Guidelines for writing a paper

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Abstract
Guidelines are presented for writing scientific papers in a clear and consistent style. Most instructions are based on generally accepted practice or international conventions, or they are just common sense. Only a few reflect the author's personal taste. Notes on English usage were taken from various authoritative sources. A practical checklist concludes the text.

I Introduction

Whatever help we can get from word processors and graphics software nowadays, writing a scientific paper remains a difficult, time-consuming process by nature – and unfortunately, so is reading an early draft written too casually. The purpose of this article is to present guidelines that intend to strike a balance between achieving the greatest speed in the production cycle, maximum clarity in reading, and utmost perfection in presentation.[#]

Many of the instructions may appear excessively detailed. Why bother so much? Sceptics should realize that a poorly prepared paper has less impact on the reader than a professionally written one, and that it may even be irritating to read. Moreover, its chances to pass by a referee favorably are substantially smaller.

This overview is not meant to be complete. A good dictionary is indispensable. Other well-established sources of information on the subjects covered here are the 1990 *Style Manual* of the AIP (American Institute of Physics) and the 1987 *SUN Report* of the IUPAP (International Union of Pure and Applied Physics).

Read in the *Style Manual* especially the following parts:

- Section II – Writing the Paper, Writing the Abstract, and Preparing the Manuscript
- Appendix B – Correct Spelling
- Appendix D – Standard Abbreviations
- Appendix G – Journal Title Abbreviations

The SUN Report should be used to look up the recommended symbols for physical quantities (e.g. σ for surface tension), SI units, and values of the fundamental physical constants.

[#] The text discusses only traditional publications printed in black and white. Electronic papers, intended for on-line reading via computer networks, are not covered here. However, this kind of publishing will rapidly become common practice. Expect that you will be using colors, sound, and animations in the near future, and that you may want to allow readers access to your data and software.

II General considerations

A Who should become author?

This is about the only problem that you cannot run away from. The answer is not too difficult: people who have contributed considerably *and* in a creative, non-routine way should be in the list of authors. A sensible test is that any author should be able to give a full talk or poster presentation of the paper in considerable detail.

B Organization of the paper

The following list shows the order in which the various parts of a paper are normally presented. Some notes on what should be covered in the abstract and in the main text body are included.

- Title, Authors, Affiliation, Postal address, E-mail address
- Abstract

  An abstract is not the same as the conclusions. It is a summarized account of the work described in the paper and states its most important achievements and conclusions. The abstract is a very important part of the paper, since many people don't get any further than reading just the abstract (often it is the only part available to readers). *It should be written last.*
- Body of the paper:
  - Introduction

    What is the problem, why is it interesting?
    What is known from earlier work by others and by your own group?
    What do you want to accomplish, and how are you going to tackle the problem?
    What are you going to do in the main sections of the paper?
  - Theory
  - Experimental

    Give enough details so that other people could in principle repeat the experiments. Don't forget to pay attention to matters of accuracy. Computer simulation methods should also be described here (under an appropriate heading).
  - Results

    Present the results, and show how you interpret them using the theories discussed earlier. The data-reduction process, leading to values for physical quantities and materials parameters introduced earlier, should also be covered in this section.
  - Discussion

    Discuss the outcome of the experiments in a broader context. How does it compare to results found by others? Have you accomplished what you set out to do? How will you continue this work in the future?
  - Conclusions

    Do not summarize the paper. Just repeat the main conclusions. Never introduce anything new here.
- Acknowledgments
- Appendices
- List of literature references

Unless the paper is a "camera-ready" document, this list is continued:

- Tables
- Figure captions
- Figures (one per page)

C Golden rules for writing

- Communicate with your readers, don't talk to yourself.
- Get your readers interested quickly; most scientists are very busy people.
- Pay close attention to the clarity and organization of your main arguments.
- Help your readers by breaking up your paper into clear sections and subsections, and by using sentences that act as signposts on the logical journey through the argumentation, such as

  > We will next derive...
  > Having shown that..., we will next present experimental evidence that...
  > This result now allows us to... .

- Think out your paper backwards. First decide what your conclusions are, then construct the roads that lead up to them.
- Ask somebody who is not a co-author to read your paper; prefer an English native speaker.

III Styles and conventions

Keep in mind that many journals have their own style conventions. Once every so many issues they publish "Instructions for Authors", in which these conventions are listed. Often it is good enough to examine a few papers already published in a journal to find out what its idiosyncrasies are. Nevertheless, the guidelines below represent a sensible average and are frequently based on internationally accepted conventions.

A Headings

Don't use more than four levels of headings:

I. Main section
A. Section
1 Subsection
a) Special case

Each heading level normally gets its own font, as in this paper, and its own numbering scheme. An alternative to the one used here is the so-called legal numbering style, such as 1.4.2.2.

The title of the paper, the acknowledgements, the list of references, the list of tables, and the list of figure captions have unnumbered headings.

B Equations

Number all equations to which you refer in the text. Use Arabic numerals, always between parentheses. Examples of references to equations are:

eq. (3)
eqs. (3) and (5)
eqs. (5)–(8)

Some people prefer capitalization, although there is no obvious need for it:

Eq. (4)

Symbols used for the first time should be explained in the running text following the equation. Don't use a tabular list for this; it interrupts the flow of words. A definition of a symbol by means of an equation should be in "displayed" format, such as

$$c = \sqrt{a^2 + b^2}\,, \tag{1}$$

because otherwise the equation would be hard to find.

Equations, also "displayed" equations, are grammatically *part of the running sentence*. Always check the punctuation marks on both sides of an equation. This is best done by pretending that the equation is a word or expression, in-line with the running text. In the example above, no punctuation mark is necessary before the equation, but a comma is necessary after the equation. Do not use a colon (:) before an equation, unless the introductory text contains an anticipatory expression (usually *the following*). When you do use a colon, remember that the sentence cannot continue beyond the equation.

If a displayed equation will not fit on a line, break the equation in parts. *Begin* each new line with a mathematical operator, do not end the previous line with it.

Relational operators in equations can grammatically function in two ways: as a verb or as part of a "noun".

If $x = 1$, the Sunderland model...
If $x > 1$ is used as a limiting condition, ...

C Acknowledgments

Don't forget to thank persons who have *directly* contributed to the work. Examples of acknowledgments are:

[This contribution] by [somebody] is gratefully acknowledged.
We are much indebted to [John Bardeen] for [critically reading the manuscript].
[He] made essential contributions to [the modification of the Betatron accelerator].
We thank [Professor Hafner] for [her skillful construction of the thermometer][making available her results prior to publication].

Acknowledgments are personal by nature, so do not use awkward constructions like

The authors are much indebted to ... .

Don't forget to thank FOM or any other sponsoring party. FOM *requires* the following ugly sentence (literally):

This work is part of the research program of the Stichting voor Fundamenteel Onderzoek der Materie (Foundation for Fundamental Research of Matter), and was made possible by financial support from the Nederlandse Organisatie voor Wetenschappelijk Onderzoek NWO (Netherlands Organization for Scientific Research).

D Literature references

A list of literature references comes after the text body. The list is usually numbered according to the order of appearance of the references in the text (including tables and figures). Sometimes some sort of alphabetical scheme is employed, such as [Beu88].

Examples of literature citations (1=paper in a journal, 2=paper in proceedings, 3=book):

1 Gale Young and Robert E. Funderlic, J. Appl. Phys. **44** (1973) 5151.
2 D.K. Edwards, E. Teller, and A. Einstein, in *Proc. 7th Int. Conf. on Computational Fluid Mechanics*, edited by Raymond B. Landis and Gary J. Hordemann (Stanford University, Stanford, CA, 1993), pp. 71–78.
3 L.S. Birks, *Electron Probe Microanalysis*, 2nd ed. (Wiley, New York, 1971), p. 40.

Pay attention to the font types and the positions of commas, etc. Journal editors are always very precise about this.

Avoid references such as

...private communication
...unpublished results
...thesis
...to be published
...submitted (accepted) for publication

but if you have to, specify the affiliation of the person or the title (and date) of the journal. Don't use a literature reference in the abstract. If you really must, give the full citation.

Refer to the original work, not to an article that just "passes on" the reference. Make sure that you have a copy of the papers you refer to, and that you have read them.

In the text, one normally uses a numerical superscript in smaller font or, in-line with the running text, the notation [....], or the abbreviation *ref.* Superscripts are placed after punctuation marks, not before them.

> Defects in silicon are of fundamental importance for device reliability.[1]
> Since the lattice constant of CO_2 is unusually small,[2,3] ...
> The Stuttgart group's test runs at 400 K clearly showed that A is proportional to $\exp(1-b)$,[4] from which we conclude that ...
> It was pointed out in refs. 5, 6, and 7 that neon has an unusual behavior ...

Let it be clear to the reader what he will find when he looks up the reference, so that he knows whether or not to make a trip to the library. The best way to do this is to state it explicitly, as in the third and fourth examples above. If a reference is mentioned "in passing", as in the first two examples, it should always imply: *in this reference you can find more about what I just mentioned*. It should not mean: *in this reference you can find more on the same general subject*, and certainly not: *this work is in some sense related to the subject treated here*.

An alphabetical referencing scheme is always convenient in early versions of a paper, since it does not require renumbering in the text when references are added or removed. Another advantage is that co-authors will quickly recognize the paper by its abbreviation without having to consult the list of citations.

E Tables

A list of tables follows the list of literature references. The table caption, fully spanning the top of the table, must be complete and *intelligible in itself without reference to the text*. Conversely, the text must remain intelligible even if the reader does not turn to the table. Make sure that every table is referred to in the text. These are hard rules.

Tables take Roman numerals. A table caption does not start with an article (*the*, *a*, or *an*).

> Table III. Thermal conductivity λ of noble metals at various temperatures T. ...

Place units (between parentheses) at the top of each column, below the symbol denoting the quantity. Choose units so that entries are near unity in magnitude and powers of 10 can be avoided. Note that tables usually have no vertical lines in print, and only a minimum of horizontal lines. References to tables are not abbreviated:

> table II
> tables III and IX

F Figure captions

A list of figure captions follows the list of tables. A figure caption must be complete and *intelligible in itself without reference to the text*. Conversely, the text must remain intelligible even if the reader does not turn to the figure. Make sure that every figure is referred to in the text. These are hard rules. The figures *themselves* should be on separate pages, without captions. In "camera-ready" manuscripts, figure captions fully span the bottom of the figure.

Figures take Arabic numerals. A figure caption does not start with an article (*the*, *a*, or *an*).

> Fig. 2. Activation energy Q_1 versus time t for various pressures indicated. ...

References to figures are abbreviated:

> fig. 4
> figs. 9a–c

Figure captions are excellent places to point out highlights.

> The middle curve shows that melting occurs at 3.3 Mbar.

Guidelines for figures

Figures are very important. They are the eye-catchers of a paper, so many people start reading a paper by first looking at all the figures. Therefore, make sure that they tell the essential parts of the story, and that they tell it well. Exploit the fact that humans are very good at processing visual information, especially at recognizing patterns, detecting shape differences, etc. Use high-quality graphing, drawing, and 3D-rendering software, and try to create intelligent illustrations.

Some tips for ordinary graphs are:

- A graph should have a closed rectangular frame; all four sides should have ticks, normally only two have text and numbers alongside.
- Graph axes begin and end at "nice" numerical values, which should be indicated. Never start or end an axis at a point that has no value mentioned.
- Logarithmic axes should be clearly marked as such: 10^3 ... 10^4 ... 10^5 at the major ticks.
- Corresponding graphs should have the same axes. This is a hard rule.
- Avoid large areas of unnecessary white space, but the previous rule prevails.
- If possible use solid curves for theoretical or model predictions, and dashed curves just "to guide the eye".
- Prefer smooth curves, indicating your best estimate of the true behavior, to zigzag lines running from datapoint to datapoint.
- Consider showing data in some sensible *relative* or *normalized* form. This facilitates making comparisons. Moreover, people tend to like dimensionless quantities, since they suggest that the author already did some of the thinking for them.
- Label curves with short explanatory phrases, unless this would clutter the graph too much. When there is no room, use a legend; if possible, have the same top-to-bottom order in the legend as in the graph.
- Lines, symbols, and letters should be able to withstand reduction of the figure to one-column width (7.5 cm). The smallest letters and symbols should be at least 1.5 mm after reduction.
- Numbers along the axes should not have superfluous decimals (not: 1.00).
- Texts along the axes should mention the quantities displayed and show the units in parentheses. A quantity is indicated by its symbol(s), and may or may not be preceded by an explanatory phrase. Examples are:

  T_c (K)
  Particle flux Φ (m^{-2} s^{-1})
  Absorption ratio I / I_0
- The quantity or the unit may be modified by powers of ten. Keep in mind that the parentheses around the unit formally mean: "divided by".

  T_c (μK)
  Particle flux Φ (10^{12} cm^{-2} s^{-1})
  Particle flux Φ / 10^{12} (cm^{-2} s^{-1})
  10^3 / T (K^{-1})
  1000 K / T

G Symbols and units

A physical quantity has a certain *dimension* and is the *product* of a pure number and a *unit*. In the example E = 200 J, E has dimension Energy = Mass × Length^{-2} × Time^{-2}; the unit J is equal to kg m^{-2} s^{-2}. There are seven fundamental dimensions: Length, Mass, Time, Electric

current, Temperature, Amount of substance, and Luminous intensity. The corresponding SI units are m, kg, s, A, K, mol, and cd.

Examples of incorrect equations are:

$R = \rho l/A$ (Ω)

$\upsilon = 10^{13} \exp(-18500 / T)$

In the first expression, (Ω) should not be mentioned. Aren't we allowed to use μΩ as unit? The second equation is a painful mess, because units are omitted at two points. The correct version is

$\upsilon = (10^{13}\ \mathrm{s}^{-1}) \exp(-18500\ \mathrm{K} / T)$

The only acceptable non-SI units are:

ångström	Å	
bar	bar	
minute	min	
hour	h	
liter	l	
atomic mass unit	u	($\approx 1.661 \times 10^{-27}$ kg)
electronvolt	eV	($\approx 1.602 \times 10^{-19}$ J)

Symbols for physical quantities should be *single* letters of the Latin or Greek alphabet with or without modifying signs (superscripts, subscripts, primes, etc.). Avoid the letters *o, O,* and *l*; they are too easily confused with the digits 0 and 1. Don't use just the first symbol that comes to mind. There are internationally recommended symbols for many physical quantities. Consult the *SUN Report*.

Abbreviations, such as RDF for Radial Distribution Function, may be used in the text but should never be used in equations.

Don't begin a sentence with a symbol, especially not when the previous sentence ends in one, or when the symbol is an ordinary letter. This is to avoid confusion with mathematical notation and with capitalization conventions. For instance,

...is larger than the vortex density φ. *A*, corrected for temperature effects, ...

This is completely unintelligible, unless you pay *very* close attention to the typography.

F is the force on the ion.

It is not clear whether the force is *F* or *f*.

Do not place commas or parentheses around a symbol or expression if it immediately follows the noun that defines it.

The relaxation time τ decreases rapidly...

But: The relaxation time without magnetic field, τ_0, decreases rapidly...

H Fonts

Do not use a sans serif font for the text. Just as newspaper editors you want a typeface that reads easily. *Times* is a good choice. In addition, it may be the only one that your "equation editor" knows.

Symbols for physical quantities and mathematical variables should be printed in *Italic* type. This also applies to sub- or superscripts which denote a physical quantity or which are mathematical indices. Vectors should be printed in ***Italic bold***, tensors in ***Italic bold sans serif***,

but the modulus (length) of a vector, and the components of a vector or tensor in normal *Italic* type. (Alternative notations for vectors and tensors: one or more arrows above the symbol, or one or more underscores below it.)

The following items should be printed in Roman type:

Symbols for units	J (for joule*), V (for volt), but V for voltage
Ordinary numbers	3, –0.77, 9.0×10^{-8}, Q_1
Standard mathematical functions and operators	$\sin x$, $\ln(1+y)$, $e^{-Q/kT}$, dR/dT
Sub- or superscripts that are just descriptive	E_k (k=kinetic [descriptive]), but C_p (p=pressure)

Use the following recommended mathematical symbols, all of which can be found in the Symbol font:

Minus sign	−	do not use an ordinary hyphen (-)
Multiplication sign	×	do not use an ordinary x or an asterisk (*)
Approximately equal to	≈	
Proportional to	∝	do not use ÷ or ~
Tends to	→	
Of the order of magnitude of	~	this does not mean “approximately equal to”

Apart from their use in floating-point notations, multiplication signs are seldom needed.

* This SI unit is named after James Prescott Joule. As for all SI units whose names are derived from the proper name of a person, the first letter of its symbol is uppercase (J). But when an SI unit is spelled out, it should always be written in lowercase (joule), unless it begins a sentence or is the name "degree Celsius".
— Based on The International System of Units, section 5.2.

IV English language

For most of us, writing in English does not come naturally. It is *absolutely crucial* to use all the tools that your word processor can offer in this area:

- Spelling checker
- Grammar and Style checker
- Thesaurus (to let you check word meanings and find synonyms)
- Hyphenation tool
- Outline view (to keep track of the logical organization of the paper)

Useful suggestions for English writing are gathered in the upcoming sections. They have been compiled from various sources.[†, ‡, §]

A Punctuation marks

1 Commas and semicolons

Use commas to set off *nonessential* expressions – words and phrases that are not necessary for the meaning of the sentence. Use no commas when the phrase is *essential*.

> The sample, which had been annealed up to 500 K, showed no sign of contamination.
> The sample that had been annealed up to 500 K showed no sign of contamination.

The second sentence implies that there were also other samples involved.

Use a comma to separate two main clauses when they are joined by *and, but,* or *or*. The two clauses should each contain a subject. A *semicolon* is used if the conjunction is omitted.

> The samples were studied by XPS, and the results indicated an unusual state of the uranium atoms.
> The samples were studied by XPS; the results indicated an unusual state of the uranium atoms.
> But: The samples were studied by XPS and were later transferred to the UHV chamber.

Use a comma in a list of *three* or more items, even if the last item is preceded by *and* or *or*.

> Note that eq. (17) contains the mass, the charge, and the spin of the particle.

If the items in a list contain commas themselves, use *semicolons* to separate them.

> Note that eq. (17) contains D, the diffusion coefficient; λ^2, the square of the jump length; and n, the index of refraction.

Use a comma between adjectives.

> For this experiment one requires a strong, inhomogeneous magnetic field.
> But: For this experiment one requires a strongly inhomogeneous magnetic field.

Use a comma after *introductory elements* – words and phrases that begin a sentence.

> To find a physically realistic solution, one should apply Von Neumann boundary conditions.

Use a comma after a *transitional expression* – a nonessential word or phrase that relates the preceding thought with the idea now being introduced; and after a *comment*, expressing the opinion of the writer.

> Furthermore, however, in addition, moreover, accordingly, as a result, consequently, therefore, in summary, in conclusion, as a rule, for the most part, as usual, generally, in other words, apparently, clearly, evidently, surprisingly, as expected.

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† W.A. Sabin, *The Gregg Reference Manual*, 5th ed. (McGraw-Hill, New York, 1977).

‡ M.A. Nicholson, *A dictionary of American-English usage* (Signet, New York, 1958).

§ A.J. Thomson and A.V. Martinet, *A Practical English Grammar,* 2nd ed. (Oxford University Press, London, 1969).

However, a comma is not needed after *common expressions of time or place* that have no particular emphasis.

Recently, frequently, here, in this case.

2 Colons

Use a colon between two independent clauses when the second clause explains or illustrates the first clause and there is no transitional expression in between.

The results have a general application: the approximation $a = 0$ is no longer needed.

Use a colon when a clause contains an anticipatory expression (usually *the following, several*, or a certain number) and directs attention to a series of explanatory words or phrases.

The samples were given the following treatments: polishing until optically flat, annealing up to 1900 K, and dropping them on the floor.

Do not use a colon if the explanatory series follows a preposition or verb.

The equipment consists of a mass spectrometer, a vacuum gauge, ...

The procedure involves a Fourier transform, a smoothing step, ...

The three remaining cases are (a) solid-state amorphization, (b) diffusion, and (c) length measurements.

B Spelling

1 American or British

This paper was meant to be written in American English. Evidently, British English is equally acceptable in scientific writing. Whatever you choose, be consistent. Generally, stick to the following spelling rules:

American	*British*	
-ize	-ise or -ize	characterize, characterise (but always: to devise)
-yze	-yse	analyze, analyse
-er	-re	center, centre
-or	-our	color, colour
-og	-ogue	prolog, prologue
-gram	-gramme	program, programme
-ense	-ence	defense, defence
-ice	-ise	practice, practise
occurring	occurring	Consonant doubling of an accented syllable
modeling	modelling	Consonant doubling of an unaccented syllable
(heavier)	(lighter)	Use of punctuation

2 Numbers

In running text, spell out numbers from 0 to 10; use figures otherwise.

We determined the Hall coefficient for five samples, each measurement yielding 17 datapoints.

3 Latin expressions

ab initio	from first principles
ad hoc	for a particular purpose
a priori	based on a hypothesis rather than on experience
e.g.	for example
et al.	and others
ibid.	in the same place
i.e.	that is
viz.	namely
vs.	in contrast with, against

4 Special plurals

Singular	*Plural*	
-us	-i	nucleus, nuclei
-um	-a	medium, media (seldom: -ums)
-on	-a	phenomenon, phenomena
-a	-as	formula, formulas (not: formulae)
-ix	-ices	matrix, matrices
-is	-es	hypothesis, hypotheses

Use *'s* to form plurals of abbreviations (RDF's).

The word *data* is nowadays considered a singular word (just as *agenda*), but it has no plural form.

The room-temperature data on magnetized Ni has been analyzed in two ways.

In English language one tends to combine plurals with plurals consistently.

The widths of the spectral lines indicate a metallic state.
Not: The width of the spectral lines indicates a metallic state.

5 When a final consonant is doubled

When a word ends in a single consonant preceded by a single vowel, double the consonant only if the accent falls on the last syllable and does not shift when the suffix is added.

Occur-occurring, refer-referring-referred-reference, model-modeling.
There are exceptions, e.g. gas-gaseous, program-programming.

6 Compound words

Compound words are words consisting of two or more words that express a single thought. Guidelines for spelling are difficult. A basic rule is that in modern American usage hyphens are dropped as soon as possible: solid and separated words are preferred.

Words with a *common prefix or suffix* are solid, unless the word could be misinterpreted.

Biannual, cooperative, decentralize, independent, multimedia, nonessential, renormalize, subdivision, unrelated, threefold, uppermost.
Semi-infinite, de-emphasize.

Hyphenate *self-, -free, and half-* words.

Self-consistent, divergence-free, half-width.

Other compound nouns

No hard rules. Many words ending in *-up, -out, -off, -over* are solid.

Setup, cutout, standoff, crossover.

Many words ending in *-in* are hyphenated.

Check-in.

Words ending in a *present participle* are separated.

Problem solving, word processing.

Miscellaneous examples:

δ function, x ray, β-brass.

Other compound adjectives

A compound adjective *before a noun* gets a hyphen.

Long-range order, x-ray analysis, thin-film results, well-known expression (but: this expression is well known).

In other situations, always hyphenate *noun+adjective, noun+participle, adjective+participle, adjective+noun+ed, adverb* (not ending in *-ly*)*+participle*.

Water-free, cpu-effective.
Air-cooled, load-bearing.
Odd-looking, Higher-ranking
Left-handed, small-sized.
Above-mentioned, clear-cut.

7 Hyphenation

English syllabication is often difficult for Dutch native speakers. Divide a word at an "intelligent" or otherwise "natural" point. Better yet, let your word processor do it, or consult a dictionary.

Preferably divide a word

- just after a common prefix (*anti-symmetric, dis-continuity, un-relaxed*)
- just before a common suffix (*cover-age, measur-able, care-ful*)
- so that the new line starts with an accent-carrying syllable

Never divide a word

- consisting of four or fewer letters
- if it leaves a one-letter syllable on either side of the break
- if it leaves *-ed, -er, -ic* on the new line (*ex-cited, greater , mag-netic*)
- inside a common prefix or suffix (*ingen-ious*)

C Grammar

1 Subjects and verbs

Use a singular verb in constructions like:

This result, together with other data from literature, is shown in fig. 5.
The data has been analyzed.
The underlying mathematics is not straightforward.
The number of parameters in this equation is three.
But: Data from various researchers are collected in table III. (several groups of data)
But: A number of parameters need to be determined. (*a number of* denotes more than one object)
But: Part of the walls were baked out at 400 K. (the form of the noun following *part of* determines the form of the verb)

2 Verbs and tenses

The present tense is used:

- To express present time, or more accurately: to express the time you want your reader to experience as present time. This allows you to manipulate the moment at which you want the reader to stand beside you and witness what you are doing or explaining. Using the present tense leads to a vivid style, which keeps the reader alert.
  The sample is a polycrystalline ZnS thin film. After cleaning, it is mounted in the specimen holder...
- To make a statement that (you think) is true at all times.
  After performing the analysis, we could conclude from the results that ZnS has a transition temperature of 433 K.
- To explain a general procedure.
  The width of the peak is then divided by its coefficient of asymmetry, from which a first-order estimate of the charge ratio can be obtained.

The past tense is used to express past time. It indicates a *particular action at a definite time and place*, even if these are not mentioned. The action was completed sometime in the past.

We performed susceptibility measurements under high pressure.

The present perfect tense indicates action that was started in the past and has recently or just now been completed. *It does not necessarily refer to a particular action at a definite time*. There is always a strong connection with the present, e.g. the action could be repeated now, or it is the result rather than the action that is now relevant.

We have analyzed the results.

The present participle emphasizes *action in progress*, started in the past and still going on now, or taking place in the future.

We have been developing a large computer code...
The equipment will be undergoing major modifications...

The passive form is used when it is more interesting or convenient *to stress the thing done* than the doer of it.

The system was pumped down to 0.01 mbar.

The passive form is frequently employed by scientific writers, mostly to avoid using *we* in active sentences. However, don't carry this too far. The passive form makes rather dull reading. More importantly, it can be confusing. The reader should be able to deduce what you have done and what you are claiming, as compared with what you learned from other people or what is generally assumed to be true. For example,

It is suggested that the specific heat has a logarithmic singularity at 3.19 K.

Do *you* suggest this, or is it suggested by other authors? Is the statement based on evidence just presented, or do you formulate a hypothesis that you are going to test?

The thermometer was calibrated to 0.1 degrees.

Did you do this yourself or are you merely repeating what the manufacturer said?

When a sentence containing a direct and an indirect object is made passive, the *indirect* object becomes the subject.

We gave the samples a heat treatment.
The samples were given a heat treatment.
Not: A heat treatment was given to the samples.

Avoid splitting an infinitive (*to*+verb).

It proved impossible to analyze the results carefully.
Not: It proved impossible to carefully analyze the results.

To be + past participle may be split.

The results need to be carefully analyzed.

3 Pronouns, adjectives, adverbs, prepositions

Who refers to persons, *which* and *that* refer to objects.

Which is always used to introduce nonessential clauses, and *that* is used to introduce essential clauses. However, when there are two essential clauses in the same sentence, *which* is used.

The sample, which had been annealed up to 500 K, showed no sign of contamination.
The sample that had been annealed up to 500 K showed no sign of contamination.
The samples which were reheated and which were later found to be distorted were studied by positron microscopy.

A word that follows a verb but describes a noun rather than the verb is an adjective, not an adverb.

The analysis appears correct.

The results proved reliable.
The manipulator had remained clean.

Some frequently used adverbs have two forms, one of which *looks* like an adjective. In a number of cases the two forms have different meanings, in other cases it is a matter of idiom. They are given in the following table.

close, closely	fair, fairly	loud, loudly	short, shortly
deep, deeply	hard, hardly	quick, quickly	slow, slowly
direct, directly	late, lately	right, rightly	wide, widely

Note the following prepositional phrases:

Usual in scientific writing	*Less usual*
Account for The increase in electron density cannot account for the observed anomaly.	Account to You have to account to your supervisor for ruining that expensive valve.
Agree with The theory agrees with the data.	Agree to FOM agrees to your salary terms.
Apply to The theory applies to the problem.	Apply for Oppenheimer applied for a job.
Compare with The helium results are compared with those for argon.	Compare to I compare his physics intuition to that of Einstein.
Contrary to	
In contrast with	
Correspond to The data does not correspond to the theory.	Correspond with I have been corresponding with Bohr for quite some time.
Dependent on	
Differ from Curie's data differed from her theory.	Differ with I differ with you (=a person) over the interpretation of the data.
Identical to	
Equivalent to	
Independent of (but: dependent on)	
Opposite to	
A measure of	A measure for

D Sentence structure

In general, adverbs have preferred positions in a sentence. If not used as introductory word, they are usually placed as follows:

- Adverbs of place – after the direct object.
- Adverbs of time – at the end of the sentence.
- Adverbs of frequency, and *still* – before a verb, but after a form of *to be*.

  We kept the sample *there* for seven days.
  New experiments will be undertaken *soon*.
  The results have not been discussed *yet*.
  The algorithm *rarely* leads to reliable approximations.
  This classical experiment is *still* appropriate for determining the charge of the neutron.

The following adverbs should be placed as close as possible to the word modified, usually before it:

Only, nearly, almost, ever, scarcely, merely, also.

These sentences have different meanings:

We can estimate only three parameters.
We can only estimate three parameters.

The leading words in combinations such as

both... and...
either... or...
not only..., but also...

should be followed by elements in parallel form.

The largest samples were studied by both microscopy and scanning calorimetry.
Not: The largest samples were studied both by microscopy and scanning calorimetry.

Dangling constructions are very common mistakes. When a sentence begins with a phrase containing a verb-form but not a subject, make sure that the *implied* subject of that phrase is the same as the *actual* subject of the rest of the sentence.

Not: After having analyzed the data, a few remarkable things were observed.
But: After having analyzed the data, we observed a few remarkable things.
Not: To obtain reliable results, clean samples should be used.
But: To obtain reliable results, one should use clean samples.
Or: To obtain reliable results, use clean samples.
Not: Substituting eq. (3) in eq. (4), the thermal conductivity becomes 3 *kNVL*.
But: Substituting eq. (3) in eq. (4), we obtain 3 *kNVL* for the thermal conductivity.
Not: If heated above 800 K, EPMA analysis can be safely applied to the samples.
But: If heated above 800 K, the samples can be safely analyzed by EPMA.

E Miscellaneous

a–an. When choosing between *a* or *an*, consider the sound of the following word, not its spelling.

An sp-orbital, a UPS apparatus, an 18-point smoothing routine.

and/or. This legal term should be avoided.

as. In clauses of reason, prefer *because, since,* or *for*.

Since (not: As) the pilot project proved successful, the research program was continued.

beside–besides. *Beside* means *by the side of*, or *out of contact with* (this is beside the point). *Besides* means *in addition to, along with, in addition to*.

between–among. Although normally not used when referring to more than two things, *between* is the correct word when the things are being considered in pairs as well as in groups.

There were only insignificant differences between the three datasets.

due to. This expression is often misused. *Due to* should say something about a noun, not about a verb. It is normally used after some form of *to be*. To say something about a verb, use *because of* or *on account of*.

The failure was due to extreme corrosion.
The sample failed because of extreme corrosion.

fewer-less. *Fewer* is used with plural nouns, *less* with singular nouns.

Fewer isotherms have been measured.

Less voltage was applied.

first–firstly. In enumerations, use *first, second, third*, not *firstly, secondly, thirdly*.

may–can. *May* (past tense: *might*) implies permission or probability. *Can* (past tense: *could*) implies ability or power.

should–would. Prefer *would*, except to indicate *ought to* or to express a condition in an *if* clause.

A larger heat loss would cause excessive damage to the surface.
One should apply Monte Carlo methods.
If the temperature should fall too quickly, additional heating is advisable.

so. *So* means *therefore*. *So that* means *in order that*.

Fukunaga blew up his power supply, so he had to order a new one.
Fukunaga was careful not to blow up his power supply so that he could continue with the experiments.

thus. Use *thus* to express *in this manner*, not as a synonym for *hence, therefore, consequently*.

V Final checklist

Before submitting your paper, run once more through this checklist. It is part of the *Guidelines for Review* issued by the editor of the Journal of Non-Crystalline Solids.

1. Is the abstract specific about purpose, experiments or calculations performed, results, and their consequence?

2. Does the introduction and its citations properly identify the background for the paper? Are the reasons and justifications for the reported research clearly expressed?

3. Are the experimental and calculational procedures well described, adequate, and properly designed?

4. Are the data presented in unambiguous form? Are the figures and tables well organized and necessary to the purpose of the paper? Can condensation be accomplished without compromising the paper? Are the sources of all lines drawn on figures explained?

5. Are the random and systematic errors in the data identified and quantified? Are the effects of variations of theoretical parameters on the results of theoretical calculations quantified?

6. Does the discussion adequately relate this research to past reported research?

7. Are the conclusions logically related to the data, and are the data sufficient to support the conclusions advanced? Are conclusions stated as simple declarative sentences?

8. Is the presentation well organized and concise?