

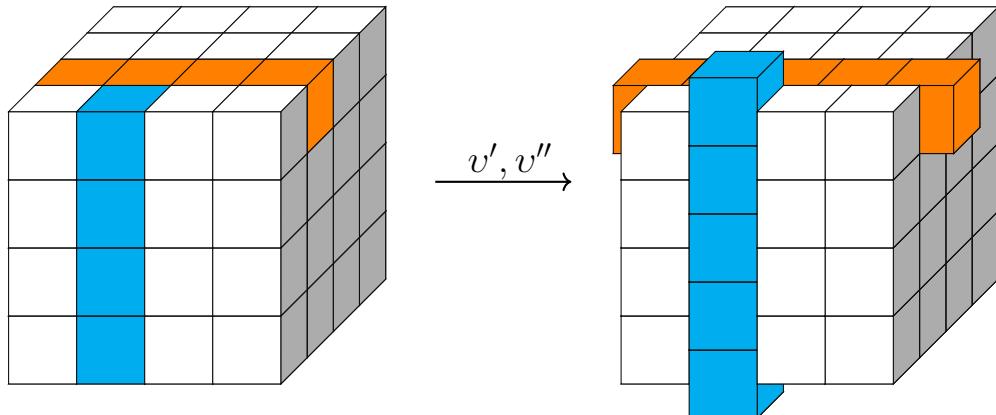


NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

INSTITUTE OF MATHEMATICAL SCIENCES

MA3911 — MASTEROPPGAVE I MATEMATISKE FAG

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30th August 2023

Abstract

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Sammendrag

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.

Preface

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Max Lunde Haug
Trondheim, June 2023

'A famous person once said...'

— Max in writing this document

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Chapter 1

Introduction

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Sit amet risus nullam eget felis *ipsum*. Mattis pellentesque id nibh tortor id aliquet lectus. Nisl nunc mi ipsum faucibus vitae. Amet massa vitae tortor condimentum. Consequat interdum varius sit amet mattis ULTRICIES enim. Aliquam vestibulum morbi blandit cursus risus at ultrices. Adipiscing commodo elit at imperdiet. Facilisis mauris sit amet massa vitae tortor condimentum lacinia. Quis eleifend *quam* adipiscing vitae proin facilisis. Egestas erat imperdiet sed euismod. Nec feugiat nisl pretium fusce id velit ut tortor pretium. Auctor augue mauris augue neque gravida in. Donec ac odio tempor orci dapibus ultrices in iaculis. Tempor orci eu lobortis elementum nibh tellus. Nunc mi ipsum faucibus vitae aliquet nec.

Conjecture 1.1 (Spectral set Conjecture or Fuglede's Conjecture). *Let $\Omega \subset \mathbb{R}^d$ be a bounded subset with positive finite measure. Then Ω is a spectral set if and only if Ω is a tile.*

Pharetra pharetra massa massa ULTRICIES mi. Sed viverra *ipsum* nunc aliquet bibendum enim facilisis gravida. Pharetra convallis posuere morbi leo urna. Consectetur adipiscing elit duis tristique sollicitudin nibh sit. Eget nulla facilisi etiam dignissim diam quis enim. Et tortor consequat id porta nibh. A lacus vestibulum sed arcu non odio. Cras semper auctor neque vitae. Dictum varius duis at consectetur lorem donec massa sapien faucibus. At risus viverra adipiscing at in Conjecture.

Theorem 1.2. *Let $\Lambda \subset \mathbb{R}^d$ and $\Omega = [0, 1]^d$ be the unit cube in \mathbb{R}^d . Then (Ω, Λ) is a spectral pair if and only if (Ω, Λ) is a tiling pair.*

and

Theorem 1.3. *blablablabla*

$$= 42 \tag{1.1}$$

Lemma 1.4. *blablabla*

$$1 + 1 = 2 \tag{1.2}$$

$$6 + 9 = 69 \tag{1.3}$$

Gravida neque convallis a cras semper. Adipiscing enim eu turpis egestas pretium. Odio pel-lentesque diam volutpat commodo sed egestas egestas fringilla phasellus. Libero volutpat sed cras ornare arcu dui vivamus arcu **Theorem 1.2**. Aliquet nibh praesent tristique magna. Integer vitae justo eget magna fermentum iaculis eu. Faucibus purus in massa tempor nec feugiat. Aliquet nec ullamcorper sit amet. Eu non diam phasellus vestibulum lorem sed risus ultricies tristique. Elit at imperdiet dui accumsan sit amet nulla facilisi morbi. Ultrices dui sapien eget mi. In mollis nunc sed id. Dolor sit amet consectetur adipiscing elit dui tristique sollicitudin nibh. Ultrices dui sapien eget mi proin sed libero enim. Enim lobortis scelerisque fermentum dui faucibus. Consequat interdum varius sit amet mattis vulputate enim. Ipsum faucibus vitae aliquet nec ullamcorper sit amet. Vitae auctor eu augue ut lectus arcu bibendum at varius **Theorem 1.2**. Pharetra pharetra massa massa ultricies mi. Sed viverra ipsum nunc aliquet bibendum enim facilisis gravida. Pharetra convallis posuere morbi leo urna. Consectetur adipiscing elit dui tristique sollicitudin nibh sit *vice versa*.

The text is structured as follows:

- We begin with a...
- The third...
- The fourth...
- Finally, we conclude the thesis with a...

(Some final equations for use later)

$$2 + 2 = 4 \tag{1.4}$$

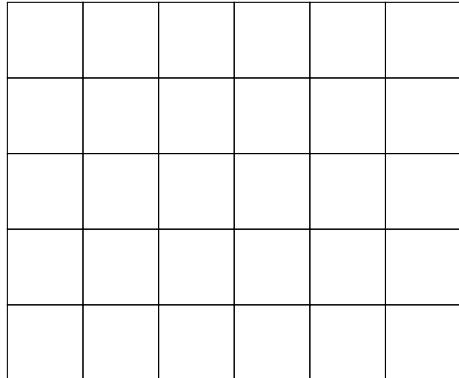
$$m + a + x = max \tag{1.5}$$

Chapter 2

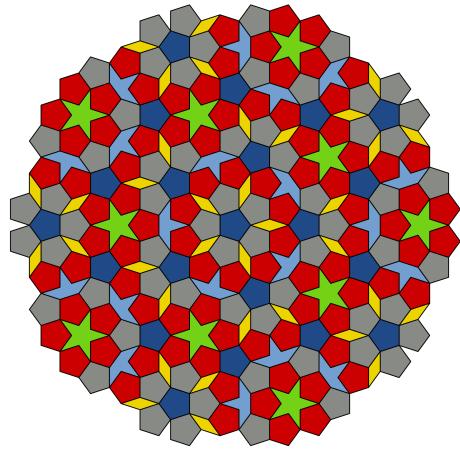
LaTeX Documents Hacks

The preceding introduction showcased how full-fledged text will look like, with some math environments, code comments (only viewable in the `\TeX`editor) and a short overview of highlighting specific text with small-caps and italics. Here is a more detailed overview of a few selected topics.

Here is an example of loading a figure with both Tikz and PNG.



(a) Lattice tiling



(b) P1 Penrose tiling [Ind]

Figure 2.1: Two contrasting tilings of the plane to emphasize the range of complexity. Figure 2.1a shows a simple monohedral tiling, and 2.1b shows an intricate, non-periodic tiling using four different tiles. The coloring in the latter is used to distinguish the tiles more easily and highlight the three *matching rules* for the pentagonal tiles, the only ones with different colors for the same shape. Matching rules are needed in order to tile aperiodically [Pen79].

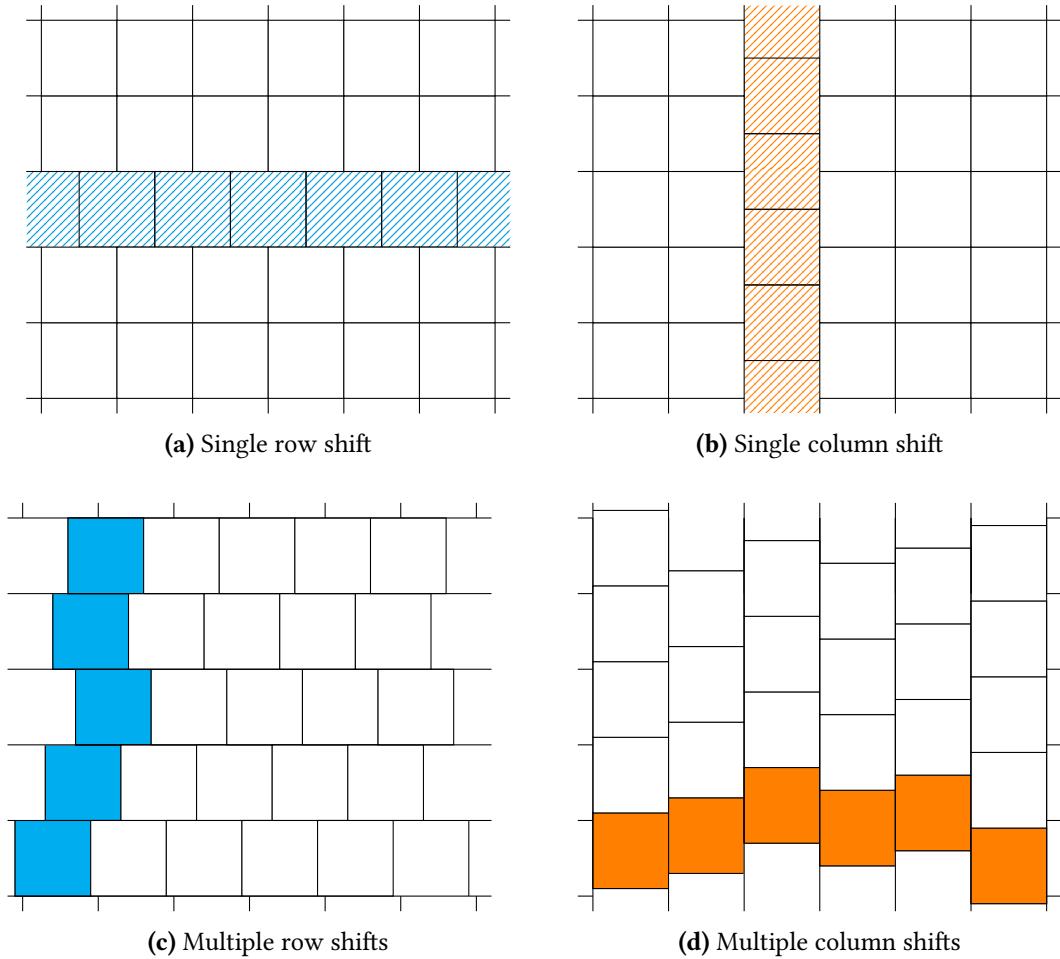


Figure 2.2: Illustration of four tiling pairs for (I^2, Λ) covering \mathbb{R}^2 . The cyan and orange colors represent shifts in the horizontal and vertical direction, respectively. The dashed line pattern in Figures 2.2a and 2.2b highlights the single row or column which is shifted, and the filled cubes in Figures 2.2c and 2.2d highlights the different shifts used for each row or column. Note that if this were a lattice tiling, all the cyan-filled or orange-filled squares would be on the same vertical or horizontal line, respectively.

2.1 Another figure example

Example of a figure with multiple tikiz fikures.

2.2 Citation and Crossreferencing

Citations

For citation use either

- [Hei19] – via the `\cite{heilIntroductionRealAnalysis2019}`
- [Hei19, p. 279] – via the `\cite[p.~279]{heilIntroductionRealAnalysis2019}`
- [Hei18; Hei19] – via the
`\cite{heilMetricsNormsInner2018, heilIntroductionRealAnalysis2019}`
– Note that there cannot be spaces when citing multiple sources in one bracket.
- [Hei18; Hei19, p. 279, p. 365] – via the
`\cite[p.~279, p.~365]{heilMetricsNormsInner2018, heilIntroductionRealAnalysis2019}`

Here 'heilIntroductionRealAnalysis2019' is the label of this citation in my bibliography. See [Chapter 3](#) for tips on a bibliography manager (which also will create these labels for you)

Crossreferencing

To reference parts of the text the following package CLEVERREF provides smart and useful commands. Before going into the commands it is smart when using the `\label{MyLabel}` command to use the following label groups:

- For chapters `\label{chap:MyLabel}`
- For sections `\label{sec:MyLabel}`
- For subsections `\label{subsec:MyLabel}`
- For figures `\label{fig:MyLabel}`
- For definition `\label{def:MyLabel}`
- For remark `\label{rem:MyLabel}`
- For theorem `\label{thrm:MyLabel}`
- For lemma `\label{lem:MyLabel}`
- For equation `\label{eq:MyLabel}`
- For examples `\label{ex:MyLabel}`
- etc.

The normal way of crossreferencing anything in the document is via the `\cref{.}` command. Additionally one might only choose to reference either the label via `\label\cref{.}` command or the name via `\namecref{.}` command (which also has 'lnameref' which produces the output with lowercase letter in front). An advantage of 'nameref' is a case when crossreferencing a specific Theorem which is later changed into a Lemma. In such cases, all discussion that was related to the Theorem will be changed into Lemma automatically. However this also requires the author to be very detailed in the writing so that one does not write Theorem, but rather `\namecref{thrm:main_result}` which gives Theorem. It is not

as laborious as it might sound if one gets into the flow early. Also changing the label group is not advised in these cases, that is a laborious change.

Often when referencing equations (not any one of the other reference categories (in general)) one usually only uses the label yielding (1.1) instead of **Equation (1.1)**. Furthermore, they can be nested into a "single cref" yielding '**Equations (1.1) to (1.3)**' using

```
\cref{eq:another_result, eq:cool_equation, eq:four}
```

or only '**(1.1) to (1.3)**' via the 'labelcref' using

```
\labelcref{eq:another_result, eq:cool_equation, eq:four}
```

Note that these equations are all subsequent, in the case where one has three non-subsequent equations one will get '**Equations (1.1), (1.3) and (1.5)**' using

```
\cref{eq:another_result, eq:four, eq:six}
```

or '**(1.1), (1.3) and (1.5)**' using

```
\labelcref{eq:another_result, eq:four, eq:six}
```

For two items, one will simply get: **Equations (1.1) and (1.2)**, or the label variant: **(1.1) and (1.2)**.

When using `\namecref{ . }` on one or multiple items it will simply produce either **Equation** or **??**. Meaning, 'nameref' does not support multiple items of the same category.

It is important that there is NO SPACE, only COMMAS separating each item.

When referencing multiple items from different categories it will look like this: **Theorems 1.2** and **1.3**, **Lemma 1.4**, and **Equations (1.1) and (1.2)** using the following command

```
\cref{thrm:main_result, thrm:another_result,
      lem:another_result, eq:another_result, eq:cool_equation}
```

Or using 'labelcref': **1.2 and 1.3 ??** or

or using 'namecref': **??**,

The latter two indicate that when using either 'labelcref' or 'namecref', one needs to split the contents into different references.

Last, the captions in figures [Figure 2.1a](#) and [Figure 2.1b](#) highlight a few ways to refer to multiple figures within a figure. This is also illustrated in the following paragraph which also uses ‘nameref’ + ‘cref’ when discussing the referenced theorem and conjecture.

Increasing the dimension by one, we get more flexibility. In particular, when $d = 2$, we do not necessarily need to have a lattice tiling as the one in [Figure 2.1a](#). We can have tilings where we translate single or multiple *columns* of the unit cube, shown in [Figures 2.2b](#) and [2.2d](#); or single or multiple *rows* of the unit cube, shown in [Figures 2.2a](#) and [2.2c](#). In ??, when classifying all tiling sets in the two-dimensional case, we will show that [Figure 2.2](#) to some extent fully captures the flexibility one has in dimension two. We remark that all [Figures 2.2a](#) to [2.2d](#) clearly illustrates that all tilings of the unit cube in \mathbb{R}^2 indeed must satisfy both Keller’s Theorem and Keller’s Conjecture, the latter of which will be of focus for the remainder of this ??.

The following is only included so that the above text works properly.

Conjecture 2.1 (Keller’s Conjecture). *All tilings of \mathbb{R}^d by translations of the unit cube contain two cubes that share an entire $(d - 1)$ -dimensional face.*

Theorem 2.2 (Keller’s theorem). *If Λ is a tiling set for the unit cube, then for any two $\lambda, \lambda' \in \Lambda$ with $\lambda \neq \lambda'$, there exist a $j \in \{1, \dots, d\}$ so that $\lambda_j - \lambda'_j \in \mathbb{Z} \setminus \{0\}$.*

2.3 Text types

A few different text samples. Note that the Libertine font does not support all of L^AT_EX's different font types.

- A text sample for you — Roman using `\textrm{.}`
- A text sample for you — Sans Serif using `\textsf{.}`
- *A text sample for you* — Italic using `\textit{.}` or `\emph{.}`
- *A text sample for you* — Sans Serif Italic using `\textsf{\textit{.}}` or using '`emph`'
- **A text sample for you** — Bold Face using `\textbf{.}`
- **A text sample for you** — Sans Serif Bold Face using `\textsf{\textbf{.}}`
- A TEXT SAMPLE FOR YOU — Sall Caps using `\textsc{.}`
- A TEXT SAMPLE FOR YOU — Sans Serif Small Caps using `\textsf{\textsc{.}}`

Note that when using any of the 'it', 'sf', 'bf', or 'sc' font types it will change the underlining font used. As an example, if it is in a normal text environment it will change the Roman text type, and if it is in a title environment it will change the Sans Serif text type. This can be overwritten using either `\textrm{.}` or `\textsf{.}`, which is why when showing the 'it', 'bf', and 'sc' types of the Sans Serif in the above list it had to be nested. Similarly in a different environment, it would be the Roman text environment that would need to be nested. Note that the order in which one nests these commands does not matter, meaning `\textsf{\textit{.}}` is the same as `\textit{\textsf{.}}`.

Math Fonts

The different Math text types loaded into the document in addition to the above text types are the following

- `\mathrm{.}`
- `\mathit{.}`
- `\mathbf{.}`
- `\mathnormal{.}`
- `\mathcal{.}`
- `\mathscr{.}`
- `\mathbb{.}`
- `\mathbbm{.}`

ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz, 0123456789
ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz, 0123456789
ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz, 0123456789
ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz, 0123456789
ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz, 12

Greek letters

The lowercase and uppercase Greek letters

- Italic – $\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\vartheta\iota\lambda\mu\pi\omega\rho\sigma\tau\upsilon\varphi\chi\psi\omega$
 - Bold Face – $\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\vartheta\iota\lambda\mu\pi\omega\rho\sigma\tau\upsilon\varphi\chi\psi\omega$
 - Italic – $\Gamma\Gamma\Delta\Delta\Theta\Theta\Lambda\Lambda\Xi\Xi\Pi\Pi\Sigma\Sigma\Upsilon\Upsilon\Phi\Phi\Psi\Psi\Omega\Omega\aleph$
 - Bold Face – $\Gamma\Gamma\Delta\Delta\Theta\Theta\Lambda\Lambda\Xi\Xi\Pi\Pi\Sigma\Sigma\Upsilon\Upsilon\Phi\Phi\Psi\Psi\Omega\Omega\aleph$

To get the boldface *greek* we have used the `\textbf{\{ . \}}` command, provided by a specific package I have forgotten the name of.

Custom Letters

In addition to the above font types, there are two custom-made letters of a 'z' with a stroke through. This mimics the often-used written variant of this letter.

- \mathfrak{z} via the command `\zstroke`, can be used in both text and math mode
 - \mathbb{Z} via the command `\Zstroke`, can be used in both text and math mode

2.4 Math specific commands

The following collection of commands are shortcuts for the normal set notation for natural numbers, integers, rationals, real numbers, etc. Feel free to add more if needed.

- $\mathbb{N} - \setminus \mathbb{N}$
 - $\mathbb{Z} - \setminus \mathbb{Z}$
 - $\mathbb{Q} - \setminus \mathbb{Q}$
 - $\mathbb{R} - \setminus \mathbb{R}$

- $\mathbb{C} - \backslash C$
- $\mathbb{F} - \backslash F$
- $\mathbb{F}_p - \backslash Fp$
- $\mathbb{F}_q - \backslash Fq$

The following collection of commands has been created for creating math brackets. They come in two variants; one in which the brackets do not automatically size to the contents inside (mainly for use in text), and the other automatically size to the contents inside. The difference is simply that the latter has the suffix 'Med' in the commands. Feel free to edit/add more if needed.

- $(A^2) - \text{Normal brackets} - \backslash brac\{A^2\}$
- $(A^2) - \text{Normal brackets auto-sized} - \backslash bracMed\{A^2\}$
- $[A^2] - \text{Square brackets} - \backslash bras\{A^2\}$
- $[A^2] - \text{Square brackets auto-sized} - \backslash brasMed\{A^2\}$
- $\{A^2\} - \text{"Curly" brackets} - \backslash braq\{A^2\}$
- $\{A^2\} - \text{"Curly" brackets auto-sized} - \backslash braqMed\{A^2\}$
- $\langle A^2 \rangle - \text{Angled brackets} - \backslash braa\{A^2\}$
- $\langle A^2 \rangle - \text{Angled brackets auto-sized} - \backslash braaMed\{A^2\}$
- $|A^2| - \text{"Length" brackets} - \backslash bral\{A^2\}$
- $|A^2| - \text{"Length" brackets auto-sized} - \backslash bralMed\{A^2\}$
- $\|A^2\| - \text{Norm brackets} - \backslash bran\{A^2\}$
- $\|A^2\| - \text{Norm brackets auto-sized} - \backslash branMed\{A^2\}$

The following collection of commands has been created for creating common functions. Feel free to edit/add more if needed.

- $\not\subset - \text{Not a (proper) subset} - \backslash nsubset$
- $C_{\text{per}} - \text{Set of continuous periodic functions} - \backslash Cper$
- $\mathbb{Z} \setminus \{0\} - \text{Integers without zero} - \backslash intnozero$
- $\mathbb{1}_A(x) - \text{Indicator function} - \backslash indicator\{A\}\{x\}$
- $\mathbb{1}_A - \text{Indicator function without variable } x - \backslash indicatorNoVar\{A\}$
- $\text{span}() - \text{The (finite linear) span} - \backslash spn\{\}$
- $\text{span}() - \text{The (finite linear) span auto-sized brackets} - \backslash spnMed\{\}$
- $\overline{\text{span}}() - \text{The closed span} - \backslash spnclos\{\}$
- $\overline{\text{span}}() - \text{The closed span auto-sized brackets} - \backslash spnclosMed\{\}$
- $\text{mes}() - \text{Measure of a set} - \backslash mes\{\}$
- $\text{mes}() - \text{Measure of a set auto-sized brackets} - \backslash mesMed\{\}$

Math environments

The following math environments have currently been created in addition to the standard 'equation' and 'align' environments. Feel free to edit/add more if needed.

- Theorem
- Lemma
- Proposition
- Corollary
- Conjecture
- Definition – where the environment closes with a \diamond
- Remark
- Construction
- Observation
- Example – where the environment closes with a \diamond
- Proof – where the environment closes with a \square

Changing the style of the environments can be done in the `ntnuthesis.cls` file. Details on how to do this are in the comments there. Furthermore, it is also somewhat intuitive where to put in a new symbol if one wishes to change the already set up \diamond and \square . Note that you might need to be in math mode for these symbols to appear correctly. The same goes for expanding the number of environments to have a closing symbol. Simply copy the already written code and change the environment name. Note that you can create very custom environments for your field, it does not need to be related to maths. One can also fit these environments into colored boxes ([link to tex.stackexchange](#)).

HOT TIP: If the closing symbol appears in a weird spot or you want to force it to a specific spot, you can use the `\qedhere` command within the environment.

A note on the proof environment.

If the proof appears straight after a theorem (or lemma, or etc.) one can simply use

```
\begin{proof}
    Here is my very short proof
\end{proof}
```

Proof. Here is my very short proof \square

However, if there is text, a note, or anything in between the theorem (or lemma, or etc.), then the following is used, which also hyperlinks to the result you're proving.

```
\begin{proof} [Proof of \cref{thrm:keller_tiling}]
```

```
Here is my very short proof
\end{proof}
```

Proof of Theorem 2.2. Here is my very short proof □

Rep environments

A very handy implementation (it is not a package you can load) is code that allows for repeating/recalling a previously stated environment. We dub this the 'rep environment'. To use 'rep environment one must use the following command with double curly brackets:

```
\begin{repEnvironment}{TheLabel}
    MyText, i.e copy/paste the identical content of
    the environment you want to repeat
\end{repEnvironment}
```

This can be edited in 'ntnuthesis.cls' file. Example in use

```
\begin{reptheorem}{thrm:MyTheoremLabel}
    TheContents of the thrm
\end{reptheorem}
```

or

```
\begin{replemma}{lem:MyLemmaLabel}
    The Contents of the lemma
\end{replemma}
```

Example of repeating an actual theorem

```
\begin{reptheorem}{thrm:main_result}
    Let  $\Lambda \subset \mathbb{R}^d$  and  $\Omega = \{0, 1\}^d$  be the unit cube in  $\mathbb{R}^d$ . Then  $(\Omega, \Lambda)$  is a spectral pair if and only if  $(\Omega, \Lambda)$  is a tiling pair.
\end{reptheorem}
```

Theorem 1.2. *Let $\Lambda \subset \mathbb{R}^d$ and $\Omega = [0, 1]^d$ be the unit cube in \mathbb{R}^d . Then (Ω, Λ) is a spectral pair if and only if (Ω, Λ) is a tiling pair.*

All previously created environments support 'rep environments, if you add more environments, make sure to update this code as well if it is needed.

Tips on equation and align math modes

If one wants to continue an aligned environment with a text or content break in between, this can be done with the following

```
\begin{align*}
42 &= 4+2 \\
\intertext{Your text in here, which also supports math mode $2+2=4$}
&= 1234567890
\end{align*}
```

Example in use:

$$\begin{aligned} \langle e_\lambda, e_{\lambda'} \rangle_{L^2(\Omega_1 \times \Omega_2)} &= \int_{\Omega_1} \int_{\Omega_2} e_\lambda(t) \overline{e_{\lambda'}(t)} dt_2 dt_1 \\ &= \int_{\Omega_2} e^{2\pi i (\lambda_2 - \lambda'_2)t_2} \left(\int_{\Omega_1} e^{2\pi i (\lambda_1 - \lambda'_1)t_1} dt_1 \right) dt_2. \end{aligned}$$

Lore ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Sit amet risus nullam eget felis ipsum.

$$= \text{mes}(\Omega_1) \int_{\Omega_2} e^{2\pi i (\lambda_2 - \lambda'_2)t_2} dt_2.$$

Lore ipsum dolor sit amet, $\lambda_2 \neq \lambda'_2$ consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Sit amet risus nullam eget $\lambda_2 = \lambda'_2$ felis ipsum.

$$= \text{mes}(\Omega_1) \text{mes}(\Omega_2) \neq 0.$$

Last, note that both the `equation` and `align` environments are sensitive to newlines after the environment ends. This means if you write the following in your `LE`Xeditor of choice, the output will not be the same. The numbers on the left refer to some arbitrary section of line numbers found in `LE`Xeditors.

12 \begin{equation*} 13 1+1 = 2 14 \end{equation*} 15 Text following eq 16	12 \begin{equation*} 13 1+1 = 2 14 \end{equation*} 15 16 Text following eq
---	---

When skipping a line number in the editor this usually causes a text break with the following text on a new line. In the case to the left, the output will be closer to the equation than in the case to the right. Note that this is not the case for any other math environments such as theorems, lemmas, etc (might also be the case for figures, etc., as well). Meaning that both of the following will give the same output (nice for space and air in the code).

12 \begin{theorem}	12 \begin{theorem}
13 Contents	13 Contents
14 \end{theorem}	14 \end{theorem}
15 TextTextText	15
16	...
17	23 TextTextText

A few in-text commands

Here are a few commands for writing the norm in line with the text. Remember to add a space via the `\space` command after the command itself if it is not the last word in the sentence. Illustration of a space in code vs. a space via `\space` command as well as norm closing the sentence:

```
Texttex \LtwoNorm texttextex \LtwoNorm\space texttextex \LtwoNorm.  
TextTex  $\|\cdot\|_{L^2}$ -normTextTex  $\|\cdot\|_{L^2}$ -norm TextTex  $\|\cdot\|_{L^2}$ -norm.
```

The collection of the currently created in-text commands. Feel free to edit/add more if needed.

- $\|\cdot\|_{L^2}$ -norm
- $\|\cdot\|_{L^p}$ -norm
- $\|\cdot\|_X$ -norm
- $\|\cdot\|_H$ -norm

2.5 other commands

Please see the `commands.tex` file. There are not many outside of the ones used for math. The ones worth mentioning are the following:

- `\mycomment` A "block comment" in the sense that it removes the text from being printed to the final file. However, the counters for figures, chapters, equations, etc. will still increase as they were in the text.
- `\SigridComment` Named after the author's supervisor Sigrid, one simple way of placing comments in the text. Produces the following: **Comment: Blablablabla**
- `\SigridChange` Named after the author's supervisor Sigrid, one simple way of highlighting changes made in the text. Produces the following: **Blablablabla**
- `\SigridChangeTwo` Alternate highlight color for changes made in the text. Produces the following: **Blablablabla**

Add your own commands, change my commands, or delete my commands.

This is your document now

Chapter 3

TiPs

3.1 General tips

- Try to have an overview, makes the next tip easier.
- Prioritise and have some kind of plan
- If you have time to do something, have a list of "small" things that are easy to pick up and do.
- If you need to sit long to get something done, it is sometimes worth doing it, other times the solution is to take a break and come back. Knowing when to do either is a skill in itself.
- Breathers – i.e. a five-minute walk *outside*
- Coffee breaks, preferably with a nice group of people.
- Have food at school, be that crackers, chocolate, noodles, bread, toppings, oatmeal...
- Exercise!
- It is a marathon, not a sprint.
- Have a notebook and or, post-it notes to note down important and useful things along the way.

3.2 Writing tips

- Write a summary of articles you have read. Write ALWAYS where you have found something, the worst is spending time looking for the place something originally came from.
- Highlight PDFs for all its worth. As well as placing text boxes with notes Makes it easier to read later down the line.
- For the most used articles author did this extensively on the printed articles. Now these pages look like a mess with different colored notes in the margin, highlight colors etc.
-

Literature search

- Google is always useful, as well as Google Scholar which has its own pages for many authors and the papers they have written.
- [Litmaps](#) makes a very nice graphical web of connected papers. Useful for searching forwards in time as well as backwards in time. Sometimes some sources are referenced by a lot of authors. One can often generate new "maps" from these sources again. Hot tip: have several different tabs open with different maps. If you register you can save one map, unless you pay for premium.
- [Oa](#) Have not used it much, it seems like a capable search engine.
- [Mathscinet](#) Is a great place for searching for maths papers, many of which have user-generated summaries of high quality.
- [jstor](#) has almost all kinds of journals. NTNU provides access.
- Researchgate, Arxiv, Springer, and similar pages have many articles, usually these can be found via Google or other search engines.
- There exists probably a YouTube video with some updated hacks here.

Bibliography Manager

Make your life easier, get a bibliography manager. The author used Zotero ([link](#)), but there are a few others. Also, download the extension Better BibTex ([Link](#)) which will among a few other things make sure your citation keys stay unique. Now you can create a library inside 'My library for your thesis named 'Mastergrad' (if labeling it something else you must update the `thesis.tex` with your name of this folder), maybe some subfolders for books, articles, etc. Use the magic wand to automatically populate your bibliography. Note that it will sometimes get articles that do not match the ones you have found (there might exist different versions out there), so make sure that the contents (especially the link to the paper) lead to the same one you use. Sometimes you must create manual entries, such as for artwork, images not created yourselves, webpages, etc. When exporting do the following three steps. It will remember the location of where you saved last time and will use the standard name 'Mastergrad' for the file if you labeled the folder as such.

Thesaurus

Are you on a Mac? It has one of the best dictionaries and thesaurus for the English language – and it is built-in! Search for the program named "Dictionary" and choose your preferred languages in the app's preferences.

Write grammar free and correctly

In addition to finding synonyms via the thesaurus above, chatgpt was used to find alternate words (also if needed, doublechecking its meaning via other sources). The author does not recommend chatgpt for writing content or solving problems it is much better (although not perfect) at rewriting your content, although sometimes the result is terrible. Also note, a paragraph might initially look good, but a read over a week later might result in you finding it made no sense at all. You will however rewrite parts of your thesis many times, and this is (usually) a *good* thing <3 The most useful program for writing was Grammarly. chatgpt knows

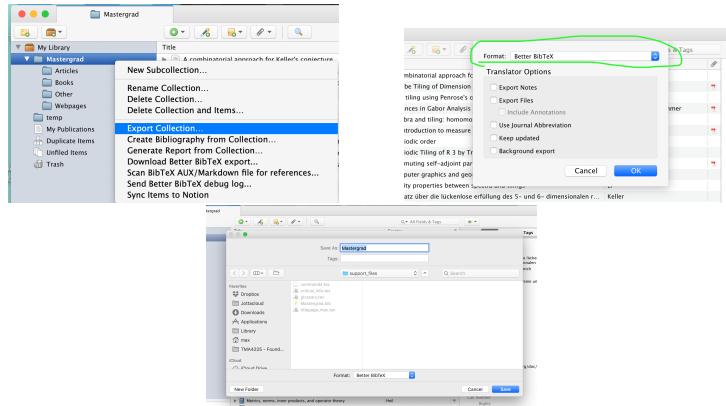


Figure 3.1: Zotero export guide. Right-click and choose 'export collection'. Make sure the format is correct (BetterBibTeX). The first time you must manually navigate to the correct save spot, later on the Zotero should remember this.

no grammar, and makes many many many grammar errors when writing. Grammarly is the bread and butter of spellchecking your thesis. An added benefit of Grammarly is that it can be integrated into many \LaTeX editors, including the one the author used (Vscode). If you need to buy it to get the extended functionality, it is well worth its steep price.

!Backup your document!

If writing locally, plz make a backup!!! I kept two of my \LaTeX code; Paying a premium to Apple to back up my *entire* desktop, documents, etc. to the cloud, and also synchronizing my one folder with the thesis itself to GitHub, a feature that is neatly integrated into Vscode, and easy to use. GitHub, in addition to providing peace of mind, has a nice interface for viewing the history of all the changes to your document (that is only the changes you have pushed/saved to git, not the changes your editor itself keeps a history of (which is usually reset every time you close/open your document)). If you work with sensitive information or do not want your thesis public, the repository (name of the "folder" you have stored the theis) can be set to private.

3.2.1 Tips on debugging \LaTeX

- Ask "chatgpt" with your problem/code/error message. This can often be helpful to understand WHAT has gone wrong. It may provide solutions that will not work. It might however be a good starting point for further search.
- Search the web
- Read the documentation for the package you are using on CTAN <https://www.ctan.org>
- Search the wiki (usually better than Wikipedia itself) <https://en.wikibooks.org/wiki/LaTeX>
- Ask a friend

If something is difficult to solve and is not directly related to the actual content of your thesis, consider making a note of what you have found out + what do to next to try and solve it, and then move on to more pressing matters.

3.2.2 Tips for creating specific things in L^AT_EX

For generating tables:

<https://tablesgenerator.com>

Genious for testing L^AT_EX code:

<https://www.latex4technics.com>

Note that in the settings tab, one can change from compiling only equations to full L^AT_EX. This can be useful for quickly testing figure code or other things in which you need a very very short compile time to test changes quickly. Important! If the page is refreshed, you lose all you have written.

Figures for biology, medicine, etc.

<https://www.biorender.com>

Wish we had this for maths sometimes!

Tikz and some thoughts on drawings

When creating drawings in L^AT_EX, I would recommend doing so using the powerful internal package 'tikz'. It can sometimes be hard to use, but here is a few tips to get you started. First, a good source for some basic knowledge is https://www.overleaf.com/learn/latex/TikZ_package, or <https://tikz.dev> for more detailed information on specific parts of Tikz and the different libraries one can use. The latter also provides some tutorials as well as providing a great overview of what it can be used to draw. The author also used chat-gpt to generate some initial code, or to ask questions on "how to do this and that", but it cannot get you all the way. To test tikz code the author used the webpage above 'latex4technics'. Functional, readable, and "good" figures are important. It is not recommended to do not push these "time thieves" to the final weeks. In addition to making your thesis better, it is also rewarding to complete a cool L^AT_EXfigure, and it was also the only thing my family partly understood of the thesis. A final mention is of this page which has tutorials for many types of figures and drawings <https://latexdraw.com>.

If one does not want to learn Tikz, one can always play around with matcha.io, but it might not give you what you want, or the result is to simple of a drawing/figure.

3.2.3 Math specific pages

A simple and useful dictionary

<https://matematikkradet.no/ordliste/>

For drawing simple arrow diagrams

<https://tikzcd.yichuanshen.de>

The superior and more powerful diagram editor

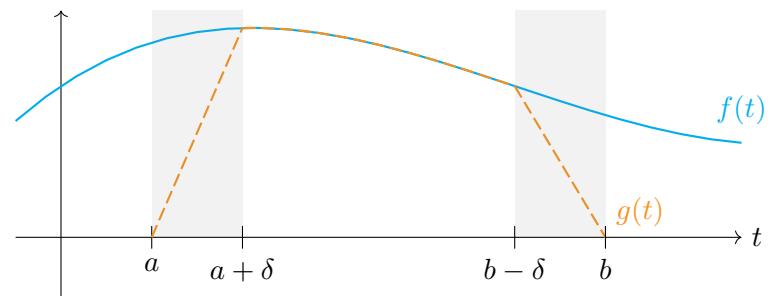
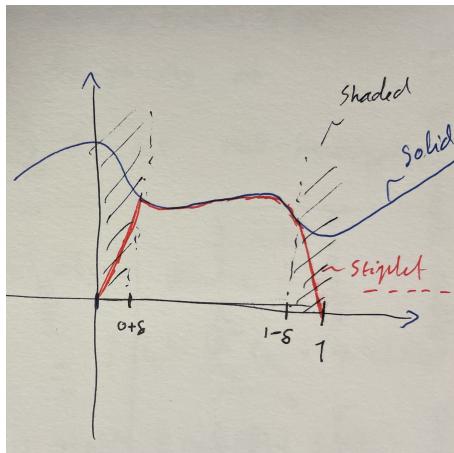
<https://q.uiver.app>

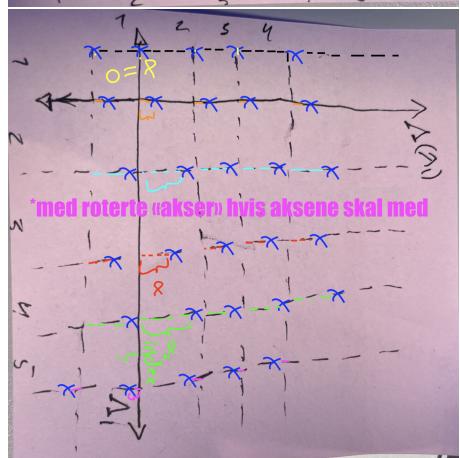
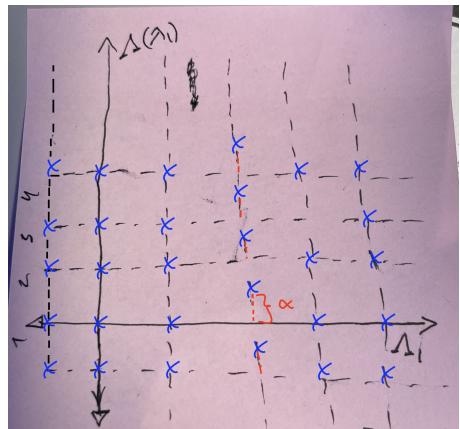
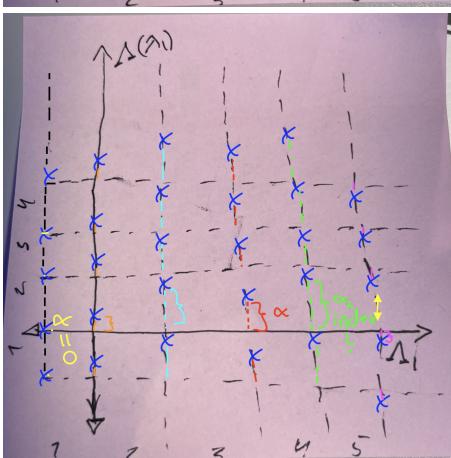
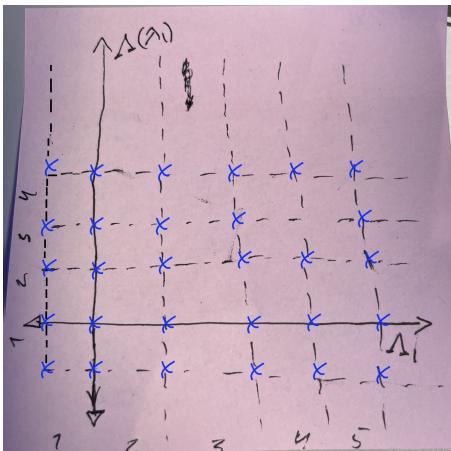
Writing advice from Tao

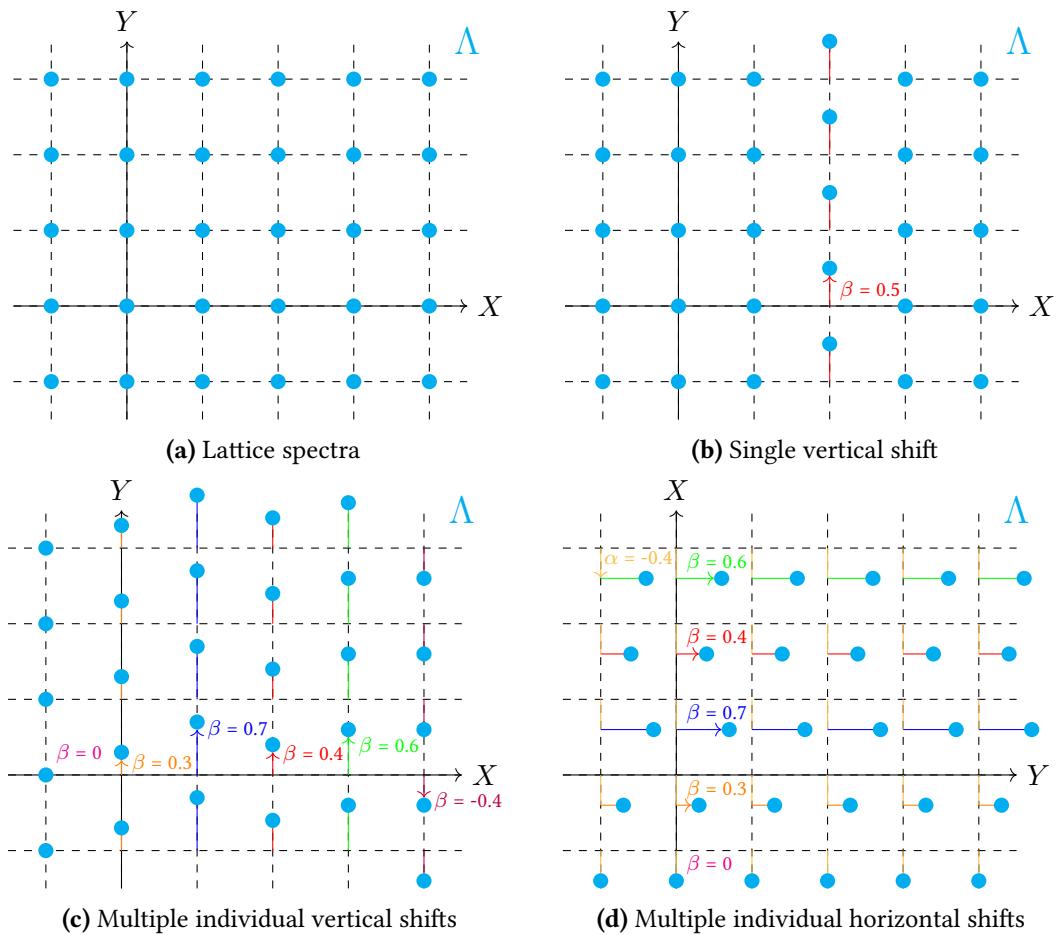
<https://terrytao.wordpress.com/advice-on-writing-papers/>

3.3 Examples from my thesis

Before and after for some figures





**Figure 3.4:** Caption

The author's thesis structure. No need to copy this "organized mess". Note the pinned `thesis.tex` and `commands.tex`, and also the happy pets down below.

```

MAX-MASTER
    chapter_notes
    chapter_trash
        chapters
            00_A_TEMPLATE_empty.tex
            00_frontmatter.tex
            00_x1_abstract.tex
            00_x2_preface.tex
            00_x2_quote.tex
            01_introduction.tex
            02_preliminaries.tex
            02_x1_asec.tex
            02_x2_vecspace.tex
            02_x3_onb.tex
            02_x4_exponential_function...
            02_x5_indicator.tex
            03_tilings.tex
            03_x1_cube_gen.tex
            03_x2_non-periodic.tex
            03_x3_aperiodic.tex
            03_x4_proof_keller.tex
            04_spectral_sets.tex
            04_x1_one_dim.tex
            04_x4_higher_dim.tex
            06_equiv_tiling_spec_ncub...
        figures
        preamble
        support_files
            OUTLINE
            TIMELINE
    VS CODE PETS

```

```

TEX thesis.tex 1  TEX commands.tex
TEX thesis.tex > ...
7   \documentclass[british, twoside]{ntnuthesis} % Language options
8   \else
9   \documentclass[british, oneside]{ntnuthesis} % Language options
10  \fi
11
12
13  %% --- Import of additional preamble files (advanced) --- %
14  \usepackage{import} % import package allows for loading self-made
15  \usepackage{preamble/head_mk2}
16
17
18  %% --- Import support files --- %
19  \input{support_files/critical_info.tex} %! Remember to update this
20  %\input{support_files/glossary.tex} % add glossary and acronym
21  \input{support_files/commands.tex} % add commands before document
22  \addbibresource{support_files/Mastergrad.bib} % add the Bibliography
23
24  %! Two-side option
25  %! Must manually check whether the page offset appears correctly
26  %? If the code is commented out (i.e. the offset appears on the wrong
27  \ifPRINTING
28      % The following code "flips" the offset for the 'left' and 'right' pages
29      \let\tmp\oddsidemargin
30      \let\oddsidemargin\evensidemargin
31      \let\evensidemargin\tmp
32      \reversemarginpar
33
34
35  %% ----- THE DOCUMENT ----- %
36  \begin{document}
37      %% --- Opening --- %
38      %? Remember to comment out the title page when creating the document
39      %\input{support_files/titlepage_max.tex} %! Temporary title
40      \input{chapters/00_frontmatter.tex}
41
42      %% --- DOCUMENT START --- %
43      %? --- NOTE: Folder structure --- %
44      % 1. Allows compilation of each subfile rather than compiling the whole
45      % 2. Subfiles must have this file as an option while using the \subfile command
46      % 3. Loading a subfile is done with \subfile{"path-to-file"}
47      % 4. Remember to use the template to get all the right \subfile commands
48
49

```

Bibliography

- [Hei18] Christopher Heil. *Metrics, Norms, Inner Products, and Operator Theory*. New York, NY: Springer Berlin Heidelberg, 2018. ISBN: 978-3-319-65321-1.
- [Hei19] Christopher Heil. *Introduction to Real Analysis*. Graduate Texts in Mathematics 280. Cham, Switzerland: Springer, 2019. ISBN: 978-3-030-26901-2. DOI: [10.1007/978-3-030-26903-6](https://doi.org/10.1007/978-3-030-26903-6).
- [Ind] Inductiveload. *A P1 Tiling Using Penrose's Original Set of Six Prototiles*. URL: <https://commons.wikimedia.org/w/index.php?curid=5839133> (visited on 17/04/2023).
- [Pen79] Roger Penrose. ‘Pentaplexity A Class of Non-Periodic Tilings of the Plane’. In: *The Mathematical Intelligencer* 2.1 (Mar. 1979), pp. 32–37. ISSN: 0343-6993. DOI: [10.1007/BF03024384](https://doi.org/10.1007/BF03024384). URL: <http://link.springer.com/10.1007/BF03024384> (visited on 17/04/2023).