A LaTeX Template Presenting: A Guide for Writing Reports

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Abstract

The abstract is independent of the rest of the report. It should be possible to read the abstract without having read the report, and vice versa. The abstract should contain a brief description of the problem, method, the most important results, and their implications. It should be complete, objective, and easy to understand. The abstract should summarise the work, and any additional information that is not present in the report should not be included. The abstract should be concise and should contain a maximum of 150–200 words. It should not include images or figures. It should not contain references or formulas, but it should describe the most important results.

Contents

Notations

ρ	Density (kg/m^3)
A	Area (m^2)

1 Introduction

The introduction familiarises the reader with the problem statement and provides the background of the problem. The introduction is crucial because it is where the author guides the reader into their thought process. The entire section should be written in a way that logically and convincingly leads the reader to the problem addressed in the report. The introduction should include an overview of relevant previous works in the field, known as a literature review and references are typically required here. An example of how to refer to previous work is given here: “In [1], Bergvall-Kåreborn et al. discovered that the application of openness, realism, and influence in the diverse spaces of living lab environments led to the transformation of these spaces into a variety of places. This transformation was influenced by factors such as the stakeholders involved, the methods used, and how activities were facilitated.”

After this it should be made clear to the reader what is the purpose of the work, i.e., what is intended to be achieved, the research questions, and any limitations. The goals should be clearly defined, and in the conclusions of the report, it should be evident how the goals have been achieved. Here too, the aim is to capture the reader’s interest and encourage them to continue reading the report. The conclusion of the introduction should create a smooth transition to the next chapter.

2 Theory

Describe the theory, assumptions, and other fundamental aspects underlying the chosen method and approach. The theory should provide insights, discussions, summaries, and connections to the problem statement. All equations, figures, and tables should be numbered consecutively. Figures and tables should have concise captions that clearly indicate what they represent, such as Table 1 and Figure 1. Figures encompass images, diagrams, graphs, etc. There should not be any additional headings within the figure other than what is stated in the caption. If not self-made, the source should be indicated, and permission from the owner should be obtained. Additionally, all figures and tables should be referred to in the main text. When using LaTeX 2_ε, the positions of tables and figures are adjusted to optimise the text flow during compilation. This also applies when publishing scientific articles. In English, they are referred to as "floats."

Regarding equations, they are considered part of the text, which means that commas and periods are used as if the equation were composed of multiple words in the text. Variables and parameters are written in the same font in both equations and the main text. Typically, variables and parameters in $\mathbb{R}$ are expressed using standard mathematical fonts, such as x and y, while vectors and matrices are often expressed in an upright font in bold style, e.g. $\mathbf{z}$ and $\mathbf{A}$. We illustrate this with the following example, which also forms the theoretical basis for interpreting the results presented in Section 4. There are many examples of physical relationships between an independent variable x and a dependent variable $y = f(x)$, which can be approximated by a power function of the form

$$y = Cx^k, \tag{1}$$

where C and k can be determined by fitting the expression to experimental data, see e.g. [2]. Note that in the above sentence, the equation is read as "...power function of the form y equals C times x raised to the power of k, where C and k can be determined...". The constants C and k are typically determined by linearising (1) through logarithmisation, i.e.,

$$\ln y = \ln C + k \ln x. \tag{2}$$

Now, if we let $\hat{z} = \ln y$, $w = \ln x$, and $m = \ln C$, we realise that (2) describes the following linear relationship

$$\hat{z} = m + kw. \tag{3}$$

Let us assume that we have three sets of measurement data (x_i, y_i), where $i = 1 \ldots 3$. By taking the logarithm of the (input and output) data and assuming a linear relationship, we can use the theory of power functions mentioned above, together with the method of least squares, to determine k and m in (3). Therefore, let us introduce the matrix $\mathbf{A}$ and the vector $\mathbf{z}$ as follows

$$\mathbf{A} = \begin{bmatrix} 1 & w_1 \\ 1 & w_2 \\ 1 & w_3 \end{bmatrix}, \quad \mathbf{z} = \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix}. \tag{4}$$

In vector notation, we can express $\hat{z}$, which is a linear combination of the columns in $\mathbf{A}$, as

$$\hat{\mathbf{z}} = \mathbf{A}\mathbf{a}, \tag{5}$$

where $\mathbf{a} = [m, k]^{\mathrm{T}}$. The method of least squares involves finding the $\mathbf{a}$ that minimizes the length[1] of the vector between $\hat{\mathbf{z}}$ and the vector $\mathbf{z}$.

We realize that the vector $\mathbf{e} = \hat{\mathbf{z}} - \mathbf{z}$ with the shortest distance $e := \|e\| = \|\hat{\mathbf{z}} - \mathbf{z}\|$ is perpendicular to the column space[2] of $\mathbf{A}$. Mathematically, this implies that

$$\mathbf{A}^T\mathbf{e} = 0. \tag{6}$$

Since $\mathbf{e} = \hat{\mathbf{z}} - \mathbf{z}$, we have

$$\mathbf{A}^T(\hat{\mathbf{z}} - \mathbf{z}) = 0 \iff \mathbf{A}^T\hat{\mathbf{z}} = \mathbf{A}^T\mathbf{z} \iff \mathbf{A}^T\mathbf{A}\mathbf{a} = \mathbf{A}^T\mathbf{z}. \tag{7}$$

The solution $\mathbf{a}$ to this linear system is thus given by

$$\mathbf{a} = \left(\mathbf{A}^T\mathbf{A}\right)^{-1}\mathbf{A}^T\mathbf{z}. \tag{8}$$

Finally, we can determine $C = e^m$ by inverting $m = \ln C$, and thus, we have fitted a power function of the form (1) to the measurement data.

[1] The length of a vector in $\mathbb{R}^n$ is determined by the Euclidean distance between its start and endpoint.
[2] The plane spanned by the columns in $\mathbf{A}$.

2.1 Theory Section One

The theory section can include subheadings. Just remember that there should always be at least two subheadings, as seen in Section 2.2 below.

When presenting variables representing physical quantities, their units should also be specified. Generally, force is denoted by F and expressed in Newtons (N). Note that a space is left between the numerical value and its units. Exceptions can be made for percentages (%) and degrees (°), e.g., 20% and 90°. The gravitational force due to mass $m = 100\,\mathrm{kg}$ is given by $F = mg$, where $g \approx 9.82\,\mathrm{m/s^2}$ is the acceleration due to gravity. Thus, the gravitational force is approximately $F \approx 982\,\mathrm{N}$.

2.2 Theory Section Two

If it is not possible to divide the section into at least two subheadings, paragraphs can be used to divide the text. Like figures, tables, and equations, different sections in the report can also be referenced. Section 3 will describe how to present the method (developed and) employed.

3 Method

This section describes the method used, and it is often appropriate to divide the text into subsections. Use up to three levels of headings. This section is sometimes divided into method description, experimental setup, theoretical approach, and/or workflow.

3.1 Method Description

Providing a clear description of the method is important, as it explains why the chosen method yields reliable results. All assumptions and simplifications must be stated and justified. Define mathematical models so that other engineers and researchers can understand what you have done. For example, MATLAB2022b (version 9.13) [3] was used to analyse the measurement results shown in Table 1 and plot the linearised data and the relationship (3) in Figure 2.

3.2 Experimental Setup

All experimental setups, if applicable, are described in a way that allows others to replicate the same experiments and verify your results. Utilise figures to simplify your description.

3.3 Experimental Procedure

Remember that there should always be at least two subsections in each section. This also applies when dividing a section under one subsection into further subsections.

3.3.1 Measurement Method One

In this study, two different measurement methods were used. The first one is described in this subsection.

3.3.2 Measurement Method Two

Measurement method number two...

4 Results

This is likely the largest part of the report. Here, the results are presented directly and objectively. It is often appropriate to divide the text into subsections. The material must be presented in a logical order, which does not necessarily have to be the order in which the experiment/work was conducted.

The reader should be able to read the report without having to flip back and forth. It should be clear what is data and what is the analysis of the data. If results are presented in table or figure form, a brief description of what is observed in the figures/tables should be provided in the text. They are preferably placed nearby (after) where they were first referred to, but due to typesetting considerations, it cannot be guaranteed that they will end up exactly where one would prefer them to be. One consequence of this is that they should not be referred to as "see Figure 2 below" or "Table 1 above". They should be simply referred to by their number, and the reader will have to locate them. The reader is now encouraged to locate Figure 2 and Table 1.

Table 1 contains measured values for the quantity remaining heat θ (in kJ) at four different times t (in s).

Table 1: Measured values for the quantity remaining heat θ at various times t.

t (s)	6	35	47	87	145	329
θ (kJ)	3.10	0.82	0.60	0.51	0.28	0.17

Figure 1 illustrates the measured values for the quantity remaining heat at the times listed in Table 1 in two different ways. The left side of the figure shows the raw data, while the right side shows the data on a log-log scale. These plots are created in MATLAB [3] and exported as `.pdf`. Using the theory presented in Section 2

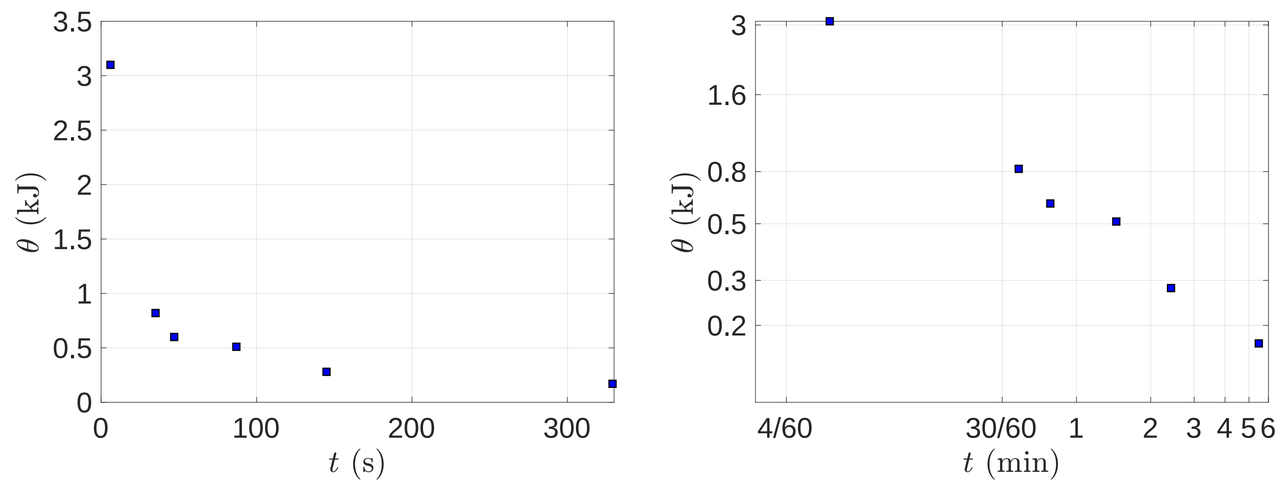

Figure 1: Measured values for the quantity remaining heat at various times (Left). Logarithmic data (Right).

and the measured values in Table 1, a power function of the form

$$\theta = Ct^k \tag{9}$$

is fitted to the data. By using the least squares method, specifically equation (8), we can determine $[m, k]^T$ to be $[9.30, -0.72]^T$ with two decimal places of accuracy. This means that

$$\hat{\theta} \approx 10938.02t^{-0.72}. \tag{10}$$

Figure 2 presents the values for the quantity remaining heat from Table 1 along with the fitted power function $10938.02t^{-0.72}$. The relative error can be obtained through further analysis, i.e.,

$$\frac{\|\hat{\mathbf{z}} - \mathbf{z}\|}{\|\mathbf{z}\|} \approx 0.014. \tag{11}$$

For those interested, there is a package in $\LaTeX\,2_\varepsilon$ for creating graphs directly in the source file. Check out https://www.overleaf.com/latex/examples/latex-figures-using-tikzpicture-pgfplots-and-overpic.

4.1 Subheading one if necessary

If you have one, you must have at least two (see below).

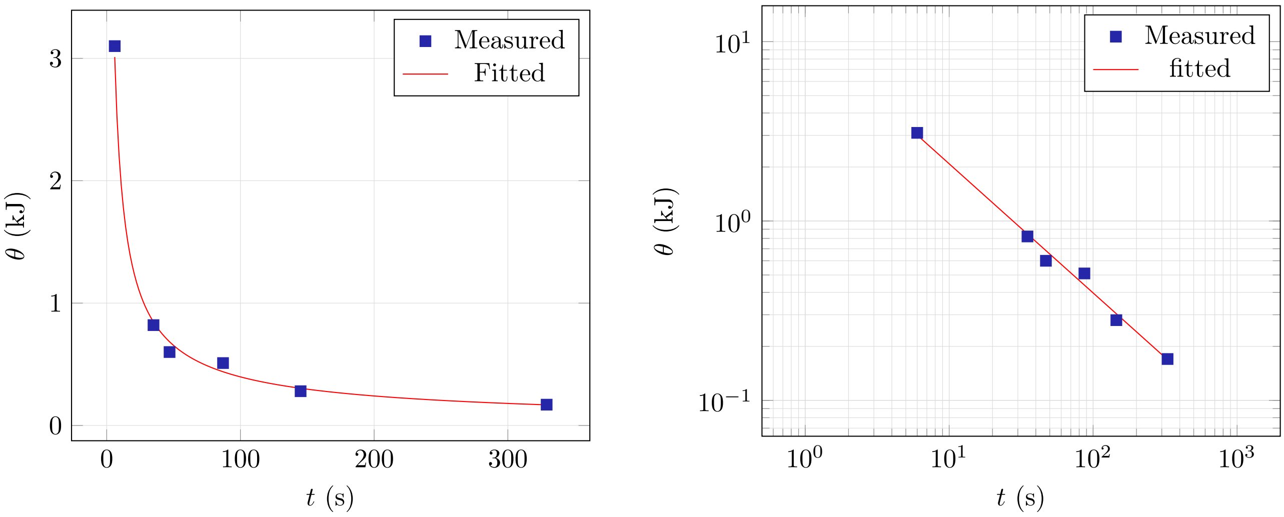

Figure 2: A tikzpicture figure displaying the measured values (blue dots) (those in Table 1) for the quantity remaining heat at various times, along with the fitted power function $10938.02t^{-0.72}$ (continuous red).

4.1.1 Sub-subheading here if needed

But if you have one, you must...

4.1.2 Sub-subheading two under subheading

...have at least one more.

4.2 Subheading two

This is on the same level as subheading 4.1, indicating that there are at least two subheadings within the results section of this report.

5 Discussion and Conclusions

In this section, the results are discussed in a broader perspective and related to previous work, if applicable. Necessary conclusions are drawn to address the stated goals and the relevance of the results. Connect the conclusions to the established goals. Discuss sources of error and uncertainties. For example, it could be mentioned that "the relative error of approximately 1.4% suggests that the power function $10398.02t^{-0.72}$ represents the remaining heat with relatively good accuracy."

It is also appropriate to conclude with suggestions and recommendations for further studies and investigations in the field. "To better ensure the accuracy of the approximation, more data points are needed." Finally, it should be noted that the discussion, conclusions, and future studies can be divided into separate chapters if desired.

References

[1] Birgitta Bergvall-Kåreborn, Carina Ihlström Eriksson, and Anna Ståhlbröst. Places and spaces within living labs. *Technology Innovation Management Review*, 5:37–47, 12/2015 2015. ISSN 1927-0321. doi: http://doi.org/10.22215/timreview/951. URL `http://timreview.ca/article/951`.

[2] Robert A. Adams and Christopher Essex. *Calculus: A Complete Course*. Pearson, 10th edition, 2021. ISBN 9780135732588.

[3] *MATLAB version 9.13 (R2022b)*. The Mathworks, Inc., Natick, Massachusetts, 2022.