**Scientific Writing and Research Methodology** PSPHY PR1, (M. Sc. Physics 4th Sem)

 Credits 4 LTPS (3106)

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**Module 3**: Science / Scientific Writing: Goals and Objectives, Structure of documents, importance of clear title, abstract or summary, Introduction, Methods, Results and Discussion. Illustrations and aids Numbers and statistics, Tables and Figures. Language and grammar. Writing proposals and instructions, Making presentations, Formatting documents, Drafts and revisions, Editing. Writing popular science / journal article, Science fiction.

**Goals and objective of Scientific writing**

Research publications aim to disseminate the know-how that is generated from an organized process of scientific research. In doing so, they expose the research, its rationale and findings to a broad audience base. There are many benefits that derive from such exposure: research institutions and research teams gain worldwide recognition and prestige, research team members get valuable feedback from their peers at other institutions, future research is better informed of what has already been achieved etc. On a personal level, reasons for writing papers range from personal satisfaction to academic graduation requirement and essential job function.

Different types of papers: research, letters/communications, review/tutorial, conference papers

Journals generally publish several different types of papers. A broad categorization of these is as follows:

i) Research papers – These are accounts of original scientific research with brief literature survey describing previous relevant work. To merit publication, the author(s) must demonstrate that they have performed important experimental, theoretical or computational research that adds substantial and non-trivial knowledge to their field. The topic of investigation, as mentioned above, must be of sufficient importance and interest to other workers in the field.

ii) Letters/communications – Letters (or letter papers) are shorter accounts of original research which are ‘prioritized’ for publication on the basis of substantial novelty that must be communicated quickly to others in the field. Letters generally get published in substantially less time than a regular research paper. Their total length, number of illustrations and references are limited so writing letter papers takes special care.

iii) Review/tutorial papers – Such papers describe research work that has been performed earlier and are thus, essentially, broad literature surveys. Reviews are usually quite long, compared to most research papers. Lengths can range from around 6,000 words, for a relatively short review, to more than 20,000 words. Review papers are also characterized by long reference lists that can have well over a hundred entries. Reading review papers is an excellent way to obtain familiarity with a given area of research activity. Such publications are also very useful when conducting literature surveys while writing original research papers.

iv) Conference papers – Conference papers are based on oral or poster presentations made at a technical conference or workshop. These are short papers that express and often elaborate on the actual conference presentation. Conference papers represent a permanent record of conference participation. Being relatively short, these papers rarely exceed 3,000 words in length and have around four illustrations and a few references. It is common for papers from major established conferences to appear in a special issue of a relevant journal. Alternatively, even shorter conference papers can appear in a conference abstract book. The latter are much less accessible to the wider scientific community owing to their limited circulation. While participating and presenting in conferences is an important intellectual and professional activity, conference papers themselves hold significantly less importance when compared with journal papers; especially if they do not appear as published papers in a regular journal.

**Contents and organization of a good paper**

A good paper not only has interesting and valuable scientific content but is also organized in a logical and lucid fashion that makes it easy to read and assimilate. A poorly organized manuscript leaves a bad impression on editors and, together with improper language use, is a leading cause of manuscripts being referred back to authors for re-drafting. A basic organization for most scientific papers follows the following scheme:

1. Title

2. List of authors

3. Author affiliations

4. Contact details of the corresponding author

5. Keywords

6. Abstract

7. Introduction

8. Main text

9. Summary and conclusions

10. Acknowledgements

11. References

12. Table and figure captions

13. Tables

14. Figures

15. Supplemental materials (if any)

It should be noted that you can organize almost any scientific paper in this manner even if a target journal has not been selected yet. Note that there will be several paper sections, often sub-divided into subsections. The exact layout of this main part of the paper will depend substantially on the requirements of any particular journal.

**How to write and organize a paper?**

Title – The title is the very first element of any research paper. It serves to describe the entire paper concisely. The title phrase must be short and to-the-point; accurately reflecting the contents of the article.

List of authors – The list of authors always immediately follows the title in any manuscript. It should include everybody who has contributed reasonably to the research work.

Author affiliations – The affiliations of all authors immediately follow the list of their names on a manuscript. This is usually in the same order as the order of authors’ names. Make sure when writing affiliations to include full postal details and include the name of the country in full. Contact details of the corresponding author – Of all the authors whose names appear on a manuscript, one author has to be identified as a corresponding author. This author will serve as the link between the publisher and the entire team of authors. The contact information must include the full postal address, phone number (land line and/or mobile), fax number (if available) and e-mail address.

Keywords – Most journals nowadays require authors to list a set of keywords on their manuscript. Listing three to five keywords is, generally, the norm. These keywords are separated from each other by either commas or semicolons. Each keyword (which may actually be more than a single word) is chosen to reflect the topic and content of the manuscript, as descriptively as possible. A good set of keywords is helpful not only for selecting appropriate referees for peer review but it also greatly contributes to the visibility of the paper, once it is published. The archival utility of keywords stems from their role in categorizing a paper so that it will come up whenever someone enters one or more of the keywords in an automated search system. Search engines, for example, work on the basis of keywords.

Abstract – An abstract is meant to capture the essence of an entire paper in just a single paragraph that consists of one to two hundred words. Around 150 words is usually a good length for an abstract. Abstracts can contain abbreviations but not references. The role of an abstract is to highlight the need for the work, the principal topics discussed in the paper; together with the methods used in the research described in the central part of the paper and the chief conclusions that come out of the work. An abstract is typically written after all or almost all of the manuscript has been written so that the authors have a good idea of what their manuscript describes.

Introduction – Introduction is the principal section of a paper that opens up its main text. Its purpose is to put the entire rest of the text in the proper context so that readers can feel comfortable in reading the material that follows it. Toward this aim, the introduction describes the reasons for undertaking the work reported in the paper, its aim and scope as well as some historical context to connect the present study to work that has been done before. Moreover, it also briefly describes the organization of the rest of the paper. A properly written introduction should be neither too short nor too long. If the amount of introductory material begins to get excessive then you will need to do some careful editing in order to remove some content which is not very directly related to the research described in your paper.

Main text – The main part of a manuscript can be organized in various ways and it is best to consult the author’s guide for the target journal before embarking on writing this major part of a paper’s text.

As you work on an academic paper manuscript, keep in mind that the universal objective of writing a paper is to inform readers and to do it in such a way that, if they desire, they can reproduce the reported research themselves. This implies that you must write your manuscript with sufficient detail so that a competent reader is able to replicate your work. Essentially, this means that you should provide all necessary procedural details, such as the identity and source of any reagents used in your work, make and model of all, important equipment, relevant weights, measures and time periods etc. These details are required to make your paper into a record of established scientific research which could be reproduced to verify its findings.

A universal advice for writing any manuscript is to use good formal language. This goes beyond merely exercising care in spelling and grammar and includes practicing accepted norms of academic writing. Technical manuscripts have to be written in a style which is specific to expressing scientific findings

All written text must be checked with the aid of spelling checking tools on the word processing program. It must then be given another careful read through to find misspellings that may have escaped the scrutiny of the spell checker. Spell checkers usually also carry out basic grammar checks. This is, in fact, a general advice for writing which is easy-to-read and understand: avoid long sentences i.e. sentences that run over three lines in length Whenever in doubt, simply rewrite a long sentence as two shorter ones.

An essential feature of well-written text is that it is very smooth i.e. it flows effortlessly while being read. This can be seen by examining any professionally-written piece of text in a good newspaper or magazine. Every writer should try to rise to a similar high writing standard. As much as possible, use simple language in your manuscript; avoiding the use of harder or less well-known words. Always make good word choices and feel free to use a thesaurus for making word substitutions to keep the narrative interesting and non-monotonous. Do not make unjustifiable and grandiose claims in your manuscript. Avoid excessive use of words such as ‘new’, ‘novel’ or ‘unprecedented’. Proof reading your manuscript is extremely important. Be very careful and deliberately slow when proof reading your manuscript. If at all possible, involve a second person to also proof read your article.

Summary and conclusions – While an introduction section, initiates the main part of a paper, a summary and conclusions section brackets, the other end of it. As its name implies, the summary section summarizes the paper. It is a brief synopsis of the contents of the paper and typically takes one or two paragraphs. It is important to understand that a summary is different from an abstract. These two parts of any manuscript have to be written completely separately. While an abstract describes the paper in brief and starts with the need for the research presented in the paper, a summary is simply a brief overview of the paper with no historical context or links to any other work. Whereas an abstract can adopt a somewhat promotional tone, highlighting the seriousness of the work, a summary is a short outline of the part of the paper that comes after the introduction. The summary usually also includes a restatement of the main conclusions obtained from the research described in the paper.

Acknowledgements – This section is not mandatory. A manuscript may or may not have an acknowledgements section. You can use an acknowledgements section to thank individuals and organizations for helping with your research project. Here, you can include the names of people who will not otherwise be included as co-authors but have had a positive influence on either the conduct of research or the preparation of the manuscript. Examples include persons who have read and commented on or corrected your manuscript, provided help in the laboratory or with computing equipment, machined parts etc. It is also customary to thank funding agencies in this section while providing the grant number that supported the research described in the paper. This helps maintain good future relations with funding agencies, among providing other benefits. Keep this section short – around 25 to 50 words is the norm.

References – References to all citations referred to in a paper are collected and listed toward the end of the manuscript. This reference list can take several forms but the two most used styles are alphabetic ordering and sequential ordering. The former refers to listing citations in order of the last names of the first author of each publication. If there are two or more publications by the same author then these are listed in the order of their publication dates with earlier publications listed before later ones. In the case of sequential numeric listing, citations are listed in a numerically-ordered list without regard to any attributes. This style is much more common in journals and other technical periodicals these days.

In the body of the manuscript’s text, citation references are indicated either by placing the first author’s last name and year of publication in square brackets or by placing a number in square brackets – depending on the style adopted in the reference list.

Table and figure captions – All tables and figures in a manuscript require text that describes them. This is called a caption and it appears below each table or figure that it describes. Captions provide a short description of their associated resource: either a table or a figure.

Tables – Some information in a manuscript may be of a nature such that it is best presented in a tabular form. This may be data that is clearly non-pictorial or even numeric data which will benefit more from explicit tabulation. You can use one or more tables to present such information in your manuscript.

Figures – Visual elements are an essential and extremely valuable component of most technical manuscripts. Illustrations can rapidly convey a great deal of information for which there may be no proper text substitute.

Supplemental materials (if any) – Supplemental information refers to information which is sent with a manuscript but does not form part of the core manuscript package. It could be a computer program/algorithm, questionnaire for survey, audio-visual material that further enhances the understanding of the research presented in a paper or the compilation of a data set that would be too long to include in the paper itself or even experimental samples related to the research that authors are willingly making available to anyone interested in acquiring them.

**All about illustrations**

Visual elements play a crucial role in making readers properly understand the contents of a research paper. These make the paper look more attractive and reinforce textual descriptions, besides providing essential information that cannot be conveyed by words alone. Figures can be photographs, micrographs (magnified pictures taken with a microscope), statistical plots, block diagrams, circuit schematics, design layouts, graph plots or some other visual depiction. Whatever it is, make sure that the figure is clear and properly ties up with its textual description. A figure file can be stored in a number of different file formats such as .jpg, .tif, .png, .bmp, .pdf etc. Two formats that are widely accepted are .jpg and .tif. Expertise with one or more graphics software package greatly helps with creating eye-catching illustrations. Graphical plots can be made using any suitable software, such as Microsoft Excel, Origin or Sigma Plot. Changing the visual appearance of a picture using a graphical editing software, such as Adobe Photoshop, while may be common in commercial magazines, is highly frowned upon in scientific circles. It is considered with the same seriousness as text plagiarism, although the original photograph may rightfully belong to the manuscript’s authors.

Each figure has to be accompanied by a figure caption that describes the content depicted in the figure. In the published paper, captions appear directly underneath the corresponding figures. In the manuscript, captions appear in a list of figure captions that is usually placed right after the list of references but just before the appearance of the figures. Each caption is numbered with the numbers corresponding to the figures that the captions refer to.

**Sources**

Committee on Publication Ethics (COPE): Guidelines on Good Publication Practice (<https://publicationethics.org/resources/guidelines>).

Moore, A. (2018). On the state of scientific English and how to improve it\_ Part 12: keeping it simple when under time pressure. BioEssays 40:1800218. DOI: 10.1002/bies.201800218.