are expressed: the neper, symbol Np, or the bel, symbol B, and decimal multiples and sub-multiples of the neper and bel formed by attaching SI prefixes to them, e.g., the decibel, symbol dB (1 dB = 0.1 B).

Level-of-a-field-quantity is defined by the relation $L_F = \log_{10}(F/F_0)$, where F/F_0 is the ratio of two amplitudes of the same kind, F_0 being a reference amplitude. Level-of-a-power-quantity is defined by the relation $L_P = (1/2)\log_{10}(P/P_0)$, where P/P_0 is the ratio of two powers, P_0 being a reference power. It is clear from their definitions that both L_F and L_P are quantities of dimension one and thus have as their units the unit one, symbol 1. However, in this case, it is convenient to give the unit one the special name , e.g., “bel” and to define these so-called dimensionless units as follows: 1 B is the level-of-a-power-quantity when $P/P_0 = 10$, that is, when $\log_{10}(P/P_0) = 1$.

3.9 Rules and style conventions when using units

3.9.1 Typeface

Unit symbols are printed in roman (upright) typeface independent of the typeface used in the surrounding text.

3.9.2 Capitalization

Unit symbols are printed in lower-case letters except when: the symbol or the first letter of the symbol is an upper-case letter when the name of the unit is derived from the name of a person, e.g. Weber (Wb), Pascal (Pa), Volt (V); and the recommended symbol for the liter in the United States is L.

3.9.3 Plurals

Unit symbols are unaltered in the plural.

3.9.4 Punctuation

Unit symbols are not followed by a full-stop (period) unless at the end of a sentence.

3.9.5 Unit symbols obtained by multiplication

There are multiple formats for representing units consisting of the concatenation of other units. It is a matter of preference which you prefer to use; however, you should be consistent within your reporting. For example,

$$k = 300.4\,\mathrm{W\,m^{-2}\,s^{-1}}, or \tag{3.1}$$

$$k = 300.4\,\mathrm{W \cdot m^{-2} \cdot s^{-1}}, or \tag{3.2}$$

$$k = 300.4\,\mathrm{W/(m^2\,s)}, or \tag{3.3}$$

$$k = 300.4\,\mathrm{W/(m^2 \cdot s)}. \tag{3.4}$$

Some care needs to be taken to avoid possible confusion. The following example shows the danger of confusing $\mathrm{m/s}$ (meters-per-second) and $\mathrm{ms^{-1}}$ (per-milli-

second). The use of symbol for division rather than the reciprocal usually avoids this difficulty.

$$v_c = 3.14\,\mathrm{m\,s^{-1}} \qquad \text{or} \qquad v_c = 3.14\,\mathrm{m/s} \tag{3.5}$$

$$k_C = 3.14\,\mathrm{ms^{-1}} \qquad \text{or} \qquad k_C = 3.14/\mathrm{ms} \tag{3.6}$$

3.9.6 Ambiguity when writing about ranges

It is important to be unambitious when writing about ranges, for example: 0 °C to 100 °C. The units should be included both at the start and end of the range definition, for example:

1. In the range from 0 °C to 100 °C, but not 0 to 100 °C,
2. The dimensions are $112\,\mathrm{m} \times 2\,\mathrm{m} \times 5\,\mathrm{m}$, but not $112 \times 2 \times 5\,\mathrm{m}$.

3.9.7 Grouping digits of numbers

Special case is needed in German speaking countries since the comma is used as a decimal separator, which in English speaking countries the full stop is used. The issue is further aggravated with programs parameterized for the German language. You must use the standard definition for numbers.

Because the comma is widely used as the decimal marker outside the United States, it should not be used to separate digits into groups of three. Instead, digits should be separated into groups of three, counting from the decimal marker towards the left and right, by the use of a thin, fixed space. However, this practice is not usually followed for numbers having only four digits on either side of the decimal marker except when uniformity in a table is desired.

Examples:

- 76 483 522 but not: 76,483,522,
- or even more confusing 43 279.168 29 but not: 43,279.16829
- or 8012 but not: 8,012,
- $B_0 = 0.183\,324\,722$ is preferred to: $B_0 = 0.183324722$

Note: The practice of using a space to group digits is not usually followed in certain specialized applications, such as engineering drawings and financial statements.

3.9.8 Some general notes

1. If the intended audience for a publication is unlikely to be familiar with a particular unit symbol, it should be defined when first used.
2. Since the use of the spelled-out name of an Arabic numeral with a unit symbol can cause confusion, such combinations must strictly be avoided. For example, one should never write *the length of the rod is five m*. To avoid any possible misunderstandings and to associate symbols with variable names it is preferable to write in the following manner, *the length of the rod,* $l_r = 5\,\mathrm{m}$.
3. You may use spelt out number when used in a literary manner, e.g, There are *two* rods each of length $l_r = 5\,\mathrm{m}$.
4. The United States Government Printing Office Style Manual (Ref. ??, pp. 181-189) gives the rule that symbols for numbers are always to be used when one expresses (a) the value of a quantity in terms of a unit of measurement, (b) time (including dates), and (c) an amount of money. This publication should be consulted for the rules governing the choice between the use of symbols for numbers and the spelled-out names of numbers when numbers are dealt with in general.
5. Unit symbols are never used as abbreviations in sentences.
6. A digit is significant[3] if it is required to express the numerical value of a quantity. In the expression $l = 1200\,\mathrm{m}$, it is not possible to tell whether the last two zeroes are significant or only indicate the magnitude of the numerical value of l. However, in the expression $l = 1.200\,\mathrm{km}$, which uses the SI prefix symbol for 1×10^3 (kilo, symbol k), the two zeroes are assumed to be significant because if they were not, the value of l would have been written $l = 1.2\,\mathrm{km}$.
7. A quantity equation expresses a relation among quantities. An example is $l = vt$, where l is the distance a particle in uniform motion with velocity v travels in the time t. At this point the equations is independent of units. It is strongly recommended to use quantity equations, because of their universality, quantity equations should be used in preference to numerical-value equations. The numerical values may be entered at a later point in tome.

3.10 Formatting Symbols in Equations according to ISO 80000

The following is a list of the most commonly needed definitions from the ISO 80000 standard:

1. Variables such as x, y, etc., and running numbers, such as i in $\sum_{i=1}^{n} x_i$ are printed in italic typeface. Parameters, such as a, b, which may be considered as constant in a specific context, are printed in italic typeface. The same applies to functions in general, e.g. $y = f(t)$.

[3] There is a separate chapter on reporting uncertainty. There are more details in that chapter on different systems of reporting uncertainty and significant digits.

2. An explicitly defined function not depending on the context is, however, printed in Roman (independent of the font used in the rest of the text) upright typeface, e.g., sin, ln, exp etc.
3. Note, the letter d in, e.g., the following mathematical elements,

$$\frac{\mathrm{d}y}{\mathrm{d}x} \qquad \text{or} \qquad y = \int f(t)\,\mathrm{d}t, \tag{3.7}$$

represents the differential operator and not a variable; consequently it should be in upright typeface.
4. Mathematical and fundamental constants, whose values never change are printed in Roman (independent of the font used in the rest of the text) upright typeface, e.g. $\mathrm{e} = 2.718\,281\,828$, $\mathrm{i} = \mathrm{j} = \sqrt{-1}$, etc.
5. Numbers expressed in the form of digits are always printed in Roman upright typeface, e.g. $\pi = 3.141\,592\,653$.
6. The argument of a function is written in parameterises after the symbol for the function, without a space, e.g., $y(t) = \cos(2\pi\omega t)$. In very simple cases the parameterises may be omitted; however, we do not recommend this practice.
7. If an expression or equation must be split into two or more lines, place breaks immediately after one of the following symbols $=, +, -, \pm, \mp$ or similar.
8. It is customary to use different sorts of letters for different sorts of entities. This makes formulas more readable and helps in setting up the appropriate context.
9. No symbol is required to indicate multiplication in an equation, e.g., $y = ax$ and not $y = a \cdot x$. The use of the center dot is incorrect and will lead to confusion when working with vector equations.
10. A list of formatting rules pertaining to matrices and vectors is given in Table 3.8.

Element	Example	Comment
Matrix	M	Capital letters, we have chosen upright sanserif font to ensure a clear differentiation. Other typefaces may be used but you must remain consistent.
Matrix transpose	M^{T}	Note the transpose is an operator and with this should be upright.
Matrix inverse	M^{-1}	
Matrix norm	$\|\mathsf{M}\|_p$	The p norm of a matrix.
Identity matrix	I	
Zero matrix	$\mathsf{0}$	
Hadamard operator	$\mathsf{C} = \mathsf{A} \circ \mathsf{B}$	Implies $\mathsf{C}_{ik} = \mathsf{A}_{ik}\,\mathsf{B}_{ik}$.
Vector	$\mathbf{x}$	Bold italic, e.g., $\mathbf{z} = \mathsf{M}\,\mathbf{x}$.
Vector transpose	$\mathbf{x}^{\mathrm{T}}$	
Zero vector	$\mathbf{0}$	

Table 3.8: List of commonly used formatting when working with matrix-vector equations.

Part II
Latex primer and template

Chapter 4
Introduction to the book template

The *test now* basic concept of the book template is to put each chapter in a separate directory. The top directory then contains the *main document* which assembles the complete document from its parts. The main idea behind this documents is that you also have the complete LaTeX source and all directories with their respective files required to generate this document. That is, you can look at the source to see how I created this document.

The basis structure of the main document is:

Listing 4.1: This LaTeXcode defines a template for the generation of a book

```
%
\frontmatter
\tableofcontents
\listoffigures
%
\mainmatter
\include{introduction/introduction}
\include{leoben/leoben}
%
\backmatter
\printindex
```

4.1 Basic structure

The LaTeXcode shown in Listing 4.1 defines the *front matter*, *main matter* and *back matter* with the commands `\frontmatter`, `\mainmatter` and `backmatter` respectively[1].

[1] Note I have define the command *emphi*, to emphasise a word or phrase and to automatically include it in the index.

4.1.1 Front matter

The front mater usually contains material such as: the table of contents, a list of figures, possibly a definition of acronyms etc.

By default the pages of the front matter are numbered with roman numerals and the arabic numbering starts with the main matter. You can use the command `\pagenumbering{Arabic}`to set arabic style page numbering for the front matter.

4.1.2 Main matter

The main mater, as the name suggests, contains the main matter of the book, i.e., the chapters.

4.1.3 Back matter

The back mater will normally contain the index, bibliography etc. For this document I have chosen to put a bibliography at the end of each chapter.

4.2 Structuring commands: parts, chapters etc

A book can be structured into Parts, Chapters, Sections, Subsection and Subsubsections with the commands `\part`, `\chapter`, `\section`,`\subsection`and `\subsubsection`, respectively. The command `\appendix` creates an appendix.

I suggest putting each chapter and appendix into it's own directory. Figure 4.1 showes and example from a text I am preparing on time series analysis. This is the directory associated with comma separated value files (CSV). The figures required for the chapter are contained in the figures directory, this ensures a tidy environment. I also keep the MATLAB code, and other documents associated with the chapter in the same directory.

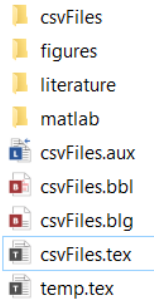

Fig. 4.1: Example of a directory for the files associated with a chapter on CSV files.

4.3 Include only

When writing a large document you may have many chapters. However, when working on a specific chapter you may wish to compile the document with all cross reference but only generate the PDF for the secrion you are working on. For this case there is the *includeonly* command. You place the command prior to starting the document, the following example would only include the preface in the PDF.

```
...
\includeonly{preface/preface}
%
\begin{document}
...
```

4.4 Things to add

1. new commands
2. bibliography
3. reference to latex book.

Chapter 5
Text

A collection of text is regarded as a paragraph until an empty line is encountered. Unfortunately, some tools try to be too smart with text wrapping and this can lead to exceptions.

5.1 Emphasises

It is common to *emphasise* a technical term when it is used for the first time. This simples solution to this is to use the `\emph{}`command. You may wish to define a command which emphasises a word and also enters it into the index. This is helpful when you wish to have an index entry to the first definition of a word. An example for such a definition is:

```
\newcommand{\emphi}[1]{\emph{#1}\index{#1}}.
```

5.2 Text alignment

5.2.1 Centering

The command:

```
\begin{center} ... \end{center}
```

can be used to center text.

5.2.2 Left and Right Justification

The commands:

```
\begin{flushleft} ... \end{flushleft}, and
\begin{flushright} ... \end{flushright}.
```

perform left and right justification, e.g., flushright

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University of Leoben
2017

5.3 Quotation marks

The correct opening and closing *quotation marks* are created in LaTeXusing:

`'text'`	creates 'text', and
`` ``text'' ```	creates "text", also
`` ``text" ```	creates "text"

5.4 Quotations, verses

There are two environments for quotations:

```
\begin{quote} ... \end{quote}, and
\begin{quotation} ... \end{quotation}.
```

"A fish swims in the ocean, and no matter how far it swims there is no end to the water. A bird flies in the sky, and no matter how far it flies there is no end to the air. However, the fish and the bird have never left their elements. When their activity is large their field is large. When their need is small their field is small. Thus, each of them totally covers its full range, and each of them totally experiences its realm."

Dogen

quote uses indentation to indicate paragraphs, whereas *quotation* uses extra spacing between the paragraphs.

The *verse* environment is more suitable for poetry; individual lines are separated using `\\` and blank lines indicate the next stanza, e.g.,

★ BEGINNEN
Begehen

Schritt für Schritt

Die alten Wege verlassen
Um neue Wege zu finden

Begegnen

Die neuen Wege verlassen
Um weiter zu gehen.

Alois Hergouth – aus Umkreisung der Nacht.

5.5 Lists

There are three standard list environments,

```
\begin{itemize} ... \end{itemize},
\begin{enumerate} ... \end{enumerate} and
\begin{description} ... \end{description},
```

whereby, the entries are denoted by `\item`for *itemize* and *enumerate*. In the case of *description* the `\item[text]` is concatenated with the text which will function as the bullet. I recommend using enumerate rather than itemize, it makes it easier to refer directly to the item via its number.

In the following example I have used the *minipage* environment to generate subpages within the current column. These is one list per mini page.

- bla
- bla bla
- bla bla bla

1. bla
2. bla bla
3. bla bla bla

bla bla
bla bla bla
bla bla bla bla

The list environments may be nested as required and different types used within the nesting.

5.6 Verbatim

Sometimes we wish to print some text as *verbatim*, i.e., exactly as it is without any interpretation of the contained text.

1. In-line verbatim can be generated using the `\verb` or `\verb*` commands. They have the following structure: `\verb` *delimiter verbatim_text. delimiter.* The text between the two delimiters is presented verbatim.

   `\verb!test text with spaces!`
   generates: `test text with spaces`
   and
   `\verb*!test text with spaces!`
   generates: `test␣text␣with␣spaces`

The $\star$ form marks the spaces with ␣ to make them visible.
2. Alternatively you can use the verbatim environment, with
   `\begin{verbatim}`
   ...
   `\end{verbatim}`.

5.7 Margin paragraphs

Margin paragraph

The `\marginpar`is provided to enable text setting in the margin (probably more correctly called the gutter). *Margin paragraphs* may be used to draw attention to special portions of text or to reiterate definitions in a particularly visible manner.

`\marginpar[Text]`sets the text in the left column, while `\marginpar{Text}`sets the text in the right column.

5.8 Footnotes

Footnotes are defined using the `\footnote{text}`. by default the footnotes are placed at the bottom of the page[1]

5.9 Additional spacing

There are a number of commands which enable manual adjustment of spacing:

[1] Footnotes are good to add additional information to a specific aspect of a statement, without interrupting the flow of the text. They belong to scientific publication.

Command	Explanation
`\hspace{1cm}`	Will leave a horizontal spacing of 1cm, for example here.
`\quad`	This command inserts a horizontal spacing equal to the current font size, e.g., 10pt in the case of a 10pt font.
`\qquad`	Inserts a double quad
`\,`	small space of $3/18$ of a quad
`\:`	medium space of $4/18$ of a quad
`\;`	large space of $5/18$ of a quad
`\!`	negative space of $-3/18$ of a quad
`\hfill`	fills the horizontal space available.
`\dotfill`	fills the horizontal ..... space available.
`\hrulefill`	fills the horizontal _____ space available.
`\\[1cm]`	generates a new line with a 1cm spacing following the line, e.g. I have used them to give this table some extra structure.
`\newpage`	will start a new page
`\clearpage`	will force the output of all pending figures and tables (actually all floating environments) and then start a new page.

Table 5.1: Selection of text spacing commands. These spacings are helpfull when making equations optically more pleasant. This table is generated using the *table* and *tabular* environments

5.10 Labels and cross references

LaTeX provides the commands *label* and *ref* to define labels for objects and references to these labels. It is important to define a structured format you are going to use for labels. I suggest the following structure.

```
<Chapter abbreviation>:<Object type>:<name>
```

for example, `\label{text:table:ListOfFonts}`. This would refer to the chapter on *text*, it refers to a *table* and the table name is *ListOfFonts*. the object types I often encounter are:

Object	Abbreviation	Comment
Equation	eqn	A methematical equation
Tabel, tabular	tab	I use the same abbreviation for tables and tabular environments
Matlab code	mcode	I use the listings package to present MATLAB code in a document
Chapter	*abbrev*	I give each chapter a specific abbreviation, I prefer this to a generic solution, since I then know which chapter the object belongs to.
Figure	fig	Reference to a figure.

5.11 Listings

I use the listing package to document MATLAB code in LaTeX. It supports for example inline code plot(x,y,'k') (command `\lstinline{plot(x,y,'k')}`). The following is an example for a code snippet, The following is an example of a listing with caption and label. This means we can reference Listing 5.1. The listings package provides for context sensitive coloring of the code. This requires a definition for the language syntax. The following lines are required to configure the listings package for MATLAB . You only need to configure once for the whole document.

```
%
% Setup the listings package for MATLAB
%
\lstset{language=Matlab,basicstyle=\small\ttfamily,
commentstyle=\color[rgb]{.133,.545,.133}\small\ttfamily,
keywordstyle=\color[rgb]{0,0,1}\ttfamily\small,
stringstyle=\color[rgb]{.627,.126,.941}\ttfamily\small,
showstringspaces=false,
xleftmargin=0.8cm,
resetmargins=true,
escapechar=\$,
captionpos=b,
breaklines=true,
breakatwhitespace=false,
breakindent=2cm,
numbers=left,
numbersep=2ex,
numberstyle=\small\ttfamily,
columns=flexible}
```

The following is an example of a MATLAB listing,

```
1     % Define the coefficients
2     cfsY = [1, 1, -1, 0];
3     % Generate the values
4     nrPts = 200;
5     x = linspace( -1, 1, nrPts )';
6     y = polyval( cfsY, x );
7     dy = polyval( polyder( cfsY ), x );
```

Listing 5.1: Code to generate values of a cubic polynomial and its first derivative.

The above listing was created using the following commands:

```
\begin{lstlisting}[caption={Code to generate values of a cubic
    polynomial and its first derivative.},label=text/mcode/adata]
    % Define the coefficients
    cfsY = [1, 1, -1, 0];
    % Generate the values
```

```
    nrPts = 200;
    x = linspace( -1, 1, nrPts )';
    y = polyval( cfsY, x );
    dy = polyval( polyder( cfsY ), x );
\end{lstlisting}
```

5.12 Font attributes

5.12.1 Predefined font sizes

Table 5.2 shows the predefined modifiers to find sizes.

Command	Explanation
`\tiny`	Leoben
`\scriptsize`	Leoben
`\footnotesize`	Leoben
`\small`	Leoben
`\normalsize`	Leoben
`\large`	Leoben
`\Large`	Leoben
`\LARGE`	Leoben
`\huge`	Leoben
`\Huge`	Leoben

Table 5.2: Predefined definitions for font sizes

5.12.2 Font families, shapes and series

Your LaTeXinstallation may have a number of additional fonts; however, there is a set of defaults which are available in any LaTeXinstallation, see. Table 5.3

Family	
\rmfamily	Switches to a default Roman font
\ttfamily	Switches to a typewriter font
\sffamily	Switches to a sans serif font

Shape	
\upshape	Switches to an upright font
\itshape	*Switches to an italic font*
\slshape	*Switches to an slanted font*
\scshape	Switches to LARGE AND SMALL CAPITALS

Series	
\mdseries	Switches to a medium font
\bfseries	**Switches to a bold font**
\normalfont	returns all settings to the predefined font.

Table 5.3: Default font family, shapes and series available in the minimal installation of LaTeX.

5.13 Bibliography and citations

The companion tool to LaTeX 2ε is Bibtex and supports the definition of bibliographies. The standard tools such as *end-note* and *Citavi* can export bibtex compatible files. The basic mechanism is that you have bibliography entries, e.g.,

```
@inproceedings{
olearyHarker2008,
Author = {O'Leary, Paul and Harker, Matthew and Suesut, Taweepol},
Title = {Combined Polynomial and Periodic Moments for the Analysis of Measured 3D Surfaces},
BookTitle = {Internationational Intrumentation and Measurement Technology Conference},
Address= {Victoria, Canada},
Pages = {1..8},
Year = {2008} }
```

. are stored in a .bib file. A .bst file (Bibliography style tex) defines the types of entries which are foreseen. Each entry has a label, in this case `olearyHarker2008`. The respective document [1] is cited via this label, the required code is

```
~\cite{olearyHarker2008}
```

for this example.

The *cite* commands leads LaTeXto collect all the reference data to the bibliography. It is then the Bibtex program that generates the entries in the bibliography.

The bibliography is generate in the document using the commands:

```
\bibliographystyle{spbasic}
\bibliography{text/bibliography}
```

these define the style of the bibliography and inserts the references from the define bibliography.

References

[1] O'Leary P, Harker M, Suesut T (2008) Combined polynomial and periodic moments for the analysis of measured 3d surfaces. In: Internationational Intrumentation and Measurement Technology Conference, Victoria, Canada, p 1..8

Chapter 6
Mathematical formulas

The possibility to set equations is a truly professional manner is my main reason to use LaTeX. The American Mathematical Society (AMS) make sets of fonts available, which cover virtually all symbols you may wish to use in your formulas. they are contained in the packages:

This is what LaTeX is all about.

```
\usepackage{amsmath}
\usepackage{amssymb}
\usepackage{amsbsy}
```

I recommend you use these in all your formulæ.

As a starting point I would like to suggest splitting the types of formula with which we work into two categories:

1. Classical mathematical equations, whereby the variables are neither vectors nor matrices, e.g. Einstein's most famous equation $E = mc^2$. In general, there will be no need to define new symbols or conventions. Furthermore, most LaTeX tools have tool bars with many tabs to support you. These are the equations most commonly encountered by students.
2. When working with matrices, vectors and families of polynomials we need to define a convention we are going to use. The convention you define should be in agreement with the ISO 80 000. Furthermore, it is advantageous if the convention is agreed upon by the group working together. I then recommend that you use the `\newcommand` to define macros to implement the convention. In this manner there is only one definition which needs to be modified to change the representation used throughout the complete document.

6.1 Inline equations

LaTeX foresees both *inline formula* and formula in a separate environment. For example, $E = mc^2$ is an example of an inline equation, i.e., the equation is part

of the text line. This is achieved by wrapping the equation definition by a pair of dollar signs, here is the LaTeX source for this example,

```
For example, $E = m cˆ2$ is an example...
```

6.2 Equation environments

The two environments I most commonly use when writing equations are the *equation* and *align environments*,

```
\begin{equation}
    formula definition
\end{equation}.
```

and

```
\begin{align}
    equation 1 ...
    equation 2 ...
\end{align}
```

6.2.1 Single equation

The equation environment is used to put an equation on a line for itself. It also automatically numbers all equations.

I recommend writing equations similar to writing computer code. The first example I shall use is the Laplace transform,

$$\mathcal{L}\{f(t)\} = \int_{0^-}^{\infty} f(t)\,\mathrm{e}^{-st}\,\mathrm{d}t. \tag{6.1}$$

This equations is generated from the following definition:

```
\begin{equation}
   \mathcal{L}\left\{ f(t) \right\}
   =
   \int_{0ˆ-}ˆ{\infty}   f(t) \, \meˆ{- s t} \md t.
\end{equation}
```

I have separated the definition of the left and right hand sides (LHS, RHS) of the equation onto separate lines. I find it easier to keep track of the sometimes complex list of symbols required to define the formula. Note: you may not have empty lines in an equation environment, you can however, use comment lines. The limits for the

integral can also be placed above and below the integral symbol using the `\limits` command, e.g.

$$\mathscr{L}\{f(t)\} \triangleq \int\limits_{0^-}^{\infty} f(t)\,\mathrm{e}^{-st}\,\mathrm{d}t \tag{6.2}$$

generated using,

```
\begin{equation}
   \mathcal{L}\left\{ f(t) \right\}
   =
   \int\limits_{0^-}^{\infty}
        f(t) \, \me^{- s t} \md t.
\end{equation}
```

This is a matter of taste and/or preference. In papers with a limited number of pages this may consume unnecessary space.

6.2.2 Aligning multiple equations

The *align environment* enable the alignment of multiple equations at a desired position in the equation. The `&` symbol is used to denote the position in the formula where the alignment is desired, for example,

$$\begin{aligned} y(t) &= (t-1)^2\,(t-2) \\ &= (t^2-2t+1)\,(t-2) && (6.3)\\ &= t^3-4t^2+5t-2 && (6.4) \end{aligned}$$

is generated using

```
\begin{align}
   y(t) & = (t - 1)^2\,(t-2) \notag\\
          & = (t^2 - 2\,t + 1) \, (t-2) \\
          & = t^3 - 4\,t^2 + 5\,t - 2
\end{align}
```

Note additionally, that I have used the `\notag` command to suppress the numbering of the first equation in this group.

6.3 Automatic scaling brackets

When we place brackets around lager expressions it is required to have the brackets scale to be appropriate for the expression contained within. The `\left` and `\right` commands are provided to this end, they must appear as pairs. In equations

they will most commonly be applied to the brackets `( )`, braces `{ }` and square brackets `[ ]`.

$$y(x) = \left[\frac{x}{1 + \frac{x}{1-x}} \right] \tag{6.5}$$

generated using

```
\begin{equation}
  y(x) = \left[
                \frac{x}{1 + \frac{x}{1 - x}}
            \right]
\end{equation}
```

An *invisible bracket* can be generated by placing a period after the left or right commands, e.g.

$$y(x) = \left. \frac{x}{1 + \frac{x}{1-x}} \right|_{x \rightarrow \infty} \tag{6.6}$$

generate using

```
y(x) = \left.
                \frac{x}{1 + \frac{x}{1 - x}}
            \right|_{x \rightarrow \infty}
```

6.4 Subscripts and superscripts

Subscripts and *superscripts* are generated using the symbols `^` and `_` respectively. However they operate only on a single following object. Consequently, to subscript more then one symbol you need to wrap them with braces `{...}`. The subscript and superscript mechanism is also used to define limits in mathematical operators, e.g., in integrals, sums, products etc.

6.5 Cases environment

The *cases environment* is from the AMS packages, e.g.

$$y = \begin{cases} -1, & \text{if } x < 0 \\ 0, & \text{if } x = 0 \\ 1, & \text{otherwise.} \end{cases} \tag{6.7}$$

generated using

```
y =
```

```
\begin{cases}
  -1, & \mbox{if } x < 0 \\
  0, & \mbox{if } x = 0 \\
  1, & \mbox{otherwise}.
\end{cases}
```

6.6 Matrices and Vectors

We have define a series of commands to support the writing of matrix equations. The definitions from Table 6.1

Command	Example	collent
`\V{ }`	$\mathbf{z}$	To define a vector.
`\VT{ }`	$\mathbf{z}^{\mathrm{T}}$	To define a transposed vector.
`\M{ }`	D	To define a matrix.
`\MT{ }`	D^{T}	To define a transposed matrix.
`\MI{ }`	D^{-1}	The inverse of a matrix.
`\MP{ }`	D^{+}	The Moore-Penrose pseudo inverse of a matrix.
`\MG{ }`	D^{-}	A generalized inverse of a matrix.
`\trace{ }`	$\mathrm{trace}\{\mathsf{D}\}$	The trace of a matrix.
`\rank{ }`	$\mathrm{rank}\{\mathsf{D}\}$	The rank of a matrix..
`\Det{ }`	$\lvert\mathsf{D}\rvert$	The determinant of a matrix.
`\diag{ }`	$\mathrm{diag}\{\mathsf{D}\}$	The diagonal inverse of a matrix.
`\nullM{ }`	$\mathrm{null}\{\mathsf{D}\}$	The null space of a matrix.
`\spanM{ }`	$\mathrm{span}\{\mathsf{D}\}$	The span of a matrix.

Table 6.1: A collection of commands defined to simplify the writing of matrix-vector equations.

The *bmatrix* environment is suitable for defining vectors and matrices with its individual entries, e.g.,

Mathematical element	LaTeX definition
$\mathbf{b} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}$	`\V{b} = \begin{bmatrix} b_{1}\\ b_{2}\\ b_{3} \end{bmatrix}\notag`
$\mathsf{A} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \end{bmatrix}$	`\M{M} = \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \\ m_{31} & m_{32} \end{bmatrix}`
Now used in a vector matrix equation. $\mathbf{c} = \mathsf{A}\mathbf{b}.$	`\V{c} = \M{A} \, \V{b}`

6.7 Some examples of formula

The following table give some examples of mathematical symbols and structures in LaTeX.

Formula	LaTeXcode
$\sqrt[n]{x}$	`\sqrt[n]{x}`
$\frac{x}{x-n}$	`\frac{x}{x - n}`
$\int_0^\infty f(t)\,\mathrm{d}t$	`\int_0^\infty f(t) \md t`
$\sum_{k=0}^{n} a_k x^k$	`\sum_{k=0}^n a_k \, x^k`
$\prod_{k=0}^{n} a_k x^k$	`\prod_{k=0}^n a_k \, x^k`

Table 6.2: Example formula. The equations in this table have been generated using the *inline* equation mode, for this reason they are smaller than when generated in a separate equation environment.

6.7.1 Another example

$$x_{med} = \begin{cases} x_{\frac{n+1}{2}}, & \text{if } n \text{ is odd} \\ \frac{1}{2}\left(x_{n/2} + x_{n/3}\right), & \text{otherwise.} \end{cases} \tag{6.8}$$

and the necessary code:

```
x_{med } =
\begin{cases}
  x_{\frac{n + 1}{2}}, & \mbox{if} \, n \,\text{is odd} \\[3mm]
  %
  \frac{1}{2}
      \left(
          x_{n/2} + x_{n/3}
      \right) , & \mbox{otherwise}.
\end{cases}
```

6.8 Some basic rules for formula

The following is a list of very basic rules you should follow when writing formula.

1. You do not use a $\star$ to indicate multiplication, e.g.

$$E = m \star c^2 \qquad \textbf{Incorrect} \tag{6.9}$$

$$E = mc^2 \qquad \text{Correct} \tag{6.10}$$

$$\tag{6.11}$$

2. Define symbolic names for variables which you then use in the equations, e.g., the length of the rod l_r depends on the application, in this case $l_r = 3.14m$.
3. Variables are in an italic font, e.g., m. In the above equation you may consider using an upright font for c since it is a fundamental constant.
4. The mathematical operators and fundamental constants e.g. $\mathrm{i} = \sqrt{-1}$, $\mathrm{e} = 2.7182\ldots$ and d, the differential operator, should be upright. We have defined the commands `\mi`, `\me` and `\md` to generate these symbols.
5. Vectors are in a bold italic fort, e.g., $\mathbf{z}$.
6. Matrixes are in a sans-serif upright font, e.g., A.
7. Minimize you notation while remaining sufficient, i.e., use as few subscripts etc as possible, but not to the point where clarity is lost.

Chapter 7
Figures and Graphics

Good quality graphics make a very major difference to the appearance of a scientific documentation. It also has an influence on how people regards your work. I feel it is important to make you best possible effort to generate high quality graphics.

7.1 Some basics

You need to be aware of the difference between raster graphics and vector graphics:

1. In raster graphics the figure is defined in terms of pixels. This is fine for images. However, plots produced in raster graphics will commonly have rastered fonts which do not look so professional.
2. vector graphics

7.2 Images

Two men contemplating the moon or sunset was a motive painted by Casper David Friedrich on man occasions, see figures 7.1 anf 7.2. The paintings were considered highly political because of the nationalist costumes depicted.

Fig. 7.1: Casper David Friedreich: *Two men*

This figure is generated using the code:

```
\begin{figure}[H]
    \centering
    \includegraphics[width=8cm]{graphics/figures/CDFTwoMen.jpg}
    \caption{Casper David Friedreich: \emph{Two men}}
   \label{graphics:fig:CDFTwoMen1}
\end{figure}
```

This code consists of a number of elements:

1. The `\begin{figure}` ... `\end{figure}` figure. This defines the figure environment. The `[h]` following the environment definition defines where the figure should be placed. The letters h, t, b, refer to here, top of the page and bottom of the page respectively. The *figure environment* is a, so called, floating environment. LaTeX automatically tries to place the figure so as to optimize the page layout. The *float* package defines a capital H qualifier to force the figure to be exactly here in the document.
2. `\centering` tells LaTeX to center the complete contents of the figure environment.
3. The line

   ```
   \includegraphics[width=8cm]{graphics/figures/CDFTwoMen.jpg}
   ```

   is the actual line of code which imports the figure. The PDF-TEX supports many different graphics formats. The portion with the square brackets `[width=8cm]` define the *width*, *height*, *angle* of the figure.
4. You may wish to size the figure relative to the column width, e.g, to scale to 90% of the column width you may use `[width=0.9\columnwidth]`, see Figure 7.2 where this has been used.

5. A *caption* followed by a *label*.

Fig. 7.2: Casper David Friedreich: *Two men*

7.3 Two graphics with one caption

We may wish to present two graphics side by side; however with one caption, see for example Figure 7.3

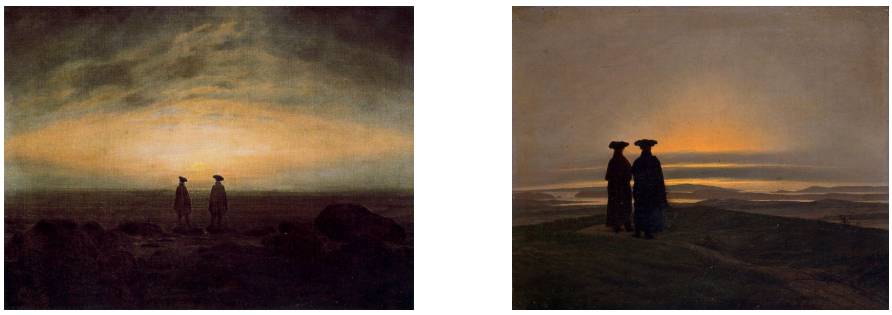


Fig. 7.3: Two of Casper David Friedreich's painting on *Two men*.

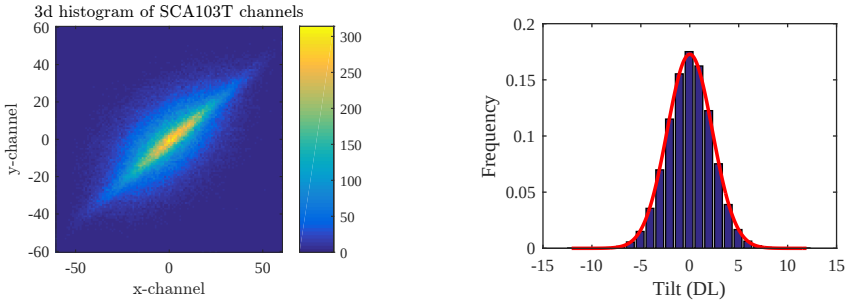
This figure is generated using the following code:

```
\centering
\includegraphics[height=4cm]{graphics/figures/CDFTwoMen.jpg}
\hfill
\includegraphics[height=4cm]{graphics/figures/CDFSunsetTwoMen.jpg}
\caption{Two of Casper David Friedreich's painting on \emph{Two men}.}
\label{graphics:fig:CDFTwoMen1and2}
```

Note in this case I have scaled the images to have the same height and used the `\hfill` command to perform a horizontal fill.

7.4 Sub-Figure environment

The *sub-figure* environment enables the definition of sub-figures within a figure.



(a) Bivariate histogram for the x and y channels

(b) Histogram for the tilt

Fig. 7.4: Example of sub-figures: each has a sub-caption and there is also a full caption. Each of the sub-figures can be labeled and references, they are assigned sub-figure numbering, e.g. see Figure 7.4(a).

The code required to generate this figure is:

```
\centering
% Subfigure 1
\subfigure[Bivariate histogram for the $x$ and $y$ channels]{
support.]{
\includegraphics[width=0.45\columnwidth]{graphics/figures/SCA103TXYCorrelation.pdf}
\label{fig:subfig1}}
\hfill
% Subfigure 2
\subfigure[Histogram for the tilt]{
\includegraphics[width=0.45\columnwidth]{graphics/figures/SignalHistSCA830.pdf}
\label{fig:subfig2}}
%
\caption{Example of sub-figures: each has a sub-caption and there is
```

```
also a full caption. Each of the sub-figures can be labeled and references,
they are assigned sub-figure numbering, e.g. see Figure~\ref{fig:subfig1}.}
%
\label{fig:subfig1and2}
```

7.5 Mini-pages

The *minipage* environment enables the definition of sub-pages within the current page. In the example I present here I will define two mini-pages, side by side, each of width 45% of the current column width. Each of these sub-pages now behavies as a normal LaTeXdocument.

Fig. 7.5: Buoy 1

Fig. 7.6: Buoy 2

Note: this has generated two completely independent figures side by side. The code required for the mini pages is:

```
\begin{minipage}[t]{0.45\columnwidth}
\centering
\includegraphics[height=4.5cm]{graphics/figures/CDFTwoMen.jpg}
\caption{Buoy 2}
\end{minipage}
\hfill
%
\begin{minipage}[t]{0.45\columnwidth}
\centering
\includegraphics[height=4.5cm]{graphics/figures/CDFSunsetTwoMen.jpg}
\caption{Buoy 2}
\end{minipage}
```

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