

AL-FARABI KAZAKH NATIONAL UNIVERSITY
Faculty of Physics and Technology
Department of Plasma Physics, Nanotechnology and Computer Physics

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Lecture Notes for the Discipline
SCIENTIFIC RESEARCH METHODS

on the educational program "8D01501 – Physics", "8D05306 – Physics", "8D07106 – Thermal Power Engineering", "8D05308 – Nuclear Physics", "8D07112 – Nanomaterials and Nanotechnologies", "8D07502 – Standardization and certification", "8D06201 – Radio Engineering, Electronics and Telecommunications"

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“Good research is discovered; good theses are designed.”

LECTURE 8

The Concept and Structure of a PhD Thesis

Learning outcomes

- Explain the place of the PhD thesis within the doctoral training program.
- Define the concept of a PhD thesis and acceptable forms of ‘contribution’.
- Outline a standard structure and what belongs in each section.

Key Questions

1. What makes a document a PhD thesis (beyond a collection of papers)?
2. How should chapters be arranged so that the logic ‘Problem → Method → Result → Conclusion’ is transparent?
3. Which requirements (university/faculty) affect structure, publications, and defense?

Brief Conspectus

Concept of a PhD Thesis

- Scientific novelty and originality
- Theoretical significance (contribution to scientific knowledge)
- Practical/applied value (for physics, technology, education, industry)
- Methodological correctness (research design, methods, data processing)
- Publication of results in recognized journals/conferences

Typical Structure (General Model)

Title page, abstract (annotation), table of contents

Introduction

Chapter 1 – Review and problem statement

Chapter 2 – Methodology and research design

Chapter 3 – Experimental/theoretical results and analysis

Conclusion, list of references, appendices

Introduction (What to Write)

Relevance of the research topic

Scientific problem and its current state

Aim (overall goal) of the research

Research objectives (tasks) – 4–6 concrete actions
Object, subject, hypothesis (if accepted in your faculty)
Scientific novelty, practical significance, approbation

Chapter 1 – Literature Review / State of the Art

Systematic analysis of modern research on the topic
Classification of approaches, methods, models, materials, and instruments
Identification of contradictions, gaps, and limitations
Formulation of the research problem and justification of the chosen direction
End of chapter: “Thus, the research problem can be formulated as ...”

Chapter 2 – Methodology and Research Design

General strategy: theoretical, experimental, or combined research
Description and justification of methods used
Description of experimental setup/modeling environment
Data collection, measurement, and processing procedures
Criteria of validity, reliability, and reproducibility

Chapter 3 – Results and Their Analysis

Presentation of obtained theoretical/experimental data
Graphs, tables, models, and comparison with existing results
Error/uncertainty estimation, discussion of limitations
Interpretation of results with respect to research questions
Link to the stated aim and objectives

Conclusion / General Conclusions

Brief restatement of the aim and how it was achieved
Numbered main results (usually 5–8 items)
Scientific novelty – what is obtained for the first time
Practical value – where and how it can be applied
Recommendations and directions for future research

Supporting Elements of the Thesis

Abstract (author’s summary, autoreferat) – short version for a wide audience. List of publications on the thesis topic. List of abbreviations and symbols (important in physics).
Appendices: large tables, circuit diagrams, program codes, protocols

Publication and Approbation Requirements

Results must be published in peer-reviewed / indexed journals. Conference presentations, seminars, department reports. For physics/technology: patents or innovation proposals, if applicable. All publications must be cited and linked to thesis chapters

Typical Mistakes in PhD Theses

- The topic is too broad / the problem is unclear
- Review is descriptive, not analytical – gap is not visible
- Methods are not justified or reproducible
- Results are presented but not linked to the aim and objectives
- No clear statement of novelty and practical significance

Thesis and Supervisor / Department Requirements

- Follow faculty formatting rules (fonts, margins, reference style)
- Follow national standards (structure, volume, language)
- Coordinate the chapter plan with the supervisor before writing
- Keep track of changes in regulations (attestation, publication lists)

Questions for Reviewing the Material Covered

1. Write a one-paragraph problem statement and gap leading to your RQs.
2. Draft the aim and 3–5 objectives aligned with your methods and expected outputs.
3. Outline a thesis table of contents; list 2–3 appendices you will include.
4. Prepare a checklist of publications/approbations you already have (with evidence).

Recommended List of References

1. Peter K Dunn Scientific Research and Methodology An introduction to quantitative research and statistics in science, engineering, and health RStudio, PBC 2021
2. Creswell, J. W. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. – 5th Edition. SAGE, 2018.
3. Michael P. Marder. Research methods for Science. Cambridge University Press, 2011, 210 pp.
4. Phillips, E. M., & Pugh, D. S. (2015). How to Get a PhD (6th ed.). Open University Press.
5. Madsen, D. (1992). Successful Dissertations and Theses (2nd ed.). Jossey-Bass.