



SAINT VINCENT COLLEGE

DEPARTMENT OF  
PHYSICS

JOHN PIERRE MENEGHINI

# COMPUTATIONAL MODELING OF X-RAY ATTENUATION AND SIMULATION OF MEDICAL IMAGING

BACHELOR OF SCIENCE

Saint Vincent College

*Draft: April 1, 2024*



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## COMPUTATIONAL MODELING OF X-RAY ATTENUATION AND SIMULATION OF MEDICAL IMAGING

JOHN PIERRE MENEGHINI

Thesis submitted in partial fulfillment of the requirements  
for the degree of *Bachelor of Science*

**Adviser:** Fr. Michael Antonacci O.S.B  
*Associate Professor*

BACHELOR OF SCIENCE

Saint Vincent College

*Draft: April 1, 2024*

## ABSTRACT

Regardless of the language in which the dissertation is written, usually there are at least two abstracts: one abstract in the same language as the main text, and another abstract in some other language.

The abstracts' order varies with the school. If your school has specific regulations concerning the abstracts' order, the NOVAthesis L<sup>A</sup>T<sub>E</sub>X (`novathesis`) (L<sup>A</sup>T<sub>E</sub>X) template will respect them. Otherwise, the default rule in the `novathesis` template is to have in first place the abstract in *the same language as main text*, and then the abstract in *the other language*. For example, if the dissertation is written in Portuguese, the abstracts' order will be first Portuguese and then English, followed by the main text in Portuguese. If the dissertation is written in English, the abstracts' order will be first English and then Portuguese, followed by the main text in English. However, this order can be customized by adding one of the following to the file `5_packages.tex`.

```
\ntsetup{abstractorder={<LANG_1>, ..., <LANG_N>}}  
\ntsetup{abstractorder={<MAIN_LANG>={<LANG_1>, ..., <LANG_N>}}}
```

For example, for a main document written in German with abstracts written in German, English and Italian (by this order) use:

```
\ntsetup{abstractorder={de={de,en,it}}}
```

Concerning its contents, the abstracts should not exceed one page and may answer the following questions (it is essential to adapt to the usual practices of your scientific area):

1. What is the problem?
2. Why is this problem interesting/challenging?
3. What is the proposed approach/solution/contribution?
4. What results (implications/consequences) from the solution?

**Keywords:** One keyword, Another keyword, Yet another keyword, One keyword more, The last keyword

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## GLOSSARY

**computer** An electronic device which is capable of receiving information (data) in a particular form and of performing a sequence of operations in accordance with a predetermined but variable set of procedural instructions (program) to produce a result in the form of information or signals. This is a test that adds a citation [2] to the glossary! (*p. 18*)

## ACRONYMS

## S Y M B O L S

$\mu$  Mu (*p. 18*)

$\pi$  the numerical value of pi (*p. 18*)

$r$  the radius of a circle (*p. 18*)

## INTRODUCTION



This is the **novathesis** L<sup>A</sup>T<sub>E</sub>X template Version 7.1.19 from Template!date2024-03-28.

*This work is licensed under the [L<sup>A</sup>T<sub>E</sub>X Project Public License v1.3c](#). To view a copy of this license, visit the [LaTeX project public license](#).*

### 1.1 Welcome to the novathesis Template

This first Chapter introduces the **novathesis** template and how it is organized. In Chapter 2 you can find some specific instructions on how to use this template. Chapter 3 shows some examples and give some hints on how to write your text. Please read these next Chapters carefully.

#### 1.1.1 Your Time is Precious

Did you learn how to drive by sitting by the wheel and throwing your car into the road? Most probably you did take your time *learning the rules* and *practicing* first! Likewise, it is not wise to throw yourself at the task of writing a thesis/dissertation in L<sup>A</sup>T<sub>E</sub>X without seriously considering the following recommendation!

If you are going to spend zillions of hours writing your thesis/dissertation using the **novathesis** L<sup>A</sup>T<sub>E</sub>X template (or some other L<sup>A</sup>T<sub>E</sub>X template), be wise and spend a couple of hours learning how to use it properly by reading its manual. And then, be even wiser, and spend a few more hours *learning some L<sup>A</sup>T<sub>E</sub>X*. I am sure that the time you are investing now will pay itself countless times before you submit your thesis/dissertation.

— João Lourenço

### 1.1.2 Recognition

The **novathesis** template was born in 1996, and what you see now accumulates to many many hundreds (thousands?!) of working hours, unpaid and stolen from family and friends. This work is available to the community under the [LaTeX Project Public License v1.3c](#), which means you are entitled to use it for free and change it at your will. However, if you decide to use this template to write your thesis/dissertation, **be fair to the developers** and:

1. Cite the **novathesis** manual [11] in a place of your choice (e.g., in the *Acknowledgments*) of your thesis/dissertation with “\cite{novathesis-manual}”. If you cite it this way, the correct entry will be added automatically to your bibliography (no need to worry with the necessary BibTeX entry, as it will be added automatically);
2. Go to the [project web page in GitHub](#) and give the project a star (marked with a red ellipse at the top-right in Figure 1.1); and
3. Make a donation by visiting the **novathesis** project page and clicking in the button marked with a green ellipse at the top-center in Figure 1.1). Alternatively, just click [HERE](#) and your browser will be directed to the right page.

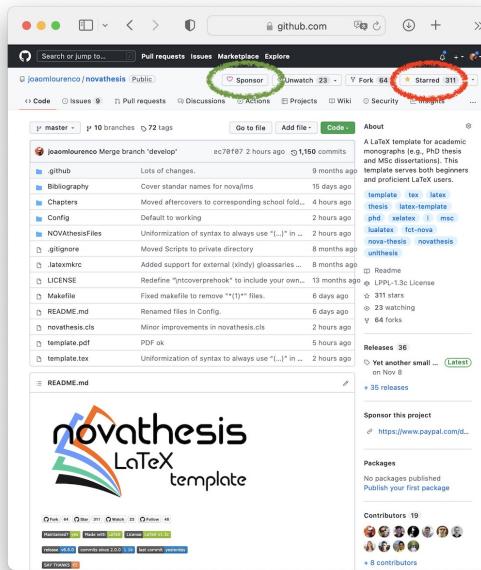


Figure 1.1: The **novathesis** project web page in GitHub.

## 1.2 The NOVAthesis Template

The **novathesis** template was born at the Department of Computer Science (DI) of NOVA School of Science and Technology (FCT) of NOVA University Lisbon (NOVA), Portugal.

But the user base grew... initially grew to other Departments of FCT-NOVA, then to other Schools of NOVA, and later to other Schools of other Universities. Currently more than 25 Schools are natively supported by the `novathesis` template (see Tables 1.1, 1.2, 1.3, 1.4, 1.5, and 1.6).

Table 1.1: NOVA University Lisbon's Schools supported by the `novathesis` template

NOVA University Lisbon
<p><b>NOVA School of Science and Technology (FCT-NOVA)</b></p> <ul style="list-style-type: none"> <li>• All PhD Programs (<a href="#">PhD</a>)</li> <li>• All MSc Programs (<a href="#">MSc</a>)</li> </ul>
<p><b>NOVA School of Social Sciences and Humanities (FCSH-NOVA)</b></p> <ul style="list-style-type: none"> <li>• All PhD Programs (<a href="#">PhD</a>)</li> <li>• All MSc Programs (<a href="#">MSc</a>)</li> </ul>
<p><b>NOVA Information Management School (NOVA-IMS)</b></p> <ul style="list-style-type: none"> <li>• All PhD Programs (<a href="#">PhD</a>)</li> <li>• Master's in Data Science and Advanced Analytics (<a href="#">MMAA</a>)</li> <li>• Master's in Statistics and Information Management (<a href="#">MEGI</a>)</li> <li>• Master's in Information Management (<a href="#">MGI</a>)</li> <li>• Master's in Geographic Information Systems and Science (<a href="#">MCSIG</a>)</li> <li>• Master's in Geospatial Technologies (<a href="#">GeoTech</a>)</li> </ul>
<p><b>National School of Public Health (ENSP-NOVA)</b></p> <ul style="list-style-type: none"> <li>• All PhD Programs (<a href="#">PhD</a>)</li> <li>• All MSc Programs (<a href="#">MSc</a>)</li> </ul>

## CHAPTER 1. INTRODUCTION

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### Instituto de Tecnologia Química e Biológica (ITQB-NOVA)

- All PhD Programs ([PhD](#))
- All MSc Programs ([MSc](#))

Table 1.2: University of Lisbon's Schools supported by the **novathesis** template

University of Lisbon



### Instituto Superior Técnico (IST-UL)

- All PhD Programs ([PhD](#))
- All MSc Programs ([MSc](#))



### Faculdade de Ciências (FCUL)

- All PhD Programs ([PhD](#))
- All MSc Programs ([MSc](#))



### Faculdade de Medicina Veterinária (FMV-UL)

- All PhD Programs ([PhD](#))
- All MSc Programs ([MSc](#))

Table 1.3: University of Minho's Schools supported by the **novathesis** template

University of Minho



### School of Architecture (EA-UMINHO)

- All PhD Programs ([PhD](#))
- All MSc Programs ([MSc](#))



### School of Sciences (EC-UMINHO)

- All PhD Programs (PhD)
- All MSc Programs (MSc)



### School of Law (ED-UMINHO)

- All PhD Programs (PhD)
- All MSc Programs (MSc)



### School of Engineering (EE-UMINHO)

- All PhD Programs (PhD)
- All MSc Programs (MSc)



### School of Economics and Management (EEG-UMINHO)

- All PhD Programs (PhD)
- All MSc Programs (MSc)



### School of Medicine (EM-UMINHO)

- All PhD Programs (PhD)
- All MSc Programs (MSc)



### School of Psychology (EP-UMINHO)

- All PhD Programs (PhD)
- All MSc Programs (MSc)



### School of Nursing (ESE-UMINHO)

- All PhD Programs (PhD)
- All MSc Programs (MSc)



### Institute of Social Sciences (ICS-UMINHO)

- All PhD Programs (PhD)
- All MSc Programs (MSc)

## CHAPTER 1. INTRODUCTION

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### Institute of Education (IE-UMINHO)

- All PhD Programs ([PhD](#))
- All MSc Programs ([MSc](#))



### School of Arts and Humanities (ELACH-UMINHO)

- All PhD Programs ([PhD](#))
- All MSc Programs ([MSc](#))



### Research Institute 13Bs (I3B-UMINHO)

- All PhD Programs ([PhD](#))
- All MSc Programs ([MSc](#))

Table 1.4: Instituto Politécnico de Lisboa's Schools supported by the `novathesis` template

---

Instituto Politécnico de Lisboa

---



### Instituto Superior de Engenharia de Lisboa (ISEL-IPL)

- All MSc Programs ([MSc](#))

Table 1.5: Instituto Politécnico de Setúbal's Schools supported by the `novathesis` template

---

Instituto Politécnico de Setúbal

---



### Escola Superior de Tecnologia de Setúbal (ISEL-IPL)

- All MSc Programs ([MSc](#))

Table 1.6: Other Universities/Schools/Degrees's Schools supported by the `novathesis` template

Other Universities/Schools/Degrees

**Escola Superior de Enfermagem do Porto (ESEP)**

- All MSc Programs ([MSc](#))

## 1.3 Getting Started

The template provides an *easy to use* setting for you to write your thesis/dissertation in  $\text{\LaTeX}$ :

- Select your school;
- Fill your thesis metadata (title, research field, etc) in the file “`template.tex`”;
- Create your thesis/dissertation contents using the files in folder “`Chapters`”; and
- Process using you favorite  $\text{\LaTeX}$  processor (`pdf\LaTeX`, `Xe\LaTeX` or `Lua\LaTeX`).

### 1.3.1 Using Overleaf

Overleaf is a collaborative cloud-based  $\text{\LaTeX}$  editor used for writing, editing and publishing scientific documents. Like “Google Docs”, for  $\text{\LaTeX}$  users. You can edit and compile your  $\text{\LaTeX}$  source on the cloud, without installing software in your own computer, and, much like *Google Docs*, you can share your document with others users and everybody can edit the same file at the same time (this may be dangerous).

If you do not have an account in Overleaf, you must [create one first](#).

Once you have an account, please access the `novathesis` template in [Overleaf](#) and select the green button *Open as Template* (see [Figure 1.2](#)).

*Please notice that the version currently available in Overleaf (v6.10.10) is slightly outdated (current version is v7.1.19). A new version (v7.0.0) will be submitted to Overleaf soon. Until then, please:*

1. *Download the [latest version](#) from the GitHub repository as a Zip file.*
2. *Login to your favorite  $\text{\LaTeX}$  cloud service. I recommend [Overleaf](#) but there are alternatives (these instructions apply to Overleaf and you'll have to adapt for other providers).*

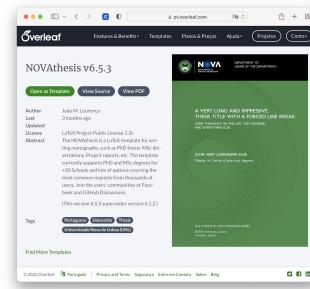


Figure 1.2: NOVAtesis template in Overleaf.

3. In the menu select: *New project* → *Upload project*.
4. Upload the zip file.
5. Select “*template.tex*” as the main file.
6. Let Overleaf compile the document.

### 1.3.2 Using a Local L<sup>A</sup>T<sub>E</sub>X Installation Local

First of all, start by installing L<sup>A</sup>T<sub>E</sub>X in your computer. There are two main distributions, [Mik<sup>T</sup>E<sub>X</sub>](#) and [T<sub>E</sub>XLive](#), and both of them are available for the 3 most popular Operating Systems: Linux, macOS and Windows.

Be aware that a full installation of Mik<sup>T</sup>E<sub>X</sub> or T<sub>E</sub>XLive will take near 5 GB of hard disk space. So, think twice before installing the full distribution. See the [novathesis](#) Wiki for the [list of packages required to compile the template](#).

Once you have L<sup>A</sup>T<sub>E</sub>X up and running, remember to install a good L<sup>A</sup>T<sub>E</sub>X text editor. I recommend you to take a look at [this post](#) in the [tex.stackexchange.com](#) site. If you want a quick and dirty recommendation, try [TeXStudio](#).

Now, you must access the [novathesis](#) repository in [GitHub](#), select the green button *Code* and then *download* (or *clone*) the template. You will always get the latest version of the template (currently v7.1.19 from 2024-03-28).

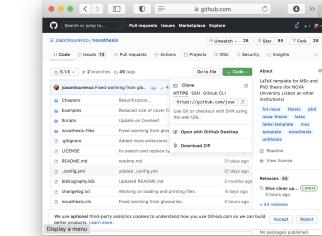


Figure 1.3: The NOVAtethesis Project page in GitHub.

## 1.4 Getting Help

No! You don’t have to use this template to write your thesis. You don’t even have to use L<sup>A</sup>T<sub>E</sub>X. However, writing a thesis is serious stuff, and which tool you shall use to write it is not a decision to make lighthearted.

L<sup>A</sup>T<sub>E</sub>X is hard enough by itself. This template aims at making your life easier, but not easy. If you choose to use this template to write your thesis, you are very welcome. However, don’t expect me to provide you help with L<sup>A</sup>T<sub>E</sub>X. Look for help with your friends (you have some friends, don’t you?), or search the web, or try even to read some book(s) on L<sup>A</sup>T<sub>E</sub>X. In the end you will certainly find the experience rewarding.

When you come to the point of “*How do I do this with the novathesis template?*”, remember . . .

1. To check the [novathesis wiki](#) and have some hope! :D
2. [Google](#) is your best friend.
3. Search the [GitHub Discussions](#) page for a question related to yours. *If and only if* you don’t find one, then post your own question in English please!

4. Search the [NOVAtheis Facebook group](#) for a question related to yours. *If and only if* you don't find one, then post your own question in either Portuguese or English, at your preference.

When you post your own question, remember to **always** state the **novathesis** version number you are using and referring to.

**Please do not attempt to contact me directly (email, Messenger, etc)...**  
**I WILL NOT REPLY!**

#### 1.4.1 Suggestions, Bugs and Feature Requests

**Help:** If you just need some help, see above [Section 1.4](#).

**Suggestion:** Do you have a suggestion/recommendation? Please add it to the wiki and help other users!

**Bug:** Did you find a bug? Please open an issue. Thanks!

**New Feature:** Would you like to request a new feature (or support of a new School)? Please open an issue. Thanks!

## 1.5 Donors

The [list of Donors](#) is available in the **novathesis** Project page.

## 1.6 Disclaimer

Although the **novathesis** template is endorsed by some Schools (e.g., [linked from FCT-NOVA web site](#)), the **novathesis** template **this not an official template** for any School.

The **novathesis** template exists to make your life easier and we do our best to make it compliant to the supported (25) Schools' regulations but, in the end of the line, you and only you are accountable for both the look and the contents of the document you submit as your thesis/dissertation.

# NOVA<sup>THESES</sup> TEMPLATE *USER'S MANUAL*

**This manual is outdated and must be revised!**

## 2.1 Introduction

This Chapter describes how to use the NOVA<sup>THESES</sup> L<sup>A</sup>T<sub>E</sub>X (`novathesis`) template. It is assumed that you have a working of L<sup>A</sup>T<sub>E</sub>X, either local (in your own computer) or remote (in [Overleaf](#)), and that you were able to generate a PDF for the default configuration of the template: a PhD thesis for NOVA School of Science and Technology (FCT).

## 2.2 Quick Start

### 2.2.1 With a Local L<sup>A</sup>T<sub>E</sub>X Installation

Follow these steps to get started with a local L<sup>A</sup>T<sub>E</sub>X installation:

1. Download L<sup>A</sup>T<sub>E</sub>X. There are two major L<sup>A</sup>T<sub>E</sub>X distributions — [Mik<sub>T</sub>E<sub>X</sub>](#) and [T<sub>E</sub>XLive](#) — that share lots of similarity, and L<sup>A</sup>T<sub>E</sub>X documents are portable between them. This means that, for most users, both systems are equally usable.

[T<sub>E</sub>X-Live](#) is maintained by (La)T<sub>E</sub>X developers and is certainly the best distribution you may install in your computer: However, the default distribution will take more than 5 GB on your hard disk... so, if you are not short on disk space, install T<sub>E</sub>XLive!

[Mik<sub>T</sub>E<sub>X</sub>](#) will, by default, install only a minimal set of packages. The extra/additional packages will be installed on the fly. Installing packages on the fly is useful if disk space is limited, but has its own caveats in the longer term. Definitely choose Mik<sub>T</sub>E<sub>X</sub> if you're short on disk space.

Which one to download? There are [pros and cons for both distributions](#) so it is essentially a question of where does your heart fall first! Mine falls to T<sub>E</sub>XLive, but yours can fall elsewhere! :D

2. Install  $\text{\LaTeX}$ . Installation of  $\text{\LaTeX}$  is as hard as installing any other software. Just do your best and you will certainly succeed.
3. Update your  $\text{\LaTeX}$  installation using the *TeXLiveUtility* program of the Mik $\text{\TeX}$  console.
4. Download the **novathesis** template by either:

- Cloning the [GitHub repository](#) with

```
git clone --depth=1 https://github.com/joaomlourenco/novathesis.git
```

or

- Downloading the [latest version from the GitHub repository as a Zip file](#).

5. Download additional School specific files if applicable:

**Universidade do Minho (UMINHO)** download the required *NewsGotT* font files from <https://github.com/joaomlourenco/novathesis-extras/raw/main/Fonts/NewsGotT.zip>  
then unzip the file and copy the 3 font files

“n015002t.ttf”, “n015003t.ttf”, and “n015006t.ttf”

to the folder

“NOVAthesisFiles/FontStyles/Fonts”.

**Escola Superior de Enfermagem do Porto (ESEP)** download the required *Calibri* font files from <https://github.com/joaomlourenco/novathesis-extras/raw/main/Fonts/Calibri.zip>  
then unzip the file and copy the 4 font files

“Calibri.ttf”, “Calibrib.ttf”, “Calibrii.ttf”, and “Calibriz.ttf”

to the folder

“NOVAthesisFiles/FontStyles/Fonts”.

6. Compile the document with you favorite  $\text{\LaTeX}$  processor ( $\text{pdf}\text{\LaTeX}$ ,  $\text{Xe}\text{\LaTeX}$  or  $\text{Lua}\text{\LaTeX}$ ).

- The main file is named “`template.tex`”, but you are free to rename it as you please.
- Either load the main file in your favorite [LaTeX text editor](#) and press the appropriate (*magic*) button to generate a PDF file, or open a terminal and compile it with “`latexmk -pdf template`”. If you use a  $\text{\LaTeX}$  text editor, please notice that the **novathesis** template uses “`biber`” and not “`bibtex`” to process the bibliography, which means that most probably you have to open

the *Editor Preferences* and somewhere (depending on the Editor you are using) change “`bibtex`” to “`biber`”.

- Notice that, due to the external font sets used, `pdflatex` will not work for both **UMINHO** and **ESEP**, and you have to use either `XeLaTeX` (“`latexmk -pdfxe template`”) or `LuaLaTeX` (“`latexmk -pdflua template`”).

7. Edit the files in the “Config” folder:

File	Contents
<code>0_memoir.tex</code>	Options specific for the <code>memoir</code> package. <i>Don't touch this file unless you know what you are doing!</i>
<code>1_novathesis.tex</code>	Configure the template (e.g., the document type, the school, the languages used, etc.)
<code>2_biblatex.tex</code>	Select how your citations and bibliographic references will be printed. The default is numbers inside square brackets, e.g. [11], but you can change it to other formats, such as author-year, e.g., Lourenço (2021).
<code>3_cover.tex</code>	Configure cover contents (e.g., thesis/dissertation title, author's name, advisers' names, committee members' names, date, etc.).
<code>4_files.tex</code>	Select the files for chapters, appendices, annexes, abstracts, glossaries, etc.
<code>5_packages.tex</code>	User's customization. Load additional packages and define your own commands to be used throughout the document.
<code>6_list_of.tex</code>	Configure the lists to be printed (table of contents, list of figures, list of tables, list of listings, etc). <i>Don't touch this file unless you know what you are doing!</i>
<code>9_nova_fct.tex</code>	Configuration specific to NOVA-FCT. Otherwise ignored.
<code>9_nova_ims.tex</code>	Configuration specific to NOVA-IMS. Otherwise ignored.
<code>9_nova_itqb.tex</code>	Configuration specific to NOVA-ITQB. Otherwise ignored.
<code>9_ulisboa_fmv.tex</code>	Configuration specific to ULISBOA-FMV. Otherwise ignored.
<code>9_uminho.tex</code>	Configuration specific to UMINHO (all Schools). Otherwise ignored.

8. Recompile de document.

9. And you're done with a beautifully formatted thesis/dissertation! :D

### 2.2.2 With a Remote Cloud-based Service

Follow these steps to get started with a remote `LATeX` installation:

- Download the [latest version from the GitHub repository as a Zip file](#).

- Login to your favorite LaTeX cloud service. I recommend [Overleaf](#) but there are alternatives. These instructions apply to Overleaf and you'll have to adapt for other providers.
- In the menu select [New project](#) → [Upload project](#).
- Select “`template.tex`” as the main file.
- Follow from Step 5 above in Section 2.2.1 ([With a Local L<sup>A</sup>T<sub>E</sub>X Installation](#)).

## 2.3 Folder and Files

The `novathesis` template is organized into many files and folders. At the main level it includes the following files and folders listed in Table 2.1.

Table 2.1: The folders and files.

Name	Type	Access	Contents
<code>novathesis.cls</code>	<code>file</code>		The main class file.
<code>template.tex</code>	<code>file</code>		The main template file. You need to <i>compile</i> this file with one of pdfL <sup>A</sup> T <sub>E</sub> X, X <sub>E</sub> L <sup>A</sup> T <sub>E</sub> X, or L <sup>A</sup> u <sub>L</sub> AT <sub>E</sub> X to obtain the PDF file (“ <code>template.pdf</code> ”).
<code>template.pdf</code>	<code>file</code>		A possible result of applying pdfL <sup>A</sup> T <sub>E</sub> X to the “ <code>template.tex</code> ” file. The look and feel of the document will depend on the parametrization/configuration (e.g., School) of this template.
Chapters	<code>folder</code>		Examples of document contents, including Chapters, Appendices, Annexes, Abstracts, Glossaries, Lists of Symbols, etc. Replace them with your own.
Bibliography	<code>folder</code>		Where all your bibliography files should be located. You may have as many as you want, as long as you add them to the template with “ <code>\ntaddfile{bib}{FILENAME.bib}</code> ”.
NOVAthesisFiles	<code>folder</code>		Additional files for the <code>novathesis</code> template. This is where all the juice is so, unless you are a T <sub>E</sub> Xmagician, don’t mess up with the files and folders inside this folder.

## 2.4 The novathesis.cls Class Options

The **novathesis** class (`novathesis.cls`) can be customized with the options listed below.

<b>doctype=OPT</b> <i>phd, phdprop, phdplan, msc, mscplan, bsc, plain</i>	<b>The type of the document.</b> phd → PhD thesis ( $\Leftarrow$ default). phdprop → PhD thesis proposal (for FCT-NOVA). phdplan → PhD thesis plan. msc → MSc dissertation. mscplan → MSc dissertation plan. bsc → BSc report. plain → Other report.
<b>school=OPT</b> <i>nova/fct, nova/fcsh, nova/ims, nova/ensp, nova/itqb, ulisboa/ist, ulisboa/fc, ulisboa/fmv, uminho/ea, uminho/ec, uminho/ed, uminho/ee, uminho/eeg, uminho/em, uminho/ep, uminho/ese, uminho/ics, uminho/ie, uminho/elach, uminho/i3b, ips/ests, ipl/isel, ulht/deisi, other/esep</i>	<b>Selection of the university and of the school.</b> ⇒ Default: <i>nova/fct</i> This option changes the typesetting of the de document to some specific School formating and layout, like covers, margins, fonts, paragraph spacing and indentation, etc.
<b>docstatus=OPT</b> <i>draft, provisional, final</i>	<b>The current status of the document.</b> draft → Working version ( $\Leftarrow$ default). provisional → Version for submission. final → Final version.
<b>lang=OPT</b> <i>en, pt, de, es, fr, gr, it</i>	<b>The main language for the document.</b> en → Enlgish ( $\Leftarrow$ default). pt → Portuguese. de → German. es → Spanish. fr → French. gr → Greek. it → Italian.
<b>abstractorder=OPT</b> <i>{L<sub>1</sub>, L<sub>2</sub>, ..., L<sub>n</sub>} {DL={L<sub>1</sub>, L<sub>2</sub>, ..., L<sub>n</sub>}}</i>	<b>Forces the abstracts languages and order.</b> DL → Document language ( $\Leftarrow$ defaults to the main language). L <sub>i</sub> → A two-letters language code.
<b>lang/extralang=OPT</b> <i>{L<sub>1</sub>, L<sub>2</sub>, ..., L<sub>n</sub>}</i>	<b>Additional languages used in the document.</b> ⇒ Default: {} Besides the main language and those used in the abstracts. L <sub>i</sub> → A two-letters language code.

<b>linkscolor=OPT</b> <i>A color of your choice.</i>	<b>The color for all the hyperlinks in the PDF file.</b> ⇒ Default: <i>darkblue</i> The “ <i>media=paper</i> ” option (see below) will override this option to “ <i>black</i> ”
<b>media=OPT</b> <i>screen, paper</i>	<b>The target of the PDF.</b> ⇒ Default: <i>screen</i> By default, PDF for screen has colored links and identical left and right margins, while PDF for paper (to print) has black links and may have different left and right margins.
<b>print/index=OPT</b> <i>true, false</i>	<b>Produce the document index.</b> ⇒ Default: <i>false</i> The index ( <i>índice remissivo</i> ) is a keyword index typeset at the end of the document. WARNING: Should not be confused with the table of contents.
<b>fontstyle=OPT</b> <i>bookman, charter, fourier, kpfonts(*), mathpazo1, mathpazo2, newcent</i>	<b>The font set to be used in the document.</b> Please note that a font set include definitions for the main text, headings, maths, etc.
<b>chapstyle=OPT</b> <i>bianchi, bluebox, brotherton, dash, default, elegant(*), ell, ger, hansen, ist, jenor, lyhne, madsen, pedersen, veelo, vz14, vz34, vz43</i>	<b>The chapter style</b> The look of the chapter beginning.
<b>converlang=OPT</b> <i>en, pt(*)</i>	<b>The language to be used when typesetting the cover page.</b>
<b>otherlistsat=OPT</b> <i>front(*), back</i>	<b>Where to put the other lists besides the table of contents.</b> The default is (front) before the main text. But some scientific areas prefer them at the end of the document (back), just before the Appendixes.
<b>statement=OPT</b> <i>true, false(*)</i>	<b>Include or don't include the contents of the “<b>statement</b>” file.</b> The default is for this file to be ignored (if it exists).
<b>spine=OPT</b> <i>true, false(*)</i>	<b>Generate the book spine and the last page in the PDF.</b>

**biblatex=OPT***OPT={list of options for biblatex}*

**Customize biblatex, the bibliography management system used in this class.**

Probably you will want to change the value of the biblatex “style” option. For other customizations of biblatex check its manual.

---

**memoir=OPT***OPT={list of options for memoir}*

**Customize the base class memoir.**

The memoir manual should be the first document to be consulted when looking for “**how can I do this?**” You may want to change the base font size from 11pt to a smaller (10pt) or larger (12pt) size. Also, remember to change the “draft” to final when your document is finished.

---

## 2.5 Additional considerations about the class options

In this section we will provide some additional considerations about some of the customizations available as class options.

### 2.5.1 The main language

The choice of the main language with the option “`lang=OPT`” affects:

- **The order of the summaries.** First is printed the abstract in the main language and then in the foreign language. This means that if your main language for the document is English, you will see first the “abstract” (in English) and then the “resumo” (in Portuguese). If you switch the main language for the document for Portuguese, it will also automatically switch the order of the summaries to “resumo” and then “abstract”.
- **The names for document sectioning.** E.g., “Chapter” vs. “Capítulo”, “Table of Contents” vs. “Índice”, “Figure” vs. “Figura”, etc.
- **The type of documents in the bibliography.** E.g., “Technical Report” vs. “Relatório Técnico”, “PhD Thesis” vs. “Tese de Doutoramento”, etc.

No matter which language you chose, you will always have the appropriate hyphenation rules according to the language at that point. You always get Portuguese hyphenation rules in the “Resumo”, English hyphenation rules in the “Abstract”, and then the main language hyphenation rules for the rest of the document.

### 2.5.2 Class of Text

You must choose the class of text for the document. The available options are:

1. **bsc** — BSc graduation report.
2. \***mscplan** — Preparation of MSc dissertation. This is a preliminary report graduate students at DI-FCT-NOVA must prepare to conclude the first semester of the two-semesters MSc work. The files specified by `\ntdedicatoryfile` and `\acknowledgmentsfile` are ignored, even if present, for this class of document.
3. **msc** — MSc dissertation.
4. **phdprop** — Proposal for a PhD work. The files specified by `\ntdedicatoryfile` and `\acknowledgmentsfile` are ignored, even if present, for this class of document.
5. **prepphd** — Preparation of a PhD thesis. This is a preliminary report PhD students at DI-FCT-NOVA must prepare before the end of the third semester of PhD work. The files specified by `\ntdedicatoryfile` and `\acknowledgmentsfile` are ignored, even if present, for this class of document.
6. **phd** — PhD dissertation.

### 2.5.3 Printing

You must choose how your document will be printed. The available options are:

1. **oneside** — Single side page printing.
2. \***twoside** — Double sided page printing.

### 2.5.4 Font Size

You must select the encoding for your text. The available options are:

1. **11pt** — Eleven (11) points font size.
2. \***12pt** — Twelve (12) points font size. You should really stick to 12pt...

### 2.5.5 Text Encoding

You must choose the font size for your document. The available options are:

1. **latin1** — Use Latin-1 ([ISO 8859-1](#)) encoding. Most probably you should use this option if you use Windows;
2. **utf8** — Use [UTF8](#) encoding. Most probably you should use this option if you are not using Windows.

### 2.5.6 Examples

Let's have a look at a couple of examples:

- Preparation of PhD thesis, in portuguese, with 11pt size and to be printed single sided (I wonder why one would do this!)  
`\documentclass[prepphd,pt,11pt,oneside,latin1]{thesisdifct-nova}`
- MSc dissertation, in English, with 12pt size and to be printed double sided  
`\documentclass[msc,en,12pt,twoside,utf8]{thesisdifct-nova}`

## 2.6 How to Write Using L<sup>A</sup>T<sub>E</sub>X

Please have a look at Chapter 3, where you may find many examples of L<sup>A</sup>T<sub>E</sub>X constructs, such as Sectioning, inserting Figures and Tables, writing Equations, Theorems and algorithms, exhibit code listings, etc.

## 2.7 Example glossary, acronyms, and symbols

This is the first occurrence of an abbreviation: abbreviation of a longer text (abbrev). And now the second occurrence of the same abbreviation: abbrev. And a new acronym with capital letter: And extension of a xpto (xpto) and reused xpto. Let's also use a few other acronyms such as acronym aaa (aaa), acronym aab (aab), acronym aba (aba), acronym bbb (bbb) and xpto. In geometry, the area enclosed by a circle of radius  $r$  is  $\pi r^2$ . Here the Greek letter  $\pi$  is equal to the ratio of the circumference of any circle to its diameter. Lets add "computer" to the glossary! Be carefull with mathematical symbols in acronyms, please see the definition of  $\mu$ .

# A SHORT L<sup>A</sup>T<sub>E</sub>X TUTORIAL WITH EXAMPLES

This Chapter aims at exemplifying how to do common stuff with L<sup>A</sup>T<sub>E</sub>X. We also show some stuff which is not that common! ;)

Please, use these examples as a starting point, but you should always consider using the *Big Oracle* (aka, [Google](#), your best friend) to search for additional information or alternative ways for achieving similar results.

## 3.1 Document Structure

## 3.2 Dealing with Bibliography

Citing something online [4, 7, 9].

## 3.3 Inserting Tables

## 3.4 Importing Images

## 3.5 Floats, Figures and Captions

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

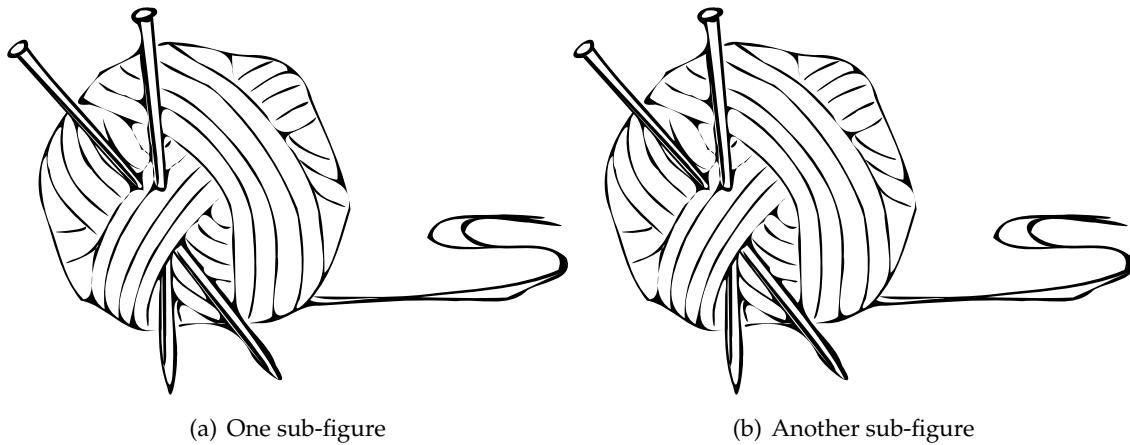


Figure 3.1: A figure with two sub-figures!

**And this is a small text that references the Figure 3.1 and its Subfigures 3.1(a) and 3.1(b).**

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan

eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

## 3.6 Text Formatting

## 3.7 Generating PDFs from L<sup>A</sup>T<sub>E</sub>X

### 3.7.1 Generating PDFs with pdflatex

You may create PDF files either by using `latex` to generate a DVI file, and then use one of the many DVI-2-PDF converters, such as `dvipdfm`.

Alternatively, you may use `pdflatex`, which will immediately generate a PDF with no intermediate DVI or PS files. In some systems, such as Apple, PDF is already the default format for L<sup>A</sup>T<sub>E</sub>X. I strongly recommend you to use this approach, unless you have a very good argument to go for `latex + dvipdfm`.

A typical pass for a document with figures, cross-references and a bibliography would be:

```
$ pdflatex template  
$ bibtex template  
$ pdflatex template  
$ pdflatex template
```

You will notice that there is a new PDF file in the working directory called `template.pdf`. Simple :)

Please note that, to be sure all table of contents, cross-references and bibliographic citations are up-to-date, you must run `latex` once, then `bibtex`, and then `latex` twice.

### 3.7.2 Dealing with Images

You may process the same source files with both `latex` or `pdflatex`. But, if your text include images, you must be careful. `latex` and `pdflatex` accept images in different (exclusive) formats. For `latex` you may use EPS ou PS figures. For `pdflatex` you may use JPG, PNG or PDF figures. I strongly recommend you to use PDF figures in vectorial format (do not use bitmap images unless you have no other choice).

### 3.7.3 Creating Source Files Compatible with both `latex` and `pdflatex`

Do not include the extension of the file in the `\includegraphics` command. E.g., use

`\includegraphics{sonwman}`

and not

`\includegraphics{sonwman.eps}`.

If you use the first form, `latex` or `pdflatex` will add an appropriate file extension.

This means that, if you plan to use only `pdflatex`, you need only to keep (preferably) a PDF version of all the images. If you plan to use also `latex`, then you also need an EPS version of each image.

## To be included in the sections above

Para fazer citações, deverá usar-se a chave da referência no ficheiro BibTeX. Se for uma única referência [2], usar um “~” para ligar o `\cite{...}` à palavra que o precede (`... referência~\cite{Artho04}`). Caso queira fazer múltiplas citações [12, 13, 6], deverá agrupá-las dentro de um único `\cite{...}`.

Note que o ficheiro de bibliografia pode ter tantas entradas quantas quiser. Apesar das aquelas cuja chave seja referenciada no texto é que serão incluídas na listagem de bibliografia.

Footnotes<sup>1</sup> will be numbered and shown in the bottom of the page.

A Tabela 3.1 ilustra alguns conceitos importantes associados à construção de tabelas:

- i) Não usar linhas verticais;
- ii) A legenda deve ficar por cima da tabela;
- iii) Usar as macros `\toprule`, `\midrule` e `\bottomrule` para fazer a linha horizontal superior, interiores e inferior, respectivamente.

Table 3.1: Test results summary.

Test	Anomalies	Warnings	Correct	Categories	Missed
Connection [3]	2	2	1	C	1
Coordinates'03 [1]	1	4	1	2B, 1C	0
Local Variable [1]	1	2	1	A	0
NASA [1]	1	1	1	—	0
Coordinates'04 [2]	1	4	1	3C	0
Buffer [2]	0	7	0	2A, 1B, 2C, 2D	0
Double-Check [2]	0	2	0	1A, 1B	0
StringBuffer [8]	1	0	0	—	1
Account [14]	1	1	1	—	0
Jigsaw [14]	1	2	1	C	0
Over-reporting [14]	0	2	0	1A, 1C	0
Under-reporting [14]	1	1	1	—	0
Allocate Vector [10]	1	2	1	C	0
Knight Moves [3]	1	3	1	2B	0
Total	12	33	10	5A, 6B, 10C, 2D	2

As figuras a inserir no documento deverão ser de qualidade, preferencialmente em formato vectorial (PDF vectorial) e não em *bitmap* (PNG, JPG, etc). As imagens *bitmap* (Figura 3.2) não escalam bem e têm reflexos negativos na qualidade do seu documento. Pelo contrário, as imagens *vectoriais* Figura 3.3 escalam muito tanto quanto o necessário sem degradar a qualidade da imagem.

<sup>1</sup>This is a simple footnote.

Só deve usar *screenshots* se não tive mesmo nenhuma alternativa. Em vez e gerar um *screenshot*, tente usar uma impressora virtual PDF e imprimir para um ficheiro PDF. Regra geral obterá um PDF vetorial. Mesmo que o seu PDF contenha imagens, elas terão sempre qualidade maior ou igual à que obteria com um *screenshot*.

Para agregar várias figuras numa única... Poderá assim referenciar o conjunto como Figura 3.4 ou as sub-figuras separadamente como 3.4() e 3.4(a).

## 3.8 Equações

O LaTeX é uma ferramenta poderosa para escrever em estilo matemático. Permite inserir fórmulas no meio do texto como por exemplo esta:  $ax^2 + bx + c = 0$ . Também permite que as fórmulas sejam destacadas numa linha separada e centradas na página

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

ou numeradas

$$\text{aaa} \tag{3.1}$$

que depois pode ser referida no texto como sendo a equação 3.1

$$\text{aa}$$

$$a \tag{3.2}$$

$$b \tag{3.3}$$

$$c \tag{3.4}$$

$$(3.5)$$

## 3.9 Test for minted

Testing the package “minted”...

```
if(a==b)
    puts("YES! ")
```

Listing 1: Example of a listing.

## 3.10 Test for algorithms

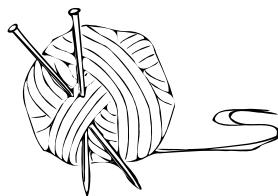
Uncomment the algorithms source below and add the following to file “5\_packages.tex”



Figure 3.2: Imagem em formato *bitmap* (JPG)



Figure 3.3: Imagem em formato PDF vectorial



(a) Novelo de lã



(b) Tempestade com neve

Figure 3.4: Exemplo de utilização de *subbottom*

```
\usepackage{algorithm2e}  
\RestyleAlgo{ruled}
```

and uncomment

```
\ntaddlistof{listofalgorithms}
```

in file “8\_list\_og.tex”.

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# A

## NOVATHESIS COVERS SHOWCASE

This Appendix shows examples of covers for some of the supported Schools. When the Schools have very similar covers (e.g., all the schools from Universidade do Minho), just one cover is shown. If the covers for MSc dissertations and PhD thesis are considerable different (e.g., for FCT-NOVA and UMinho), then both are shown.

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# B

## APPENDIX 2 LOREM IPSUM

This is a test with citing something [5] in the appendix.

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  Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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## APPENDIX B. APPENDIX 2 LOREM IPSUM

Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetur.

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# I

## ANNEX 1 LOREM IPSUM

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Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum

## ANNEX I. ANNEX 1 LOREM IPSUM

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Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetur.

