

# Lecture notes on “*Art of Scientific Writing*”

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## 1 Introduction

“If we knew what it was we were doing, it would not be called research, would it?” – Albert Einstein

In popular opinion, Art or Literature is a representation of cultures, emotions, and philosophies whereas Science is a representation of rationalism, critical thinking, and evaluation. As it seems from the outside, these two distinct representations of human society are completely uncorrelated and distinguishable. But, we, Physicists, believe that these two representations are correlated and entangled in their fashion. When we try to write science in a document emotions and philosophies tend to be bound with rationality. Otherwise, the literature we will produce will become just a collection of data and information. The story of a scientific phenomenon can be told from various aspects. All these aspects are combined in a unique type of art, that is based on both storytelling and rationalism. We call it *Art of Scientific Literature*.

## 2 Classification of scientific documents

*“In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual.”* – Galileo Galilee

A normal document differs from a scientific document at a core level. A document can be thought of as a collection of various information. Based on the information it contains, the document can be classified into two groups, as *Scientific* and *Non-scientific*. Non-scientific documents can be classified in various other ways, like, novel, short stories, etc. We are not going in that direction. Rather, we may study in details, how a scientific document can be written.

A *Scientific* document always contains some information, assertions, assumptions, and proper justification of those assumptions and assertions by using rational arguments based on the information and evidence. The logical reasoning and as we have used the term several times, rationalism is the backbone of the scientific document. So, in a nutshell, your scientific document can tell a story but that must be based on some solid foundation of science and reasoning. Further, the Scientific document can be categorized as,

1. Article (for Journal/Book chapter/Conference proceedings etc.)
2. Thesis
3. Project proposal
4. Presentation

## 3 Article

### 3.1 Introduction

A scientific article is the most common form of scientific document. Any scientific article is always a collection of logically reasoned information. The contribution of this information to the scientific community can be quantifiable by a detailed reviewing process. Any standard publishing house publishes an article that is ‘*peer-reviewed*’. Now, what does it mean? It means that the article is verified by expert individuals on the particular subject matter. Any standard publishing house works on two components, Editorial Board and Referee. A submitted article, at first, is verified by an editorial board. After that, the Editorial Board sends the paper to independent referee(s). These referees are individuals who are experts on the subject matter. The referee will analyze the article on the basis of the arguments presented by the paper and its novelty aspect. If a certain journal rejects a scientific article it doesn’t mean the article, can be categorized as “Non-Scientific”. An article can also be rejected on the basis of journal policy. Now, beyond this process of quantification of the contribution of an article towards science, another important aspect is always there and that is, the literary representation of the logically reasoned information provided by the author himself. Two scientific articles can be interpreted through the same logic yet they can be different in the aspect of literary representation adopted by the author. Therefore,

a scientific article is not only objective but also subjective. Thus an integral part of the art of scientific writing is basically “telling a story from a different angle”.

### 3.2 Types of scientific article

Before going into the detailed outline of an article, we must mention the types of journal articles

1. *Regular or original articles*: Most published articles are regular journal articles with no page limits. It has a basic structure which differs from journal to journal. (see fig 1)
2. *Topical review*: There exists various journals that publish review articles only which are done by expert individuals on a specific subject based upon the invitation from the journal itself. (see fig 2)
3. *Letter-like articles*: Only original and extremely important documents concerning the present context are published as “Letter”. Most of the established journal houses have their letter-like article publishing option and there also exist specific journal houses that only publish letter-like journals (For example: Physical Review Letters, Chemical Physics Letters, etc). (see fig 3)
4. *Corrigendum or Erratum*: A corrigendum or Erratum is published as a correction of an existing published article.
5. *Comment on a paper*: Comment on a specific paper is added after publishing of a paper.

### 3.3 Outline of an article

In this section, we will restrict ourselves to the Regular article only. Various journals have their specific format for writing an article. So, we will briefly create a structure that will help a scholar to write any kind of article.

1. *Title*: Every article must have a title that covers the full essence of the topic itself. While creating a title of an article, a scholar should know two thumb rules. First, the title should be a creation of that particular individual only. It should not be plagiarised. Secondly, it contains necessary keywords that help to search that paper easily. Writing an efficient title is one of the very difficult aspects of writing a paper and it has a certain degree of correlation with the number of citations of the paper. Any scholar in the world may search your paper on Google Scholar/Researchgate etc. and he/she will download or read that paper only if the title is self-explanatory and precisely written. Otherwise, the paper will be ignored because no one in the world is researching the ground of philanthropy. An individual author is responsible for making his/her paper more accessible to the community.
2. *Authorship of an article*: An article can be written by any number of individuals but two of them are most important.
  - (a) First Author: Author who has contributed most to a paper.

- (b) **Corresponding Author:** The most senior and experienced individual in a group who communicates a paper to a journal house. He/she will communicate with the publishing house and external referees.

Most of the standard research groups around the world have strict research ethics in the aspect of author-ships. This is one of the unwritten rules that should be followed by an individual while writing a paper in a journal.

3. *Abstract:* This is the second most important part of an article. Writing an abstract is a very crucial aspect of writing an article because when a scholar or researcher searches for an article he/she will definitely read the abstract in order to know the contents of the article. The subject matter of the investigation, in a nutshell, is the abstract. In the abstract, three important elements should be present.

- (a) A very short introduction of the subject matter and precise explanation of the topic .
- (b) A summary of the methodology that is being used
- (c) A of result and its justification

These are the all-important aspects a researcher or a scholar should know from an abstract. One has to be very careful not to include the conclusion of the research in the abstract.

4. *Introduction:* An introduction of an article must enlighten the broader area of the research elaborately. Then, the broader area of research must be shortened into a specific area of interest which is extremely important to narrow down the problem or gap in an area of research from a bird's-eye view perspective. Then, a solid literature review must be done to elaborate on the progress in that field of research and justify its importance. Then, the author will explain how he/she has decided to fill the gap. The last but not the least, it is customary for an author to organize the rest of the sections of the article at the end of the introduction
5. *Methodology:* The methods implemented in the research are elaborated in this section. Methods can be categorized as *Theoretical* and *Experimental*. For theoretical research, the mathematical equation and its explanation must be elaborated. For experimental research, a schematic diagram of the experimental setup and its components must given. The author should highlight the general idea and the novelty aspect of his/her research.
6. *Results and Discussion:* In this section, the author will describe his/her findings while doing the research. The section mostly contains three types of elements.
  - (a) *Text:* The Text contains the most important part of the scientific literature which is the "description of the new findings". Figures and tables should also be cited in the text serially. This is the section where the art of telling a story of science takes its interesting form. A data or figure is just a representation of the findings of a researcher. However, the interpretation and literary representation of those findings are the most crucial part of an article. Two different individuals can produce two different and equally meaningful conclusions from the same set of data. Well, of course, these two conclusions

must be complimentary of each other, not contradictory. A self-contradictory finding of research indicates less evaluation of that particular subject of interest. So, to explain or cross-check his/her findings a scholar should have to develop his/her own method of verification which is one of the aspects of this PhD course.

- (b) *Figure:* The figures are the visual representation of the data. An author should compare his/her findings with previous findings, available in the literature, to justify his/her methodology
- (c) *Tables:* A detailed tabulation of data must be provided in the literature or it should be available in the public domain upon request. This way the findings will be available to the community.

All the tables and figures should be properly captioned.

7. *Conclusion:* In this section, the findings will be elaborately concluded, justified, and explained. Also, the novelty aspects of the finding and its contribution should also be discussed. The most important part of this section is the relevance of your research and the future aspects it holds.
8. *Acknowledgement:* In this section, a researcher will convey his/her heartfelt gratitude towards the funding agency and the fellowship he/she received. Acknowledgment towards the facility, collaboration, and Institution can also be expressed here.
9. *Data availability statement:* Data availability statements are undertakings by the authors to advocate the availability of the data to the scientific community. These undertakings are different and extremely specific for different journals.
10. *Conflict of interest:* Whether your research and its findings are creating any unforeseen conflict of interest with any individuals, institutes, authorities, or government bodies must be declared in this section. This is a mandatory practice by journal houses to stand on the other side of the fence.
11. *Bibliography:* In this section, the author will mention all the literature he/she has reviewed during the research process.

## 4 Thesis

### 4.1 Introduction

A thesis or a scientific thesis is the collective wisdom of all the scientific articles published by an individual research scholar. After the completion of PhD, a scholar has to submit a thesis based on his/her research work. During his/her PhD, a scholar can publish numerous articles. Among these articles there exist a set of articles with a common essence. A thesis must be based on the common essence of these correlated articles. A thesis is like a complete novel or a complete manga while the articles are the chapters or the story arc of that literature. Well, the analogy is somewhat problematic because, unlike a completed novel, a thesis tells a story collectively from a bird-eye view.

## 4.2 Outline of a thesis

1. *Title page:* A title page of the thesis contains the most complex part of a thesis which is the title itself. It is extremely important to create a non-plagiarised title. Next, a common statement, followed by the author's name. After that, the Logo and name of the institution signify that the thesis is the intellectual property of the institution and is protected by the intellectual property rights of India.
2. *Certificate from the supervisor:* A Certificate given by the supervisor(s) is attached to the thesis.
3. *Statement of originality and similarity index:* The thesis is being examined by the library of the university or institution via software to ensure that the thesis is not plagiarised beyond a given level (usually set by UGC). The percentage of similarity with the sentences and phrases taken from any other literature is also examined which is also known as *Similarity Index*. As per the present rule, this index must be below 10% for an acceptable thesis.
4. *Acknowledgement:* It is one of the interesting sections of a thesis in which the author has full control over whom he/she may acknowledge. Funding agency, fellowship, and institution are three common acknowledgments in any thesis. Acknowledgment is a projection of the author's mind, written and expressed with a set of words. These words can be an expression of a thousand sleepless nights, years of hardship, dedication, and a gut to never give up. The page of acknowledgment is a symbol of admiration, love, gratitude, solitude, hardship, suffering, success, and triumph.
5. *Dedication:* An author can dedicate his/her thesis to anyone. It can be your parents and teachers or one of your beloved family members, beatified through your thesis even after her tragic death, or a team of learned scientists, who dedicated their entire life to land a spacecraft to the south pole of the moon or all the taxpayers of our poor nation who supports our research from hindsight.
6. *Abstract:* After all this emotional ranting, let's get back to business. The abstract of a thesis is probably the most difficult undertaking faced by any scholar in their lifetime. Throughout your PhD life, you may have published numerous articles. Now, you have to connect those knots to form a comprehensive summary which must be original, must convey your work to a large audience, and must be concise enough to be fitted in a limited number of sentences. So, only by reading this documentation, a reader can comprehend the pain of a scholar who is struggling to write a comprehensive abstract.

An abstract should be started with a proper explanation of the broader area of your research work. Like, if you have written a bunch of papers on Quantum Entanglement, then you should start the abstract with an elaborate explanation of Quantum Entanglement without any historical context or mathematical description. Then, you have to narrow it down to the specific area of interest which you have studied over the year. Like, you have studied the quantum entanglement of a two-electron system trapped in different potentials. At the end, an abstract must contain the novelty aspects of the research on which it is being based.

7. *Tables of Contents, List of figures and tables, abbreviation:* A table of contents, figures, tables, and abbreviation of repeatedly used words should be given before the chapters. It is not customary (except the tables of contents) but a very essential practice to write a quality thesis.
8. *Chapters:* The thesis chapters mostly consist of the essentials of the scientific articles you have published over the years. As we have said earlier, a thesis is not a collection of articles but a collection of collective wisdom. So, one has to be very careful while writing the chapters of a thesis. The thumb rule is very simple: *do not copy-paste your articles as chapters*. It is an extremely bad practice and should not be encouraged. While writing the chapters, a scholar is advised to modify and concise the articles carefully. As we have discussed, every article has its own abstract, introduction, methodology, and conclusion. Now, you have to remove these parts from all the articles and combine it together. Say, you have published “N” number of papers. The first and second chapters of a thesis should be dedicated as Introduction and General Methodology.

The *first chapter or Introduction* is mostly based on the broad area of research followed by specific interest. After that a comprehensive literature review and identification of the gap in the subject from an areal point-of-view. Then, the scholar will justify his/her motivation towards the topic and the objective he/she must undertake. The introduction should be ended with a clear thesis outline.

The *second chapter* is based on general methodology, implied on all the collective research over the year. As we have discussed earlier, the methodology can be Theoretical or experimental. In both cases, a proper mathematical description or schematic diagrams with an explanation must be given.

Chapter-1 (Introduction)  
 Chapter-2 (Methodology)  
 Chapter-3  
 ⋮  
 Chapter-(N-1)  
 Chapter-N(Concluding Remarks and future outlook)  
 Appendix

Now, from chapter-3 to chapter-(N-1), all the scientific articles with a common essence must be included. Their abstract, introduction, and conclusion should be skillfully removed. In each chapter, a short introduction of the specific topic with a brief methodology should be written in one section. Then we will proceed to the next section which is based on results and findings. The literary representation of each of these segments will be a written testimony of the author’s compatibility.

At last, in the ‘N’tth chapter, a concluding remark and a future outlook must be presented. In this chapter, the author will discuss about the novelty aspect of his/her collective research.

Novelty aspects mean the contribution of a thesis to the scientific community and what are the future directions, diverging from it. A good thesis will discuss not only its future direction but also its relevance to our civilization. Well! to be honest with you, we, scientists, are all a bunch of visionary fools working at the hindsight of this puny civilization. Every research for this civilization is just a drop of water in a large ocean or a single sand particle in a huge building. Without the proper novelty aspects, research is worthless. So, try to point out all the important contributions it is making towards the community.

Now, let's discuss about a very important yet not-very-popular practice. In the general methodology chapter, we, theorists, often provide a detailed mathematical description of our methodology. Now, a detailed description of mathematics doesn't mean that you should provide a thousand pages of documentation, filled with your five years' worth of calculation. Neither your university nor your bank account will encourage this type of practice. So, instead of giving nightmares to the 'Dhar Brothers' (read: printing house), you can provide a full appendix describing the intricate intermediate steps of some rigorous analytic derivation.

9. **Bibliography, list of publications and presentations:** At the end of the thesis, a detailed list of references which was used throughout the research must be provided. Also, a list of publications with DOI and the presentation given by the scholar should be included.

## 5 Project Proposal

### 5.1 Introduction

After completion of your PhD thesis, you will get a doctoral degree from your respective university or institution. You become a battle-hardened soldier by now. Getting a doctoral degree means that now, you are a full-fledged general who can train and guide another generation of battle-hardened soldiers. To do this, you need something called 'project'. A project proposal is written to a funding agency by an independent researcher. Whether the project will be sanctioned or not depends on the sheer bureaucratic skills of that trained researcher. A project proposal is, therefore, not only a scientific article or thesis but also a bureaucratic documentation.

A quality project proposal contains a detailed explanation of an existing problem in a particular topic and a detailed methodology you want to employ to resolve the problem. Just like any other research article. What makes writing a project proposal much harder than an article, is that it also contains all the necessary requirements and funding associated with the project. A researcher can ask for funding to employ a junior research fellow or research associate, a strong non-recurring fund for equipment, or a travel fund to collaborate or visit a certain research facility, contingencies, and consumables. The proposal should also clarify the work plan and the outreach facilities to the funding agency. So, it is a daunting task. Yet, every day hundreds of projects are sanctioned all over India. Thus, we need to learn this sorcery so that we can use it to improve our academic careers.



## 5.2 Types of projects

Based on various parameters, a project can be divided into three categories. Now, before we categorise it, we need to know the parameters on which it is categorized.

1. *Time Frame*: A project must be completed within a stipulated time frame. That is why, we need a proper work plan to complete the project within that time frame. In general, in a country like India, The standard time frame of a project is three years. From different categories of projects, the time frame varies. But, why does this time frame matter? Well, punctuality is always a good practice. Emperor Napoleon Bonaparte would certainly certify this statement after losing the crucial battle of Waterloo in 1815. The time frame of a project is the most important aspect, not only for the sanction of the project but also for your career. So, if you have given a work plan to the funding agency and you haven't executed it properly then your project would not be completed within the time frame. The possible outcome will be that a battle-hardened general like you will now be branded as a project investigator (P.I.) who has failed to deliver the project in time. Not a very good tag for your academic career (the Napoleon reference is now making sense, ain't it ?).
2. *Funding categories*: A funding agency can fund your project in different categories. Broadly they can be divided into two categories.
  - (a) *Non-Recurring Fund*: The NRF is provided to the project investigator once during the project. The sanctioned money can be used to make a good laboratory or working setup. For a theorist, it can be a good server and for an experimentalist, it can be a complete setup of machinery. NRF is very essential to build a good laboratory.
  - (b) *Recurring Fund*: A Recurring Fund is a type of funding that is being sanctioned every year throughout the project duration. It can be sub-categorised as,
    - i. *Manpower*
    - ii. *Contingency*
    - iii. *Consumable*
    - iv. *Travel*
    - v. *Overhead*

The funding in manpower means that the fund can be used to employ a Project assistant (for minor support), Junior/Senior research fellow (for basic support), and Research Associate (Post Doctoral Fellow, only for advanced level support). Contingency funds are being used for day-to-day expenses. Consumables are being used to purchase small-scale equipment or components of equipment. Travel grants can be used to attend collaborative meetings (must be inside the country). Lastly, the overhead is granted to the betterment of the institution.

Based on the defined parameters, now, we can define different categories of projects.

1. *Minor project*: A minor project has a very small time scale of 1-2 years, mostly one year. An established lab can ask for this type of project when they do not need manpower to run the project. A minor project, therefore, doesn't support the funding of manpower, overhead, or NRF. It only supports consumables, small-scale travel, and contingency.

2. *Semi major project:* The category is not dignified. Mostly, state governments and their funding agency supports a semi-major project. They will grant you recurring benefits like Contingency, Travel, Consumables, and Overhead. Additionally, you can either ask for manpower or a full NRF. It depends on the decision of the P.I. whether he/she should ask for manpower or equipment.
3. *Major project:* A major project is funded by mostly, central government agencies like DST or DBT. They will provide you with full support of all kinds of funds.

### 5.3 Funding agencies

Now, the question is ‘Who will fund you?’ There are various government and private organizations that give funding. Private organizations have their agenda as they only fund the applied science projects to access the patent generated by the project. It is, therefore, the duty of the governmental organization to promote basic science projects. The list of funding agencies is given below.

1. Science and Engineering Research Board (SERB) under the Department of Science and Technology(DST)
2. Board of Research in Nuclear Science (BRNS) under the Department of Atomic Energy
3. Council of Scientific and Industrial Research (CSIR) under the Ministry of Human Resource Development (MHRD)
4. University Grant Commission (UGC) under the Ministry of Human Resource Development (MHRD)
5. Department of Biotechnology (DBT)
6. Defence Research and Development Organisation (DRDO)
7. Indian Space Research Organization (ISRO) under Department of Space (DoS)
8. All India Council of Technical Education (AICTE)

### 5.4 Outline of a project proposal

1. *Title:* A good title is necessary for any of scientific writing as well the project proposal. Your title should convey the broad area of your research. Like, “ Structural, Quantum Entanglement and Quantum information theoretic measures of a few-body atomic and molecular system”. By reading the name you can guess the broad area of the project.
2. *Summary:* A Summary in limited words is the abstract of your project without any discussion of the possible outcome.
3. *Keywords:* Important Keywords should be listed here.
4. *Proposed Referee (optional):* The project can be sent to a proposed referee for proper evaluation. A project instructor can give the proposal of a particular individual who is capable enough to judge the credibility of your project.

5. *Broad area:* In the broad area section, you will discuss the broad area of your project.
6. *Objective:* In this section, A P.I. can annotate his/her objective through the project in concise bullet form.
7. *Year-wise work plan:* This is the most important section of a project proposal and based on this section, your project will be evaluated later. A proper year-wise working plan is extremely necessary to run a project within a stipulated time frame.
8. *Budget and its justification:* As we have mentioned earlier, the project needs monetary support from the funding agency. So, you need to tabulate all the necessary amount of money required to run the project with proper justification. This is the second important aspect of your project. If the budget is outlandish the project will not be sanctioned.
9. *Institutional support:* Whether you need any kind of institutional assistance over the year during your project must be justified in this section. It is an optional section.
10. *Details of project:* After all the previous bureaucratic jargon, now, it is the time to write a detailed scientific section of the project. In this section, a detailed introduction and methodology must be given, Then followed by national and international status to justify the relevance of your project in the present context. Lastly, the references used to write the details should be given in a specific bibliography section.
11. *CV of the Investigators:* Lastly, the curriculum vitae of the investigators are to be attached in the last section. The important thing to note is that there can be any number of investigators. The one who writes the project is the Project Investigator while the others are known as Co-Project Investigators. Their names can be used in a project with proper consent.
12. *Undertakings:* In this section, the PI has to take various important undertakings. A certification from the supervisor, A plagiarism report, and a certification from the head of the institutes must be included. Also, an undertaking on environmental hazards and the protection of biological assets are required for specific cases.

## Shell-confined hydrogen atom

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(Received 17 February 2005; accepted 14 March 2005; published online 19 May 2005)

Calculations of electronic energy and static dipole polarizability are reported for the hydrogen atom in the  $ns$  states ( $n=1-6$ ) confined between *two* impenetrable concentric spheres of inner and outer radii placed at the locations of the radial nodes corresponding to the *free* hydrogen  $ns$  ( $n=2-7$ ) orbitals. Interesting new conditions of degeneracy arising due to the shell confinement are discussed. Shell-confined states of unusually high polarizability are predicted for hydrogen atom as the inner sphere radius is shifted towards the outer nodal points of the free atom corresponding to the higher principal quantum numbers. © 2005 American Institute of Physics. [DOI: 10.1063/1.1901584]

Figure 1: A Regular Journal and its abstract

## The Mathematics of Darwin's Theory of Evolution: 1859 and 150 Years Later

Peter Schuster

**Abstract.** A mathematical formulation of Darwin's theory of evolutionary optimization through variation and selection is derived in terms of conventional ODEs that can be interpreted as chemical kinetics of evolution. Variation in form of mutation and recombination operates on genotypes being DNA or RNA sequences, whereas phenotypes, which are represented by organisms or molecular structures, are the target of selection. The impact of recombination on optimization is briefly sketched. Differential equations modelling selection in populations with correct replication and mutation are derived from the molecular mechanisms of polynucleotide replication. The analysis of these ODEs reveals restrictions of the optimization principle caused by mutation. Error propagation over generations sets a limit to mutation rates in evolution, which manifests itself in the form of a phase transition-like phenomenon characterized as error threshold. Conditions on fitness landscapes for the occurrence of error thresholds derived from numerical investigations are presented: Smooth fitness landscapes show no error thresholds but gradual transitions, sufficiently steep landscapes and rugged landscapes sustain error thresholds. Sharp transitions are also found with realistic landscapes combining ruggedness and neutrality. Lethal mutants may lead to extinction of populations and set another upper limit to mutation rates in form of an extinction threshold through lethal mutagenesis.

**Mathematics Subject Classification (2000).** Primary 92D25; Secondary 80A30.

**Keywords.** Error threshold, genotype-phenotype mapping, lethal mutagenesis, population dynamics, neutrality, quasispecies, sequence space.

Figure 2: A Topical Review Paper

(a)

Few-Body Syst (2015) 56:645–649  
DOI 10.1007/s00601-015-1000-1



LETTER

Przemysław Kościuk · Jayanta K. Saha

### Ground-State Entanglement Properties of Helium Atom in a Finite Spherical Cavity

Received: 20 March 2015 / Accepted: 3 May 2015 / Published online: 20 May 2015  
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**Abstract** The effects of the spatial confinement on the ground-state entanglement properties of the helium atom have been studied. The finite oscillator potential is used to represent the confining potential. The transition to the free atom regime and the harmonic confinement regime are discussed in detail in dependence of the control parameters of the system.

(b)



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Physics Letters A 307 (2003) 326–336

PHYSICS LETTERS A

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## The compressed helium atom variationally treated via a correlated Hylleraas wave function

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Received 6 September 2002; received in revised form 2 December 2002; accepted 14 December 2002

Communicated by R. Wu

Figure 3: (a) A Letter Like Article (b) Dedicated Journal for Letter like articles only

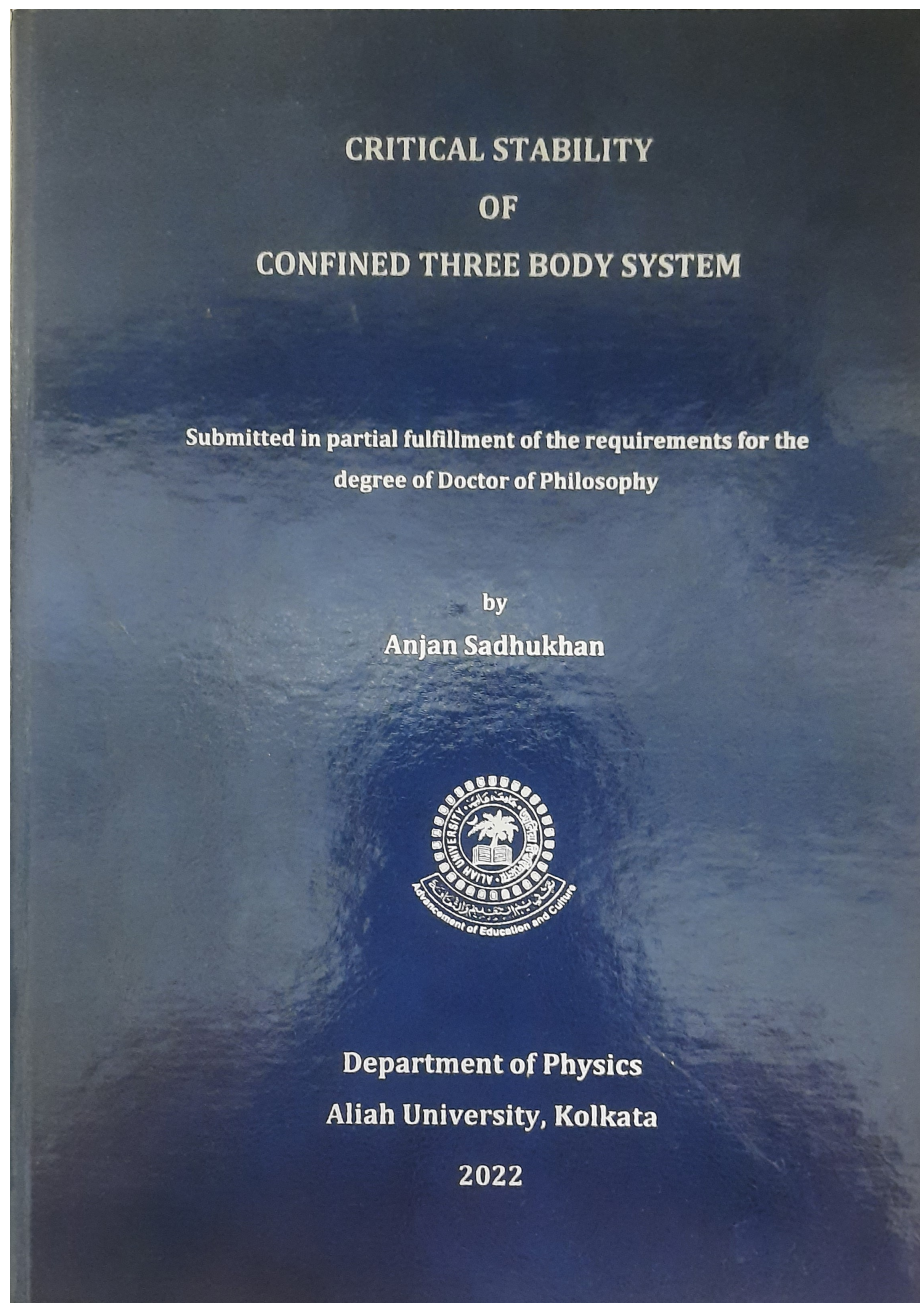


Figure 4: Title Page of the Thesis submitted by **Dr. Anjan Sadhukhan**, National Yang Ming Chiao Tung University, Hsinchu, Taiwan in 2022 to Aliah University