Numbers, Mathematics and Units of Measure

Excerpts from the ACS Style Guide, A Manual for Authors and Editors

Numbers

Both numerals and words can be used to express numbers. The usage and style conventions for numerals and words are different for technical and nontechnical material.

Numeral and Word Usage

● Use numerals with units of time or measure, and use a space between the numeral and the unit, except %, $, and ° (angular degrees), ´ (angular minutes), and ¨ (angular seconds).

<table>
<thead>
<tr>
<th>Numeral</th>
<th>Unit</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 min</td>
<td>25 mL</td>
<td>50%</td>
</tr>
<tr>
<td>0.30 g</td>
<td>273 K</td>
<td>180°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>but 180 °C</td>
</tr>
</tbody>
</table>

Exception. Spell out numbers with units of measure used in a nontechnical sense.

If you take five minutes to read this article, you'll be surprised.

● With items other than units of time or measure, use words for cardinal numbers less than 10; use numerals for 10 and above. Spell out ordinals “first” through “ninth”; use numerals for 10th or greater.

<table>
<thead>
<tr>
<th>Cardinal</th>
<th>Ordinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>three</td>
<td>third</td>
</tr>
<tr>
<td>12th</td>
<td></td>
</tr>
<tr>
<td>flask</td>
<td>trees</td>
</tr>
</tbody>
</table>

● When a sentence starts with a specific quantity, spell out the number as well as the unit of measure.

Twelve species were evaluated in this study.
Twenty slides of each blood sample were prepared.
Twenty-five milliliters of acetone was added, and the mixture was centrifuged.

However, if possible, recast the sentence.

Acetone (25 mL) was added, and the mixture was centrifuged.
A 25-mL portion of acetone was added, and the mixture was centrifuged.

● Even when a sentence starts with a spelled-out quantity, use numerals when appropriate in the rest of the sentence.

Twenty-five milliliters of acetone and 5 mL of HCl were added.
Three micrograms of sample was dissolved in 20 mL of acid.

● Use numerals for expressions used in a mathematical sense.

The incidence of disease increased by a factor of 4.
The yield of product was decreased by 6 orders of magnitude.
The efficiency of the reaction was increased 2-fold.

● When the word "times" is used in a nonmathematical sense, spell out the accompanying number if it is less than 10.

The beaker was rinsed four times.

● Use numerals in ratios.

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:10</td>
<td>a 1:10 (v/v) mixture</td>
</tr>
<tr>
<td>1/10</td>
<td>a 1/1 (v/v) mixture</td>
</tr>
</tbody>
</table>

● Numerals may be used to name members of a series.

Sample 1 contained a high level of contamination, but samples 2 and 3 were pure.

● When numerals are used as names and not enumerators, form their plurals by adding an apostrophe and “s” to avoid confusion with mathematical expressions and to make it clear that the “s” is not part of the name.
Many 6’s were registered. Intel 486’s are not as fast as Pentium processors.

- Arabic numerals in parentheses may be used to enumerate a list of phrases or sentences in text. Always use an opening and a closing parenthesis, not one alone.

  Some advantages of these materials are (1) their electrical properties after pyrolysis, (2) their ability to be modified chemically before pyrolysis, and (3) their abundance and low cost.

- Arabic numerals followed by periods or enclosed in parentheses may be used to enumerate a displayed list of sentences or to number paragraphs.

  These results suggest the following:
  1. Ketones are more acidic than esters.
  2. Cyclic carboxylic acids are more acidic than their acyclic analogues.
  3. Alkylation of the active methylene carbon reduces the acidity.

### Styles for Numerals

- For very large numbers with units of measure, use scientific notation or choose an appropriate multiplying prefix for the unit to avoid numerals larger than four digits.

  \[ 1.2 \times 10^6 \text{ s} \quad 3.0 \times 10^4 \text{ kg} \quad 5.8 \times 10^{-5} \text{ M} \]

  42.3 L, \textit{not} 42,300 mL or 42300 mL

**Exception 1.** In tables, use the same unit and multiplying prefix for all entries in a column, even if some entries thereby require four or more digits.

**Exception 2.** Use the preferred unit of a discipline, even when the numerals require four or more digits:

- g/L for mass density of fluids
- kg/m for mass density of solids
- GPa for modulus of elasticity

- In four-digit numbers, use no commas or spaces.

**Exception.** Spaces or commas are inserted in four-digit numbers when alignment is needed in a column containing numbers of five or more digits.

- Use numbers before and after a decimal point.

  \( 0.25, \textit{not} .25 \quad 78.0 \text{ or} 78, \textit{not} 78. \)

- Use a decimal and a zero following a numeral only when such usage truly represents the precision of the measurement: 27.0 °C and 27 °C are not interchangeable.

- Use decimals rather than fractions with units of time or measure, except when doing so would imply an unwarranted accuracy.

  \( 3.5 \text{ h, not} 31/2 \text{ h} \quad 5.25 \text{ g, not} 51/4 \text{ g} \)

- Use an en dash in ranges or series of three or more numbered items, whether on the line or in a superscript.

  Tables 1–4, \textit{not} 1–4

**Exception 1.** Do not use an en dash in expressions with the words "from . . . to" or "between . . . and".

  from 20 to 80, \textit{not} from 20–80
  between 50 and 100 mL, \textit{not} between 50–100 mL

**Exception 2.** When either one or both numbers are negative or include a symbol that modifies the number, use the word “to” or “through”, not the en dash.

  \(-20 \text{ to} +120 \text{ K} \quad -145 \text{ to} -30 \text{ °C} \quad 10 \text{ to} >600 \text{ mL} \)

- For ranges in scientific notation, retain all parts of all numbers to avoid ambiguity.

  \( 9.2 \times 10^{-3} \text{ to} 12.6 \times 10^{-3}, \textit{not} 9.2 \text{ to} 12.6 \times 10^{-3} \)
Alternatively, avoid ambiguity by use of parentheses.

\[(9.2–12.6) \times 10^{-3}\]

- Do not use “e” or “E” to mean “multiplied by the power of 10”

\[3.7 \times 10^5, \text{not } 3.7e5\]

**Mathematics**

**Mathematical Concepts**

**Variable.** A variable is a quantity that changes in value, substance, or amount, such as \(V\) for volume, \(m\) for mass, and \(t\) for time.

**Constant.** A constant is a quantity that has a fixed value, such as \(h\) for the Planck constant and \(F\) for the Faraday constant.

**Function.** The function \(f(x) = y\) represents a rule that assigns a unique value of \(y\) to every \(x\). The argument of the function is \(x\).

**Operator.** An operator is a symbol, such as a function (d, derivative; ln, logarithm; and exp, the exponential) or an arithmetic sign (+, −, =, and ×), denoting an operation to be performed. Never use the letter “\(x\)” for a multiplication operator (\(\times\)).

**Physical Quantity.** A physical quantity is a product of a numerical value (a pure number) and a unit. Physical quantities may be scalars or vectors, variables or constants.

**Scalar.** A scalar is an ordinary number without direction, such as length, temperature, or mass. Any quantity not a vector quantity is a scalar quantity.

**Vector.** A vector is a quantity with both magnitude and direction, such as force or velocity. For the vector \(\mathbf{V} = [a, b]\), \(a\) and \(b\) are the components of \(\mathbf{V}\).

**Matrix.** A matrix is represented by a rectangular array of *elements*; an array consists of rows and columns. The elements of matrix \(\mathbf{U}\) are \(u_{11}, u_{12}, \ldots\)

\[
\mathbf{U} = \begin{bmatrix}
u_{11} & \cdots & u_{1n} \\
\vdots & \ddots & \vdots \\
u_{m1} & \cdots & u_{mn}
\end{bmatrix}
\]

**Determinant.** The determinant of a matrix is a function that assigns a number to a matrix. For example, the determinant of the \(n \times n\) matrix \(\mathbf{B}\) is represented by

\[
\det \mathbf{B} = \begin{vmatrix}
b_{11} & \cdots & b_{1n} \\
\vdots & \ddots & \vdots \\
b_{n1} & \cdots & b_{nn}
\end{vmatrix}
\]

**Index.** An index is a subscript or superscript character in an element of a matrix, vector, or tensor; indices usually represent numbers. For example, \(i\) and \(j\) are indices of \(b_{ij}\).

**Usage and Style for Symbols**

- Define all symbols for mathematical constants, variables, and unknown quantities the first time you use them in the text. If you use them in the abstract, define them there and then again at their first appearance in text. Do not define standard mathematical constants such as \(\pi\), \(i\), and \(e\).

- Form the plurals of mathematical symbols by adding an apostrophe and “\(s\)” if you cannot use a word such as “values” or “levels”.

  at \(r\) values greater than *is better than* at \(r\)’s greater than
● Do not use an equals sign as an abbreviation for the word “is” or the word “equals” in narrative text.

\[ PV = NRT, \text{ where } P \text{ is pressure, not where } P = \text{ pressure} \]

● Do not use a plus sign as an abbreviation for the word “and” in narrative text.

a mixture of A and B, not a mixture of A + B

● Do not use an asterisk to indicate multiplication except in computer language expressions.

**Italic Type**

Use italic type for

- variables: \( T \) for temperature, \( r \) for rate
- axes: the \( y \) axis
- components of vectors: \( a_i + b_i \)
- elements of determinants and matrices: \( g_n \)
- constants: \( k \), the Boltzmann constant; \( R \), the gas constant
- functions that describe variables: \( f(x) \)

**Roman Type**

Use Roman type for

- numerals
- punctuation and enclosing marks such as brackets, parentheses, braces, etc.
- most operators
- units of measure and time: mg, milligram; K, Kelvin; Pa, pascal
- nonmathematical quantities or symbols: \( s \), atomic orbitals; \( S \), molecular states
- multiple letter abbreviations for variables: IP, ionization potential; cmc, critical micelle concentration
- mathematical constants: \( e \), the base of the natural logarithm; \( i \), the imaginary number; \( \pi \)
- trigonometric and other functions: \( \cos \), \( \cosine \); \( \sin \), \( \sin \); \( \log \), \( \logarithm \) (base 10); \( \ln \), natural logarithm (base e)

**Boldface Type**

Use boldface type for

- vectors
- tensors
- matrices
- multidimensional physical quantities: \( \mathbf{H} \), magnetic field strength

**Spacing**

- Leave a space before and after functions set in roman type, unless the argument is enclosed in parentheses, brackets, or braces.

\[
\begin{align*}
\log 2 & \quad \log x & \quad 4 \sin \theta \\
\log(2) & \quad \log(x) & \quad 4 \sin(\theta)
\end{align*}
\]

- Leave a space before and after mathematical operators that function as verbs or conjunctions; that is, they have numbers on both sides or a symbol for a variable on one side and a numeral on the other.

\[
\begin{align*}
20 \pm 2\% & \quad 4 \times 5 \text{ cm} & \quad k \leq 420 \text{ s}^{-1} \\
T = 273 \text{ K} & \quad n = 25
\end{align*}
\]

**Exception 1.** Leave no space around mathematical operators in subscripts and superscripts.

\[
\Delta H_{n+1} \quad M^{(x+y)}
\]

**Exception 2.** Leave no space around a slash (\(a/b\)), a ratio colon (\(a:b\)), or a center dot (\(P \cdot V\)).
● Leave no space between simple variables being multiplied (e.g., $xy$).

● When mathematical symbols are used as adjectives, that is, with one number that is not part of a mathematical operation, do not leave a space between the symbol and the number.

$-12 \, ^\circ C \quad 400\times \text{magnification}$

**Enclosing Marks**

● Use enclosing marks (parentheses, brackets, and braces, also called fences) in accordance with the rules of mathematics. Enclose parentheses within square brackets, and square brackets within braces: $\{[()]\}$.

● Use enclosing marks around arguments when necessary for clarity.

$$\sin(x + y) \quad \sin[2\pi(x - y)/n]$$

**Subscripts and Superscripts**

● Use italic type for subscripts and superscripts that are themselves symbols for physical quantities or numbers. Use roman type for subscripts and superscripts that are abbreviations and not symbols.

$C_p$ for heat capacity at constant pressure

$C_B$ for heat capacity of substance B

**Equations**

Mathematical equations can be presented within running text or displayed on lines by themselves. Follow the guidelines for style and usage just described.

● If an equation is very short and will not be referred to again, you may run it into the text (i.e., “inline”).

A fluid is said to be Newtonian if it obeys Newton’s law of viscosity, given by $\tau = \eta \gamma$, where $\tau$ is the shear stress, $\eta$ is the fluid dynamic constant, and $\gamma$ is the shear rate.

● You may use mathematical expressions as part of a sentence when the subject, verb, and object are all part of the mathematical expression.

When $V = 12$, eq 15 is valid. ($V$ is the subject, = is the verb, and 12 is the object)

● Write abbreviated compound units with a center dot or a space between the units to indicate multiplication and a slash or negative exponent for division. Enclose compound units following a slash in parentheses.

watt per meter-kelvin is $W \cdot m^{-1} \cdot K^{-1}$ or $W/(m \cdot K)$ or $W \ m^{-1} \ K^{-1}$, etc.

● Spell out units of measure that do not follow a numeral. Do not capitalize them unless they are at the beginning of a sentence or in a title.

several milligrams (not several mg)

● Do not use a slash in spelled-out units of measure. Use the word “per”.

Results are reported in meters per second.

● Leave no space between the spelled-out units of measure, whether abbreviated or spelled-out.

kilojoule or kJ (not kil joule or k J)

● In ranges or series, retain only the final unit of measure.

$10–10 \ \text{mg} \quad 5, \ 10, \ \text{and} \ 20 \ \text{kV} \quad 60-90^\circ$

● If there are multiple levels of grouping in a single expression, use parentheses for the inner most grouping, square brackets for the next level, and braces for the outer most level. For example

$$f = 5\left[(p + q)(4 + x)(y + z)\right] \quad \text{not} \quad f = 5((p + q)(4 + x)(y + z))$$