

# Preparing a scientific paper for publication

## A. WRITING THE PAPER

No two scientific papers are sufficiently alike that any tidy group of fixed rules for writing a scientific paper could apply to all papers with inevitable success. It is possible, however, to state principles and offer suggestions that will encourage any author to present a body of scientific information in a reasonably smooth and coherent form. We present the following guidelines in this spirit and with a conscious effort to help the novice.

### 1. Before beginning to write

Despite the natural tendency to feel that no work is being done on a paper if no actual writing is under way, adequate preparation can help ensure a logical, readable product and shorten the writing time. Preparation can follow these steps.

(1) Analyze the problem. Ask yourself at least these four questions:

- (a) Exactly what information do I wish to present in this paper?
- (b) For what specific group of readers am I writing?
- (c) What background information can I assume these readers have?
- (d) What is the most logical sequence in which I should present the information to the readers?

(2) Make a detailed outline. The outline will serve as your writing guide; therefore, make as many subdivisions as possible. It is easier to eliminate or combine existing subheadings than to insert new ones. As you write, you will, almost certainly, revise the outline. Even if the outline suffers drastic revision before the paper is finished, the very act of preparing and modifying it serves as a mental stimulus that goes far toward ensuring logical development of the subject matter. Be sure your outline reflects the true structure and emphasis you wish your paper to have. Remember that many hurried readers will scan the headings and subheadings to determine if they need to read the entire text; try to help them by making the headings informative and logical.

(3) Plan tables and figures. You may already have thought about the tables and figures while preparing the outline, but if not, do it at this stage. Some data lend themselves to presentation in tabular form; others

do not. Appropriate figures can be very valuable, but there are times when a few good sentences convey more information than a drawing or photograph. Avoid unnecessarily duplicating data in tables and figures. Select the form of presentation--tables, figures, or text--with the efficient presentation of your data as the only criterion.

(4) Sit and think. This step should precede, follow, and be interspersed with the others. In other words, do not try to rush through the entire process in one continuous effort, but continually stop and review what you have done and think again about what is to come.

## **2. General rules for writing**

The following rules can be applied with profit to all technical writing and to all parts of a scientific paper. For specific points of style, see Sec. III.

(1) Be clear. Consider the beauty and efficiency of the simple declarative sentence as a medium for communicating scientific information. Use it freely, but not exclusively. Avoid long, meandering sentences in which the meaning may be obscured by complicated or unclear construction.

(2) Be concise. Avoid vague and inexact usage. Be as quantitative as the subject matter permits. Avoid idle words; make every word count.

(3) Be complete. Do not assume that your reader has all the background information that you have on your subject matter. Make sure your argument is complete, logical, and continuous. Use commonly understood terms instead of local or highly specialized jargon. Define all nonstandard symbols and abbreviations when you introduce them. On the other hand, omit information unnecessary for a complete understanding of your message.

(4) Put yourself constantly in the place of your reader. Be rigorously self-critical as you review your first drafts, and ask yourself "Is there any way in which this passage could be misunderstood by someone reading it for the first time?"

## **3. The introduction**

Every scientific paper should have at least one or two introductory paragraphs; whether this introduction should be a separately labeled section depends upon the length of the paper. Paradoxically, although it appears first it should be written last. You will probably find it easier to start writing the introductory text after you have written part or all of the

main body of the paper; in this way, the overall structure and content are more easily seen.

The first sentence of the paper is often the most difficult to write. It is important enough, however, to deserve considerable time and attention. The first sentence and the first paragraph play a critical role in determining the reader's attitude toward the paper as a whole. For best results, be sure to:

(1) Make the precise subject of the paper clear early in the introduction. As soon as possible, inform the reader what the paper is about. Depending on what you expect your typical reader already knows on the subject, you may or may not find it necessary to include historical background, for example. Include such information only to the extent necessary for the reader to understand your statement of the subject of the paper.

(2) Indicate the scope of coverage of the subject. Somewhere in the introduction state the limits within which you treat the subject. This definition of scope may include such things as the ranges of parameters dealt with, any restrictions made upon the general subject covered by the paper, and whether the work is theoretical or experimental.

(3) State the purpose of the paper. Every legitimate scientific paper has a purpose that distinguishes it from other papers on the same general subject. Make clear in the introduction just what this purpose is. The reader should know what the point of view and emphasis of the paper will be, and what you intend to accomplish with it.

(4) Indicate the organization of the paper when its length and complexity are great enough. Short papers should have an obvious organization, readily apparent to the casual reader; long papers, however, can benefit from a summary of the major section headings in the introduction.

#### **4. Main body of the paper**

Presumably, you tentatively decided on the form and content of the main body of your paper, which contains all the important elements of the message you want to convey, when you first decided to write the paper. Now review those decisions in light of the advice given above and write the sections that make up this part of your article. Then read through your first draft, asking yourself such questions as:

(1) Have I included all the information necessary to convey my message?

- (2) Have I eliminated all superfluous material?
- (3) Have I given proper emphasis to important ideas and subordinated those of lesser importance?
- (4) Is the development of the subject matter logical and complete, free of gaps and discontinuities?
- (5) Have I been as quantitative as I could in presenting the material?
- (6) Have I made the best use of tables and figures, and are they well designed?
- (7) Are the facts I have presented adequate to support the conclusions I intend to draw?

Now revise the first draft of the main body of your paper in the light of your answers to these questions and others that occurred to you as you read the draft.

## **5. The conclusion**

Typical functions of the conclusion of a scientific paper include (1) summing up, (2) a statement of conclusions, (3) a statement of recommendations, and (4) a graceful termination. Any one of these, or any combination, may be appropriate for a particular paper. Some papers do not need a separate concluding section, particularly if the conclusions have already been stated in the introduction.

(1) Summing up is likely to be the major function of the final section of a purely informational paper. If you include a summary, make sure you include only references to material that appeared earlier in complete form.

(2) Conclusions are convictions based on evidence. If you state conclusions, make certain that they follow logically from data you presented in the paper, and that they agree with what you promised in the introduction.

(3) Recommendations are more likely to be found in, say, technical reports than in scientific papers. But if you do include recommendations make sure they flow logically from data and conclusions presented earlier, with all necessary supporting evidence. As with the conclusions, recommendations should not disagree with what you led the reader to expect in your introduction.

(4) Graceful termination is achieved when the final sentence introduces no new thought but satisfactorily rounds off all that has gone before. Be warned against duplicating large portions of the introduction in the conclusion. Verbatim repetition is boring, creates a false unity, and is no compliment to the reader's attentiveness.

## **6. Acknowledgments**

In general, limit acknowledgments to those who helped directly in the research itself or during discussions on the subject of the research. Acknowledgments to typists or illustrators are discouraged, as are acknowledgments to anonymous referees. Financial support of all kinds (for the specific piece of work reported, to an author, or to the institution where the work was carried out) is best acknowledged here rather than as footnotes to the title or to an author's name.

## **7. Appendixes**

Appendixes conclude the text of a paper. Few papers need them. Their best use is for supplementary material that is necessary for completeness but which would detract from the orderly and logical presentation of the work if inserted into the body of the paper. A proof of a theorem is a good example of material of this type.

Appendixes may also be used for supplementary material that is valuable to the specialist but of limited interest to the general reader.

## **8. Selecting a title**

The time to decide on a title is after the manuscript has been completed. It must achieve a compromise between succinct brevity and overly complete description. Omit decorative locutions such as "Thoughts on ...," "Regarding ...." Avoid nonstandard abbreviations and acronyms. If properly written a title is short enough to be intelligible at a glance but long enough to tell a physicist if the paper is of interest to him or her.

## **9. Authorship**

It is common to include as "authors" all those who took part in the scientific endeavor described in the paper, even though only one wrote the manuscript. Make sure that each individual whose name appears in the byline is aware of this fact. It is not the responsibility of the journal editor, or of AIP, or the Member Society that owns the journal, to confirm

that each author approves of the paper as submitted or even knows that his or her name is attached to it.

## **10. Final draft**

When you have completed the first draft of your manuscript, lay it aside for several days. Then re-read it critically for final revisions. Ask two or three colleagues, at least one of who is less familiar with the subject than you are, to read your manuscript critically for clarity, conciseness, completeness, logic, and readability. If one of these readers tells you that a passage is unclear, do not argue that it is, in fact, perfectly clear (to you!). Take the comment seriously and change the passage until it suits both of you.

## **B. WRITING THE ABSTRACT**

The primary purpose of the abstract is to help prospective readers decide whether to read the rest of your paper. Bear in mind that it will appear, detached from the paper, in abstract journals and on-line information services. Therefore it must be complete and intelligible in itself; it should not be necessary to read the paper in order to understand the abstract.

The abstract should be a clear, concise summary of the principal facts and conclusions of the paper, organized to reflect its pattern of emphasis. Remember that some readers may use the abstract in lieu of the parent document. The title and abstract together will often be used as a basis for indexing; hence they must mention all the subjects, major and minor, treated in the paper. Understanding these considerations, you will want to give as much care to writing the abstract as you did to writing the paper. Some guidelines to assist in this task follow.

(1) State the subject of the paper immediately, indicating its scope and objectives. Do this in terms understandable to a nonspecialist. Describe the treatment given the subject by one or more such terms such as "brief," "comprehensive," "preliminary," "experimental," or "theoretical."

(2) Summarize the experimental or theoretical results, the conclusions, and other significant items in the paper. Do not hesitate to give numerical results or state your conclusions in the abstract.

(3) If the paper is one of a series, indicate that there are related papers.

(4) Indicate the methods used to obtain experimental results. If they are novel, state the basic principles involved, the operational ranges covered, and the degree of accuracy attained.

(5) Do not cite the literature references by the numbers in the list at the end of the paper, and do not refer by number to a selection, equation, table, or figure within the paper. Nonstandard symbols and abbreviations used in the abstract must be defined there as well as in the main text.

(6) Use running text only. Never use displayed mathematical expressions or numbered equations. Omit tables, figures, and footnotes.

(7) Keep the length of the abstract to a small percentage of that of the paper, usually 5 % for papers of medium length, less for longer papers, and never exceeding 500 words. Write concise, straightforward English; make every word count. Try to substitute words for phrases and phrases for clauses. Be terse, but not telegraphic; do not omit a's, an's, or the's. Regardless of the length of the final draft of your abstract, study it again with a view to shortening it further to a minimum length.

(8) As with the paper itself, have the abstract read critically by some of your colleagues for clarity, completeness, proper emphasis, and objectivity.

## **C. PREPARING THE MANUSCRIPT**

Rules for the physical presentation of the manuscript are designed to ease the work of editors, copyeditors, and typesetters. If presented in the preferred format, papers are more likely to proceed smoothly through the editor's selection process and the publisher's copyediting and composition routines. As well as the general instructions given here, some journals have special requirements that are explained in the "Information for Contributors" page or pages published therein.

### **1. General instructions**

(1) Submit manuscripts in English only (American spelling). If you are not fluent in English, ask a colleague who is to read and correct your manuscript.

(2) Type or print the manuscript on good quality white paper, preferably 215 X 280 mm (8.5 X 11 in.) in size.

(3) Use a fresh black ribbon or cartridge in the typewriter or printer.

(4) If you use a word processor, do not use a dot-matrix printer in a mode that leaves a visible space between dots (usually called "draft mode").

- (5) Type or print on one side of the page only.
- (6) Leave wide margins on the left and right sides and at the top and bottom of the page.
- (7) Double space the entire manuscript, including the abstract, footnotes and references, tables and figure captions.
- (8) Indent paragraphs, so that the start of a new paragraph is clearly distinguished from the continuation of an existing one after a displayed equation.
- (9) Number all pages in sequence, beginning with the title and abstract page.

## **2. Title**

- (1) Place the title about a third of the way down from the top of the first page.
- (2) Begin the first word with a capital letter; thereafter capitalize only proper names and acronyms.

## **5. Abstract**

- (1) Begin the abstract on a new line below the receipt date.
- (2) Use wider side margins for the abstract than for the rest of the manuscript, so that it will be clear where the abstract ends and the main text begins.
- (3) Type or print the abstract double spaced, preferably as one paragraph of continuous text. Avoid displayed mathematical expressions, figures, and tables.
- (4) If a reference to the literature is needed, write it out within square brackets in the text of the abstract rather than referring to the list at the end of the paper. For example:

The measurement of hydrogen permeation into iron reported by W. R. Wampler [J. Appl. Phys. 65, 4040 (1989)], who used a new method based on ion beam analysis,...

- (5) Define all nonstandard symbols, abbreviations, and acronyms.



## **7. Section headings**

(1) For most journals four levels of section headings are available, as shown in Table I. We suggest that you write principal headings in all capital letters, and lower-level headings with an initial capital letter to the first word only, as shown in Table I.

(2) If headings are numbered or lettered, use the scheme indicated in Table 1: roman numbers, capital letters, arabic numerals, and lower-case letters in that sequence for the four levels of heading. Number or letter consecutively through the text.

(3) Headings are not required, and may be inappropriate for short papers...

## **8. Acknowledgments**

(1) The acknowledgments section follows the main text of the paper and precedes any appendixes and the list of references.

(2) In most journals it is recommended that this section be given a principal heading ("ACKNOWLEDGMENTS" ), but if there is only one acknowledgment the singular form may be used.

TABLE 1. The four levels of section headings in the body of a manuscript.

As printed in most journals

I. PRINCIPAL HEADING

A. First subheading

1. Second subheading

a. Third subheading. Followed immediately, on the same line, by text.

## **9. Appendixes**

(1) Appendixes follow the acknowledgments and precede the list of references.

(2) Headings to appendixes have the form of principal headings. If there are two or more appendixes, they can be labeled A, B, C, etc. Examples:

## APPENDIX

### APPENDIX: CALCULATION OF $F(t)$

#### APPENDIX A

#### APPENDIX C: PROOF OF THE EQUIVALENCE THEOREM

### 10. Footnotes and references

(2) Type or print each footnote as a separate indented paragraph beginning with the appropriate superscript indicator.

(4) For references cited in the text use superscript numerals running consecutively through the text: 1, 2, 3, etc. Place citation indicators after commas, periods, quotation marks, colons, and semicolons:

As pointed out by Bray,<sup>6</sup> these calculations are in agreement with other experimental values.<sup>7,8</sup>

We obtained the following values for the two parameters:<sup>13–15</sup>  $I = 0.775$  and  $r_0 = 0.590$ .

Do not put citation indicators where they might be mistaken for numbers with a different meaning. Write:

A recent measurement<sup>2</sup> of  $\square v$ ...

instead of

A recent measurement of  $\square v^2$ ...

(5) In text, refer to authors by last name (surname, family name) only. In the references themselves, give authors' names in the form in which they appear on the title page of the cited work. For names in the west European tradition, retain the order that puts the family name last (for example, John J. Doe, not Doe, John J. ).

(6) For the recommended form and content of bibliographic references see Table II.

In journal references, give the volume number, the the article title, the inclusive page numbers (first and last), and the year of publication.

Include the issue when the journal is not paginated consecutively through the volume (for example, *Physics Today*, *Scientific American* ). Give the year in place of the volume number only when the journal does not use volume numbers. References to errata should be labeled as such, as should references to "abstract only" or "title only" publications.

In book references always include the title, the authors' or editors' names, the publisher's name and location, and the year of publication. References to laboratory reports should not contain abbreviations or acronyms for the names of laboratories or agencies; spell them out.

The use of the expression "et al." (as in "Jones et al.<sup>8</sup> studied this reaction in 1982") is encouraged in the body of the paper, but discouraged in the references unless there are more than three authors' names.

"In press" or "to be published" means that the paper has been accepted for publication in a journal, and the title of the journal must be given. Such a reference may be updated at the proof stage if the referenced paper has been published by then.

(7) Refer to the original sources whenever possible as you gather details for bibliographic references. Do not rely on intermediate citations, which may contain misspelled names or erroneous volume and page numbers and publication dates.

(8) Avoid references to unpublished material that is difficult or impossible to obtain.

(9) For footnotes to tables, see point (8) of the next section.

## **11. Tables**

(1) Tabular material more than four or five lines long should be presented as a numbered table with a caption, not included as part of the running text.

(2) Type or print each table double spaced on a separate page after the references and before the figure captions. Place the table caption directly above the table to which it belongs, not on a separate sheet. See Table III for an example.

(3) Number the tables in the order of appearance in the text, and make sure each table is cited in text. Tables displayed and cited in proper sequence in the main body of the paper may be mentioned out of sequence in the introduction.

(4) Give every table a caption that is complete and intelligible in itself without reference to the text.

(5) Give every column a heading. Make it clear and concise. Capitalize the first word of a heading unless it is a standard abbreviation that is always used lower-case.

Units of measurement should be placed in parentheses on the line below the appropriate heading. Choose units so that entries are near unity in magnitude, so that, as far as possible, powers of ten are not needed for most entries.

(6) Align columns of related numbers by decimal. Do not use "ditto" or any symbol such as quotation marks to indicate repeated entries; write each entry out in full. Use raised dots (...) instead of dashes to indicate missing values.

(7) Type or print a double horizontal line below the table caption, a single line below column headings, and another double line at the end of the table. Avoid vertical lines between columns: use appropriate spacing instead.

(8) Footnotes to a table are indicated by a sequence of lower-case letters a, b, c, etc., with a new sequence starting with a for each table. The ordering of footnote indicators should be left to right across one row, then left to right across the next row, and so on. Place the footnotes themselves below the double line at the end of the table.

#### TABLE II. Examples of footnotes

Kind of footnote    As typed in paper

Journal article citations    1Gale Young and R. E. Funderlic, "Positron decay in Na," J. Appl. Phys. 44, 5151-5153 (1973).

Issue number included    2M. D. Levinson, "Rate of decay of auditory sensation," Phys. Today 30 (5), 44-49 (1977).

Book reference    3L. S. Berks, Electron Probe Microanalysis, 2nd ed. (Wiley, New York, 1971), p. 40.

4D. K. Edwards, in Proceedings of the 1972 Heat Transfer Institute, edited by R. B. Landis (Stanford University, Stanford, CA, 1972), pp. 71-72.

Reference to unpublished work    5R. C. Mikkelsen (private communication).

(9) In designing a large table, take into account the size of the journal page on which it is to be printed. Tables may be continued onto a second page or beyond, in which case the column headings will be repeated. Tables may also be turned 90° from the usual orientation.

## **12. Figures and figure captions**

(2) Number figures in order of their appearance in the text and make sure that every figure is cited. Figures displayed and cited in proper sequence in the main body of the paper may be mentioned out of sequence in the introduction.

(3) Every figure must have a caption that is complete and intelligible in itself without reference to the text. Type each caption as one paragraph, beginning with the figure number in the form:

FIG. 1. Variation of distance R with...

(4) Figures can be reproduced in color when necessary, and where the color adds scientific information not clearly available in an equivalent monochrome version. There may be additional costs to be borne by the author for color reproductions. Consult the editor in each case.

## **E. PROOFREADING THE PAPER**

### **1. Manuscript**

(1) As a final step before submitting the manuscript, proofread it. There are always errors, however excellent the typist. Ask someone else to proofread it too: a fresh pair of eyes can find errors you have overlooked.

(2) Avoid handwritten corrections and changes. Retype instead, and proofread all retyped material.

(3) As you proofread, check the following points:

(a) If the section headings are numbered or lettered, are they numbered or lettered consecutively according to the scheme in Table I? Are the cross-references to sections correct?

(b) Are all ambiguous mathematical symbols identified?

(c) Are all numbered equations in proper sequence and cited correctly in text?

(d) Are all footnotes and references cited in the paper? Do all the citation indicators in text refer to the correct footnote or reference?

(e) Are all tables and figures cited in order in the text?