IM060 Writing and Typesetting with Math

Part 1

Main elements of mathematical notation.

Wilhelm Burger

Interactive Media, Hagenberg

WS 2016/17

Administrative issues

3 Lab Sessions:
Mon 2016-11-14
Tue 2016-11-22
Tue 2016-12-13

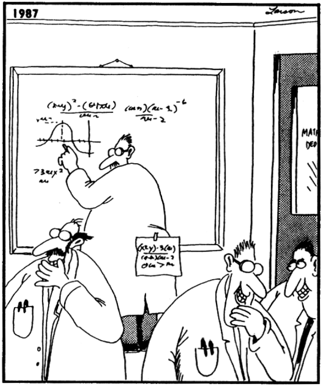
Language:
English or German (your choice)

Location:
WHS "Warehouse" (FH2.406)

Credit:
1.0 ECTS (requires presence + modest homework)

Grade:
Based on attendance and submitted homework

Goals of this workshop



Learn how to . . .

- **compose text** with mathematical elements.
- develop a **mathematical notation** for a given problem.
- understand **professional rules and conventions**.
- differentiate between **math** and **program code**.
- make use of **mathematical constructs** in **LaTeX**.
- **find joy** in mathematical writing?

Why is this important?

$$\bar{x} = \frac{1}{N} \cdot \sum_{i=0}^{N-1} x_i$$

- Mathematics is a (THE?) **universal language** with precise semantics (in contrast to prose).
- As in any language, **established rules and conventions** exist.
- In engineering, there is **no professional publishing** without mathematics.
- Most people are able to **read** mathematics, but have **no fluency in writing**.
- **Trivial mistakes** (one can find many!) can be easily avoided.

Example (Master thesis)

will not say anything about your ability. With the absolute value he wouldn't be in the middle section of this table. For that the difference in percent is used for the feature vector. This difference in percent is calculated:

$$diff = \frac{|(\sum l - \sum r)| * 100.0}{\sum k} \tag{3.1}$$

where r are the right rotation keystrokes, l are the left rotation keystrokes and k are all keystrokes.

The analysis of the keystrokes shows that the low experienced player have a significant high difference in using their rotation keys, this comes from

Note that . . .

- I am NOT a mathematician.
- I am NO walking LaTeX dictionary.
- Often there is no "right" or "wrong" (sometimes *taste* matters).
- This is a **workshop**!

Planned contents

Part 1: Mathematical notation – basic elements, combining math and prose.

Part 2: Working with operators, functions, sets, sequences, vectors and matrices.

Part 3: Mathematical graphics, algorithms, fine-tuning, custom LaTeX commands.

Let's start with a simple example ...

Buying a bat-and-ball set:

- A complete **bat-and-ball set** costs 11.00 €.
- The ball costs exactly 10.00 € less than the bat.
- What is the individual price for the bat (and the ball)?

Generalize this problem and describe it (including the way to solve it) in a short text. Define suitable variables for the individual quantities.

We jointly edit a LaTeX document on www.overleaf.com (specific link is published on the course site, anonymous access, no need to sign in).

Naming mathematical objects

One of the key achievements of mathematics is to identify relevant entities with **unique names and symbols**:

- **Single-symbol** identifiers are preferred (unlike in computer programs), e.g., $a, b, x, \boldsymbol{x}, X, \alpha$, ...
- **Avoid** identifiers typically used in **program code**, e.g., xPos, sum, $\mathrm{average}$, $\mathrm{maximumCurvature}$ etc.
- Most common: **Latin** and **Greek** alphabets.
- Avoid symbols that “normal” people cannot **read** $(\rho, \xi, \zeta, \aleph, \ldots)$!
- Follow **established conventions**, save your creativity for the hard parts!

Common symbols (quantities)

Some symbols are **associated with a particular meaning** – use them appropriately, e.g.,

- $i, j, k, m, n, \ldots$: integer (index, counting) variables
- x, y, z: real or complex variables, coordinates in geometry
- $\alpha, \beta, \gamma, \ldots, \pi, \phi, \theta$: angular values
- $K, M, N, \ldots$: integer constants
- $\mathbb{R}, \mathbb{C}, \mathbb{Z}, \mathbb{N}$: number sets
- π, ϵ, e, i (e, i): numerical constants
- $\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z}$: vectors
- $A, \boldsymbol{M}, \mathbf{X}, \mathbf{I} \ldots$: matrices
- $\mu, \sigma, \mathcal{N}, \ldots$: common symbols in statistics

Remember that math is *always* part of the prose

- **Inline math elements:**

  All inline math elements appearing in the main text, for example, the variables a and b, must be typeset in **math mode**, using `$...$`.

- **Displayed equations:**

  Important definitions, relations and elements too large to fit in a normal text line are usually typeset as **displayed equations**, such as

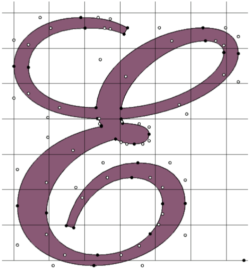
  $$f(x) = \frac{x}{3} + 7x^2, \tag{1}$$

  where x is the free variable.

- **Any math is part of the prose:**

  As in the above example, it must be easy to "**read through**" the mathematical parts of your text. Write **complete sentences** and use **proper punctuation**!

LaTeX: Math typefaces



Different typefaces effectively **enlarge the range of available symbols**:

- ABC: `\mathit{ABC}` or `ABC` (*math-italic*)
- ABC: `\mathrm{ABC}` (*math-roman*)
- $\mathbf{ABC}$: `\mathbf{ABC}` (*math-boldface*)
- $\boldsymbol{ABC}$: `\boldsymbol{ABC}` (*bold-symbol*)*
- ABC: `\mathsf{ABC}` (*math-sans-serif*)
- $\mathcal{ABC}$: `\mathcal{ABC}` (*math-calligraphic*)
- $\mathtt{ABC}$: `\mathtt{ABC}` (*math-teletype*)
- $\mathbb{ABC}$: `\mathbb{ABC}` (*math-blackboard*)**

But: Use **consistently** and **with care**!

*Part of the `AMSmath` package. **Requires the `Blackboard` font package.

Using accents

- Accents are useful for creating **distinct but related identifiers**.
- Examples: $\hat{x}, \check{x}, \breve{x}, \acute{x}, \tilde{x}, \dot{x}, \bar{x}$

```
$\hat{x}, \check{x}, \breve{x}, \acute{x},
 \tilde{x}, \dot{x}, \bar{x}$
```

- **Note:** Certain accents have a **standard meanings**, e.g., $\bar{x}, \hat{x}, \dot{x}$.

Subscripts

Subscripts are often used to enumerate individual elements:

- $X = (x_0, x_1, \ldots, x_{n-1})$

```
$X = (x_0, x_1, \ldots, x_{n-1})$
```

Sometimes, we need **more than one subscript** item, e.g.:

- $\theta_{i,j}$, $N_{\sigma,\mu}$, ...

```
$\theta_{i,j}$, $N_{\sigma,\mu}$
```

Not more. Keep them short!

Superscripts

Superscripts are usually assumed to mean **exponents**:

- $x^2 \equiv x \cdot x$

```
$x^2 \equiv x \cdot x$
```

If superscript is used for an **index** (sometimes needed), use **parentheses** to avoid confusion:

- $X_{m,n}^{(1)}, X_{m,n}^{(2)}, \ldots, X_{m,n}^{(n)}$

```
$X_{m,n}^{(1)}, X_{m,n}^{(2)}, \ldots, X_{m,n}^{(n)}$
```

Avoid **monstrous** exponents, such as

- $e^{\frac{x^2+y^2}{(2\pi xy)^2}} \equiv \exp \frac{x^2+y^2}{(2\pi xy)^2} \equiv \exp \left(\frac{x^2+y^2}{(2\pi xy)^2} \right)$

LaTeX topic: Displayed equations

LaTeX evironments for creating **equation-like constructs** are available in plain **LaTeX** and the **amsmath** package.

Most frequent:

- `equation` (LaTeX + `amsmath`)
- `align`, `split` (`amsmath` only)
- `alignat` (`amsmath` only)

equation environment (LaTeX/amsmath)

Example (see Eqn. 1):

```
\begin{equation}
  f(x) = \frac{x}{3} + 7 x^2 ,
  \label{FirstEquation}
\end{equation}
```

Used for **single-line equations**, automatically numbered. To reference the **number of this equation**, we simply use

```
\ref{FirstEquation}
```

LateX: Labeling and referencing equations

- Use a unique **label** to identify the equation, e.g., "`FirstEquation`" or "`eq:fContr`".
- In the **subsequent** text, reference this equation as Eqn. 1 or simply (1) whenever needed.
  `... reference Eqn.~\ref{FirstEquation}`
  `or simply \eqref{FirstEquation} ...`[1]
- Let **all** displayed equations be **numbered**.
- **Never ever** make a **forward reference** to a later equation, unless for *very* good reason!
- Avoid the word "**formula**" since it sounds odd. Use "**equation**" (Gleichung) or "**expression**" (Ausdruck) instead.

[1] `\eqref` is defined by `amsmath`.

LateX: Blank line/space issues (1)

- Leave **no blank lines** before/after equation environments![2]
  Correct:

```
... for which we define the function
\begin{equation}
      f(x) = a x + b x^2 + c .
\end{equation}
This function is used to ...
```

Wrong:

```
... for which we define the function

\begin{equation}
      f(x) = a x + b x^2 + c .
\end{equation}

This function is used to ...
```

[2] Unless additional paragraphs are intended.

LateX: Blank line/space issues (2)

- **Use comments** (%) to avoid empty lines before/after equations:

```
... for which we define the function
%
\begin{equation}
      f(x) = a x + b x^2 + c .
\end{equation}
%
This function is used to ...
```

- Also, **no empty lines** are allowed **inside** equation environments (**error**)!

```
\begin{equation}
      f(x) =

          a x + b x^2 + c .
\end{equation}
```

align environment (amsmath)

Used for **multi-line equations** with vertical alignment, very flexible. Example:

$$\begin{aligned} D_{\mathrm{peak}}(\boldsymbol{c}) &= D(\boldsymbol{c}) + \frac{1}{2} \cdot \nabla^T_{D}(\boldsymbol{c}) \cdot (\breve{\boldsymbol{x}} - \boldsymbol{c}) \qquad (2) \\ &= D(\boldsymbol{c}) + 0.5 \cdot \boldsymbol{d} \cdot \nabla_{D}(\boldsymbol{c}), \qquad (3) \end{aligned}$$

```
\begin{align}
D_{\mathrm{peak}}(\boldsymbol{c})
  &=
    D(\boldsymbol{c}) +
      \frac{1}{2} \cdot \nabla^T_{D}(\boldsymbol{c})
      \cdot (\breve{\boldsymbol{x}} - \boldsymbol{c})
  \label{eq:Line1}
  \\
  &=
    D(\boldsymbol{c}) +
      0.5 \cdot \boldsymbol{d} \cdot \nabla_{D}(\boldsymbol{c}) ,
  \label{eq:Line2}
\end{align}
```

`align` environment (2)

- Alignment is possible at *any* position (not only $=$ signs)
- Every line is automatically numbered. Suppress numbering with `\nonumber` or `\notag`.
- Use `align*` to turn off numbering.

align environment (3)

Can be used to create equations with **multiple aligned columns**:

For example, the relations

$$\begin{align} x &= y, & X &= Y, & a &= b + c, \tag{4}\\ x' &= y', & X' &= Y', & a' &= b, \tag{5}\\ x + x' &= y + y', & X + X' &= Y + Y', & a'b &= c'b \tag{6}\end{align}$$

are always satisfied under the given circumstances.

```
\begin{align}
x       &= y,       & X       &= Y,       & a   &= b + c,\\
x'      &= y',      & X'      &= Y',      & a'  &= b,\\
x + x' &= y + y', & X + X' &= Y + Y', & a'b &= c'b
\end{align}
```

- Be careful about **punctuation** (commas)!

Assignments

Guidelines:

1. Write a short (1–2 pages) **treatment** on a simple problem that is given in colloquial prose.
2. Identify the **relevant quantities** and define appropriate **mathematical symbols** for them (i.e., develop a math. notation).
3. Summarize the problem as a well-readable combination of **prose** and **mathematical elements**. Make sure to write complete, well-formed sentences.
4. Use **in-line math** and **displayed equations** wherever needed. Try to follow common rules.
5. Give numerical **examples** whenever appropriate.
6. Make notes of all **open questions** and uncertainties that occurred.
7. Submit a **ZIP file** containing the LaTeX source and the final PDF (Moodle upload).

Assignment 1

1. Thoroughly **read** the paper by **Mermin**, "What's Wrong With These Equations?" (available at the course site).
2. Write a **short mathematical treatment** (see slide 24) on each of the following topics:
   A. **Why the dinosaurs could not grow any bigger.** Bones need to be strong enough to carry the weight of a creature. Growing by a certain factor means that the diameter of bones grows linearly and the cross section area grows quadratically. However, the weight grows with the third power and therefore . . .
   B. **How a *section control system* works.** Section control system are efficient for controlling speed limits over relatively large distances. Identify the relevant quantities and express them mathematically. What do these systems need to measure and calculate, how do they decide to fine a particular driver?

Be **creative** and formulate your **own thoughts** (no need for Google)!