WRITING YOUR LABORATORY REPORT

A GUIDE FOR CHEMICAL ENGINEERING STUDENTS

CE 327 – Chemical Engineering Laboratory 1: DRAG ON SPHERES

Professor Tamara Kofke

by
Prof. Pneena Sageev and Mr. Floreal Prieto

Center for Technical Communication
312/313 Bell Hall, North Campus
Tel: 645-3470 x2156; Fax 645-3302
Email: prieto@eng.buffalo.edu

School of Engineering and Applied Sciences
State University of New York at Buffalo

CE 327 – Chemical Engineering Laboratory 1: DRAG ON SPHERES

WRITING YOUR LABORATORY REPORT

A GUIDE FOR CHEMICAL ENGINEERING STUDENTS

NOTE TO STUDENTS:
Please refer to your handouts for CE 212 (Introduction to Chemical Engineering) and CE 304 (Chemical Engineering Thermodynamics) for initial information on the first two sections, "Features of Technical Writing" and "Content – the Double-5 Model".

In this lecture, we will describe the "Content" requirements for this experiment, based on the single- and double-5 organization model you have covered previously. Then we will review the "Format" and "Strategy" sections. The second lecture will add new editorial tools to the 5 you have already learned.

GOALS
- **Immediate –** To help you write a better laboratory report at school and at work
- **Long term –** To give you a basis for understanding and writing a technical journal article.

SOLUTION
Thus, we'll cover these topics:
1. Content: Selecting and organizing lab information
2. Format: Using format to improve readability and graphics
3. Strategy: Writing your report efficiently – individually and in teams
4. Language: Writing concisely, accurately, clearly, and correctly.

REFERENCES
For more detailed information on language usage, refer to:

- W. Strunk and B. White, Elements of Style, 4th edition, Allyn and Bacon, Needham Heights, MA, 2000.
- CTC Website, www.ctc.buffalo.edu, for self-study modules on various grammatical problems. Click on "TC resources".

Table of Contents

1. CONTENT

The underlying model for reporting an experiment consists of five sections:

Objective
Apparatus
Method
Observations
Conclusions

This basic approach provides important features for scientific reporting:

- Logical
- Verifiable; reproducible
- Problem-solving method
- Provides platform for further discovery work
- CATEGORIZES and SEQUENCES INFORMATION

Thus, it has become the cornerstone of scientific progress.

As experiments become more complex, so do the methods for reporting them. For example:

Complexity Levels of the Scientific Model

	PROBLEM	PROBLEM SIGNIFICANCE OBJECTIVE BACKGROUND	INTRODUCTION
OBJECTIVE	OBJECTIVE		THEORY
		THEORY	
APPARATUS	APPARATUS		
		METHOD	APPARATUS & PROCEDURE
METHOD	METHOD		
		RESULTS	RESULTS
RESULTS	RESULTS		
		DISCUSSION	DISCUSSION
		CONCLUSIONS	CONCLUSIONS
		RECOMMENDATIONS	RECOMMEND
LEVELS			
8th grade	**High School**	**University**	**Technical Journal**

Thus, this basic model for reporting simple experiments has evolved into an expanded framework for reporting complex technical studies.

NOTE that the **Double-5** model also applies to experiments – but the emphasis shifts strongly to the technical side. However, we still need to explain the USES and IMPORTANCE of the experiment to practical CE problems, e.g., in industry, government agencies, or future research. For example, in this experiment, you also need to relate to a workplace SCENARIO and to solve a specific problem based on the material you have learned through this experiment.

To **organize** the information you develop during your experiment, use the following guidelines, based on the scientific model, to prepare an **outline for a lab report.** (See the content section in your handouts from CE 212 on preparing an outline.) As noted in those writing guidelines, use key words to list the main points under the prescribed headings. Such an outline could also serve as the basis for a "Table of Contents".

Note the approximate length of each section.

TITLE PAGE: Experiment title
Course name and number
Professor's name
Lab group number
Names of team members
Experiment date
Report date

TABLE OF CONTENTS: Prepare only for the Appendix section.

ABSTRACT

Include:
- Subject of your experiment
- Method you employed
- Results you obtained

Thus, theoretically, the abstract can consist of three sentences that overview these topics. However, you also need to include key numerical specifications and constraints, and quantify the main results you obtained.

INTRODUCTION (1 to 2 pages, double-spaced)

Scenario

IN YOUR OWN WORDS, state the specific problem the division of CBE, Inc., wants you to solve.

Problem

IN YOUR OWN WORDS, state the general problem, challenges, and constraints you are facing.

Uses and significance for chemical engineering

See the following section on THEORY. Describe and explain at least 2 industrial examples or actual

Objective of the experiment

Clearly and concisely state the objective of the experiment.

THEORY (1 to 2 pages)
Based on the experiment notes and instructions you received from your professor, state the main features of dimensional analysis relevant to the experiment. Explain why or how these features will enable you to achieve your objective, solve the problems this experiment poses, and help solve other CE problems.

EXPERIMENT APPARATUS AND METHOD (2 to 3 pages)
Overall sketch and description of the apparatus
- Present a general sketch of the apparatus, including the labels of its features. Describe how the apparatus functions.
- Explain the diameter of the cylinder in relationship to the diameter of the sphere
- Note potential wall effects
- Characterize the sphere's materials and size
- Explain why you are asked to repeat the measurements
- Explain why the viscosity of the fluids must be measured.

Overall method approach
In paragraph form, describe the key stages of the method for obtaining experimental results. Explain why the method in each stage is valid.

Detailed steps in the method
You already wrote detailed procedure steps in your pre-lab. Now, insert a copy in the Appendix as a reference for you or other experimenters to reproduce and verify your results.

RESULTS (2 - 3 pages, text and diagrams)
For the experiment: Describe, illustrate, and explain the results. For each procedure step, include:
- Data summary graphs (e.g., drag curves and literature values),and tables; as a basis, refer to the detailed results in the Appendix
- Explanation and interpretation of the results these graphics illustrate
- Any additional data (if provided) and source.

For the scenario problem:
Show your solution to this problem. If the calculation is long, insert it in the Appendix, but place a short "summary" solution in the report. Solve first with your own data. Then, solve with the literature data.

.
Discussion: (2 to 3 pages)
Answer the following questions, and address the noted issues:
- How "good" are the values and graphs you obtained for the "experiment" and the "scenario" problems?
- Did your results confirm the theory? If not, why not?
- How did your results compare with literature data or values? For example, why does your drag curve differ from that in the literature?
- If you found discrepancies in the results, name and explain the main likely sources of error.

CONCLUSIONS (= LESSONS LEARNED) **AND RECOMMENDATIONS** (1 to 2 pages)

Experiment

Relate your results to the lab's problem and objective:

- To what extent did you attain the lab's objective?
- Was the equipment adequate?
- What steps could be taken to substantially improve the results?

Scenario problem

- To what extent did you solve the problem?
- Within what limits?

REFERENCES

Place the references in alphabetical order, according to the first author. Consistently use a standard reference format – e.g., as in a specific text or Journal.

APPENDICES

- Place ALL the original experimental data in the Appendix: e.g., experimental data sheets or tables, spreadsheets for the data on each type of sphere, sample calculations (may be handwritten), calibration curves, data analyses, detailed theory explanations, comparisons with theory – e.g., your data vs. the three "regimes" for the drag curve.
- Include your detailed solution for the "scenario" problem.
- Attach your laboratory notebook.
- Attach your team's plan for doing the experiment and your outline for writing the lab report.

*****

Using this report framework has several benefits: It enables --

- YOU to outline a report more logically and efficiently
- YOU to write a focused report more quickly
- READERS to follow the reasoning in your experiment report – or technical article – more easily
- GRADERS to more fairly evaluate your lab report
- YOU to continually improve your outlining and report organization skills
- YOU to receive higher grades.

NOTE that this report organizational framework also follows the basic pattern for writing an article for any technical journal. Though each journal can modify the content headings, requirements, and organization to suit its needs, the **underlying model for reporting an experiment remains the same.**

2. FORMAT

DEFINITION: "Format" does not mean "organization"; it means the "form", "design", or "layout" of the pages in your report. The term “format” covers both **TEXT and GRAPHICS.** Thus, **text-format elements** include, for example: margins, font, line spacing, headings, type size, type form, page numbering. **Graphic-format** includes various types of illustrations – e.g., figures, tables, flowcharts, photos, equipment sketches.

Text

- Set up your report in the order and according to the specifications shown on pages 4 to 6 of this handout. NOTE THE FOLLOWING FORMAT SPECIFICATIONS.
- "Weight" the headings of each section to show their relative importance. For example:

LABORATORY REPORT TITLE

…

EXPERIMENT APPARATUS AND METHOD

Overall sketch and description of the apparatus

Overall method approach

Detailed steps in the method

…

You can also use type size, underlining, spacing, or different fonts to “weight” the headings-–i.e., formatting options that show the headings’ relative importance.

- Use a readable font and type size; avoid “fancy” fonts. For example, the font and type size on this page is Arial, 11 point.
- Double-space this report.
- Indent a new paragraph – at least 5 spaces
- Leave a 1 to 1 1/2 inch margin on each side of the page. Be especially careful about leaving a wide enough margin on the left-hand side for a binding.
- Use "bullets" or numbers for lists of items
- Try to keep paragraphs short and focused
- Mention and list references alphabetically. Select a reference style from a CE textbook or journal. Use the style you select CONSISTENTLY.

Graphics

- SELECT THE RIGHT TYPE OF GRAPHIIC TO ILLUSTRATE YOUR INFORMATION – e.g., a pie chart, a flow chart, a sketch, a curve or other graph. For example, a pie chart indicates percent out of 100% for each “pie” slice. Thus, do not use a pie chart to show a column of numbers when readers want to know the sum.
- Insert SUMMARY tables and figures adjacent to the text. Similarly insert example calculations, if needed.

- Designate all tables and figures you insert (e.g., Figure 1); refer to them in the text BEFORE they appear. Explain their meaning and relevance. Add the page number if the figure is not on the same page as the text.
- Place detailed tables of experiment results, work diagrams, detailed calculations and similar data in the Appendix.
- Try to place tables and figures vertically on the page. If necessary, reduce the diagram size.
- If you must use a horizontal (landscape) diagram, place it so that the caption reads from the bottom to the top of the binder, AWAY from the binding rings or clasps.
- LABEL figure elements -- e.g., axes, types of lines, units. For TABLES, include column and row headings, together with units. Use standard units -- e.g., foot/pounds, not yard/pounds...
- Add CAPTIONS (or titles) to ALL tables or figures.
- Write your report via computer.
- Center equations; number them for future reference. Under the equation, list the term definitions – for example: "…..where:

  a =

  b =

  etc.

Overall formatting

- Write your report via computer
- **PAGINATE YOUR REPORT – except for the title and cover pages.**
- Bind your lab report SECURELY.

CHECK your page limits for each section of the report. (See pages 4 to 6 of this handout).

NOTE: If you need to write a report for a trade or technical journal, a newspaper, or at your workplace, remember that publishers and places of work often set their own format parameters. Check these parameters **before** you submit an article to a publisher – or to your manager.

5. STRATEGY

This model strategy will help you and your team produce a quality report efficiently.

1. REVIEW YOUR NOTES AND HANDOUT THOROUGHLY!
2. Review the notes on TEAM WRITING
3. CAREFULLY check the Lab Report specifications, including the title page, references, and appendices, as well as the major report sections.
4. DEVELOP AN OUTLINE for your Lab Report based on the section headings and subheadings of the content-framework on pages 4 to 6. Use key words, not whole sentences, for these main points.
5. Jointly EVALUATE and IMPROVE the outline
6. SET UP the HEADINGS for your lab report according to your outline. Use your computer to select a basic style (e.g., fonts, margins, pagination). Weight the headings consistently for each section and subsection.
7. Assign team members to write specific sections of the outline

8. WRITE THE FIRST DRAFT by fleshing out your section of the outline -- mainly via sentences in paragraphs. Focus on CONTENT. Again, use the computer so you can revise and edit the draft more easily.
9. Insert initial, first-draft-graphics into the text and the Appendix..
10. Add the references at the end.
11. JOINTLY REVIEW your combined report for CONTENT: Has each team member responded to all the ***required*** questions? Is the information complete? Clear? Logical? Consistent? Can the intended audience understand your team report? Add needed information; clarify existing information. Delete irrelevant or unnecessary data. Remember: the page limit precludes excessive detail. You must focus on the main information elements in the report. Check whether your report's length is within the word-count and page limits.
12. THEN, team-edit this draft for LANGUAGE. Do the paragraphs contain well structured sentences? Are the "bridges" between sentences logical? Is the paragraph easy to follow? Is the language concise? Accountable? Particularly **review and apply "language tools" 1, to 5, plus the new tools covered for this report.** If you wish, edit the draft individually; then combine the editorial suggestions into a coherent document.
13. Correct the language and insert the graphics as needed – e.g., a table, figure, photo.
14. Assemble your lab report.

    Title page; Abstract; REPORT SECTIONS; Table of Symbols; References; Appendices

    Lay out the report so that the Title page and Abstract start on a new page.
15. Proofread, spell check and print out your briefing report.
    - Proofread for:
      - Content: Did you respond to the directions and questions in the class notes, handouts, and lectures?
      - Spelling (Remember: the spell-checker will NOT catch errors in meaning, e.g., your vs. you're; there vs. their vs. they're; steel vs. steal
      - Punctuation
      - Correct identification of any figure or table
      - Consistent formatting
      - The Appendix plus the Table of Contents for this section of your report
      - Reference accuracy
      - Quantification and calculation accuracy
      - Overall logic and consistency – a "reality check"! – especially hard in a team-written report.
    - Make final corrections
    - Review final product: each team member must read and "sign-off".
16. Submit your complete, securely bound lab report.

    Also include:
      - The outline for your lab report
      - Your team's plan for writing the report
      - Each team member's evaluation sheet of how you planned and wrote this report.