Mathematical Nomenclature

Miloslav Čapek

Department of Electromagnetic Field
Czech Technical University in Prague, Czech Republic
miloslav.capek@fel.cvut.cz

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Outline

Disclaimer:

- I am not an expert in the topic, just a fan.
- Often just a best practice or personal experience is presented.

About the Talk

- Extremely wide topic. Here: overview only!
  - From pure aesthetics, through typography, typesettings, graphics, towards colors, proportions, data processing and DTP (desktop publishing).
  - High-level (style, stylistic, templates) to low-level (figures, tables, lists, headings),
  - Appropriate number of seminars would span an entire semester.
  - Instead of being complete, let's build some interest in the topic.
- what? $\times$ how?
- Mainly for technical writing.

Be prepared for a slow going learning curve.

Structure of the Talk

Why?

- Because “good enough” is not your way...
- Because you respect standards and good practice.
- Because quality of your work and its presentation goes hand-in-hand.

Mathematical Nomenclature

Serves

- clarity,
- standardization.

Known standards:

- ISO (International Organization for Standardization),
- ANSI (American National Standards Institute),
- IEEE (Institute of Electrical and Electronics Engineers),
- IUPAP (International Union of Pure and Applied Physics),
- ČSN.

ISO 80000

International standards for physical quantities and units, part 1.

Part	Year	Name	Replaces
ISO 80000-1	2009	General	ISO 31-0, IEC 60027-1, and IEC 60027-3
ISO 80000-2	2009	Mathematical signs and symbols to be used in the natural sciences and technology	ISO 31-11, IEC 60027-1
ISO 80000-3	2006	Space and time	ISO 31-1 and ISO 31-2
ISO 80000-4	2006	Mechanics	ISO 31-3
ISO 80000-5	2007	Thermodynamics	ISO 31-4
ISO 80000-6	2008	Electromagnetism	ISO 31-5 and IEC 60027-1
ISO 80000-7	2008	Light	ISO 31-6
ISO 80000-8	2007	Acoustics	ISO 31-7

ISO 80000

International standards for physical quantities and units, part 2.

Part	Year	Name	Replaces
ISO 80000-9	2008	Physical chemistry and molecular physics	ISO 31-8
ISO 80000-10	2009	Atomic and nuclear physics	ISO 31-9 and ISO 31-10
ISO 80000-11	2008	Characteristic numbers	ISO 31-12
ISO 80000-12	2009	Solid state physics	ISO 31-13
ISO 80000-13	2008	Information science and technology	IEC 60027-2:2005 and IEC 60027-3
ISO 80000-14	2008	Telebiometrics related to human physiology	IEC 60027-7

- SI units (not only) used.
- One unit is € 138.

Variables and Units

$$f_0 = \{f_{\text{quantity}}\}\,[f_{\text{unit}}] = 12\,345(67)\,\text{Hz}$$

- Quantity always in **italic**.
  - Note that $12\,345 \pm 67\,\text{Hz}$ is incorrect from mathematical point of view.
- Unit always in **roman**.
  - A short space (`\,` in LaTeX) placed between the quantity and the unit symbol (except the units of degree, minute, and second).
  - Units are always in lowercase (meter, second), except those derived from a proper name of a person (Tesla, Volt) and symbols containing signs in exponent position (°C).
  - Different units are separated by a space (N m not Nm) or a c-dot ($1\,\text{N}\cdot\text{m}$).
  - Prefixes are written in roman with no space between symbol and prefix (1 THz vs. 1 T Hz vs. 1 T Hz vs. 1 THz).
  - $l = 1.31 \times 10^3\,\text{m}$, $l = 1.31 \cdot 10^3\,\text{m}$, $S = 20\,\text{m} \times 30\,\text{m}$.

Decimal Sign and Exponents

- Decimal sign is either a comma or a point ($1,234$ or 1.234).
- Numbers can be grouped from the decimal sign or from left ($12\,345.678\,9$ or $1\,234$), use small space then.
- Negative exponents should be avoided when the numbers are used, except when the base 10 is used (10^{-5} not 4^{-8}, type $1/4^8$ instead).
- Multiplication with $\cdot$ or $\times$. Do not use any symbol for products like ab, $\mathbf{Ax}$, etc. Use when multiplication operation has to be highlighted, *i.e.*, multi-line equation or $2.125 \cdot 10^8$.
- Number of significant digits ($410\,008$ vs $410\,000$ vs $4.1 \cdot 10^5$).

▸ Unit prefixes ▸ Mathematical symbols ▸ Guide for the use of SI units

Constants

mathematical Dimensionless with fixed numerical value of no direct physical meaning or necessity of a physical measurement.

- Examples: Archimedes' constant (π), Euler's number (e), imaginary unit (j).

physical Often carry dimensions, they are universal and constant in time.

- Examples: speed of light in vacuum (c_0), electron charge (e), permittivity of vacuum (ε_0), impedance of vacuum (Z_0).

mathematical always in roman type, *i.e.*, $\mathrm{e}^{\mathrm{j}\pi} + 1 = 0$

physical always in italic type, *i.e.*, $2c_0$, *cf.* e^2 vs. e^2

Functions

Functions always in roman, they are not variables!

$\sin(xy)$, $y \sin x$
$\mathrm{j}_1(x)$, $-\mathrm{j}\mathrm{j}_1(x)$
$\lim_{x\to\infty} f(x)$

Use parentheses whenever clarity is in question.

Sub- and Superscripts

- Italic: index represents an unknown variable or a running number/index/counter:
  - $\sum_n \alpha_n f_n(x)$, c_i, z_{mn}, $\mathbf{u}^{(p)}_{\tau\rho ml}(kr)$.
- Roman: index represents a number or an abbreviation:
  - ε_r, c_0, P_rad, Q_lb.
- Should not be overused ($n_0^{m^{k^l}}$).

1. Whenever possible, simplify and shorten, *i.e.*, $\boldsymbol{n}_0 \to \hat{\boldsymbol{n}}$, $P_\mathrm{radiated} \to P_\mathrm{rad}$.
2. Prioritize clarity, consistence.

In-line and Full Equations

Different approach needed, *cf.*

$\dfrac{a}{b}$	a/b
$\lim\limits_{x\to\infty} f\left(x\right)$	$\lim_{x\to\infty} f\left(x\right)$
$\mathrm{e}^{-\mathrm{j}\omega t}$	$\exp\left\{-\mathrm{j}\omega t\right\}$
$\int\limits_0^{2\pi} \dfrac{x}{x+a}\,\mathrm{d}x$	$\int_0^{2\pi} x/\left(x+a\right)\,\mathrm{d}x$

- In-line equations prioritize space-saving strategy.
- Equations are always a part of the text.

Integration

A small space between integrand and differential, differential roman typed:

$$\frac{1}{T}\int_{t}^{t+T}\int_{\Omega} f\left(\boldsymbol{r},t\right)\,\mathrm{dV}\,\mathrm{d}t, \quad \boldsymbol{r}\in\Omega.$$

- Be careful about in-line and full equations, *i.e.*, usage of $\int$ and $\displaystyle\int$.
- Limits of integral are written over and under the symbol, unless spatial requirements prevents it (in-line eq.).
- The variable of integration shall be written in italics if it relates to a coordinate system or if the integration domain has explicitly defined limits, roman otherwise.

Differentiation

$$\frac{\mathrm{d}f\left(x\right)}{\mathrm{d}x}$$

$$\nabla \cdot \boldsymbol{J}\left(\boldsymbol{r}\right) = -\frac{\partial \rho\left(\boldsymbol{r}\right)}{\partial t}$$

Vector identities: $\boldsymbol{r}_1 \cdot \boldsymbol{r}_2$, $\boldsymbol{r}_1 \times \boldsymbol{r}_2$, ± 5, f', f''
For fans: partial derivative should be rotated to be typed roman.

▸ Typesetting mathematics for science, Beccari C., 1997

Usage of Equations, Part 1

Be careful about the details

$$f = \frac{1}{1 + \frac{\pi}{2} n} \quad \text{vs.} \quad f = \frac{1}{1 + \frac{\pi}{2} n}.$$

Keep in mind that equation is always a part of the text, *i.e.*,

$$g = x\left(\frac{n}{2} + \left(k^2 - 2\,(x-3)\right)\right) \quad \text{vs.} \quad g = x(\frac{n}{2} + (k^2 - 2(x-3))),$$

and no matter if properly typed (left) or not (right).
If sentence continues below an equation, no indentation (no paragraph).

- MathType can be used for initial code generation.

Usage of Equations, Part 2

Complex numbers:

$$z = \overbrace{\underbrace{x}_{\text{real}} + \mathrm{j}\,\underbrace{y}_{\text{imaginary}}}^{\text{complex number}} = \mathrm{Re}\{z\} + \mathrm{j}\mathrm{Im}\{z\}\,,$$

not $\Re\{z\} + \mathrm{j}\Im\{z\}$ (this is obsolete).

- Transpose $\mathbf{A}^{\mathrm{T}}$, complex conjugate z^*, Hermitian conjugate $(\mathbf{A}^*)^{\mathrm{T}} \equiv \mathbf{A}^{\mathrm{H}}$.
- More equations are always separated (*e.g.*, by a comma).
- Physical units always on the same line as the equation.
- Prepositions and conjunctions should not be alone at the end of the line.

▸ The comprehensive LaTeXsymbol list

Vectors and Matrices

Scalars, vectors, dyads, matrices, and unit vectors.

a	a scalar number
a_m	an element of a vector $\mathbf{a}$
a_{mn}	an element of a matrix $\mathbf{A}$
$\mathbf{a}$	a vector
$\boldsymbol{a}$	a vector function
$\mathbf{a}_n$	a column of a matrix
$\hat{\boldsymbol{a}}$	unit vector
$\mathbf{A}$	a matrix
$\boldsymbol{A}$	a (time-harmonic) vector function, phasor
$\mathcal{A}$	a functional or a time-dependent function
$\boldsymbol{\mathcal{A}}$	a vector time-dependent function
$\mathbb{A}$	a field, a domain

Brackets

Brackets and their usage (personal preference).

$(\,)$	$x\,(x+2)$	structuring of an equation
	$f\,(x)$	arguments of a function
	$x \in (0,1)$	an open interval
$[\,]$	$[x_1 \;\; x_2 \;\; \cdots \;\; x_n]^{\mathrm{T}}$	a vector, a matrix
	$x \in [0,5]$	a closed interval
$\{\,\}$	$n \in \{1,\ldots,N\}$	set operations
	$\mathcal{L}\,\{\boldsymbol{J}_1\,(\boldsymbol{r})\,,\boldsymbol{J}_2\,(\boldsymbol{r})\}$	arguments of operators and transformations
$\langle\,\rangle$	$\langle \boldsymbol{x}, \mathcal{L}\,\{\boldsymbol{x}\}\rangle$	inner product
	$\langle\phi\|\psi\rangle$	bra–ket
$\|\,\|$	$\|\boldsymbol{x}\|$	absolute value, modulus
$\lceil\,\rceil$, $\lfloor\,\rfloor$	$\lceil x \rceil$, $\lfloor x \rfloor$	ceiling, floor

Matrix Typesetting

Linear system $\mathbf{y} = \mathbf{A}\mathbf{x}$, quadratic form $y = \mathbf{x}^{\mathrm{H}}\mathbf{A}\mathbf{x}$.

$$\mathbf{C}_{\mathcal{B}} = \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \end{bmatrix}^{\mathrm{T}}$$

$$\mathbf{C}_{\mathcal{B}} R_{\infty} \mathbf{C}_{\mathcal{B}}^{\mathrm{T}} = \begin{bmatrix} R_{\infty} & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & \cdots & 0 \\ 0 & 0 & R_{\infty} & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & 0 \end{bmatrix}$$

System of Equations, Complicated Equations

$$f(x) = x^4 + 7x^3 + 2x^2 + 10x + 12 \tag{1}$$

$$f(x) = ax^2 + bx + c \tag{2}$$

$$f'(x) = 2ax + b \tag{3}$$

$$C_{\mathcal{B},nn} = \begin{cases} 0 & \Leftrightarrow \quad n \notin \mathcal{B} \\ 1 & \Leftrightarrow \quad \text{otherwise} \end{cases}$$

When you are not sure, google it out! (`tex.stackexchange.com`)

Some Hints

Leslie's Corner

1. "the free space" (not "free space")
2. "wave-number" (not "wavenumber" or "wave number")
3. "the speed of light" (not "speed of light")
4. "Poynting's theorem" (not "Poynting theorem")
5. "Maxwell's equations" (not "Maxwell equations")
6. "energy in a vacuum" (not "energy in vacuum")
7. "state-of-the-art" (not "state of the art")
8. and many, many others...

- "radiation efficiency η", not only "η" should be used thorough the text

Questions?

For a complete PDF presentation see ▸ capek.elmag.org

Miloslav Čapek
miloslav.capek@fel.cvut.cz

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