

Honors Research Project Guidelines

Chemical and Biomolecular Engineering

Written Report Guidelines¹

A technical report must communicate what you did, why you did it, what you learned, and the significance of your results. The report does not have to be extremely long. In fact, the key to writing an excellent report lies in concisely presenting your *response to the objectives* of the project and justifying that response with appropriate documentation. It should consist of the following sections:

Cover Page - (1 page) which contains:

Subject of report and course number for project
Name of recipient
Name of author(s)
Date

Executive Summary (two - three double spaced pages, start a new page afterward)

The executive summary should present the purpose and limitations of the investigation, a summary of the results and major recommendations. The executive summary is a stand-alone document, often times it is the only thing that someone will read before making a decision. The executive summary is the single most important section of the report. Supervisors at your company may not be interested in the details of the problem; they are concerned primarily with the conclusions and often read only this section of the report.

The section should include (use headings suggested by these items):

1. A statement of the problem with a short paragraph stating the background and the purpose of the problem. This does not mean a review of the literature but simply the "why" of the problem.
2. Statements of the quantitative results obtained which relate to the purpose stated above. These results can usually be most clearly presented by a typical or average set of results, plus the range of variables and magnitude of errors. You can refer to attachments/appendices for further details. Be specific.
3. The definite conclusions that may be drawn from the results are stated. Hypothetical conclusions are left to the "Discussion" at the end of the report.
4. Broader implications of your work:
You should include a list of technical and career skills that you obtained as a result of your efforts.
You should describe other personal gains from this experience (improved confidence, creativity, independence, etc.)
You should describe how the results could be of benefit to society.
5. A statement of recommendations for future work (what should we do now?).
Describe as specifically as you can what should be done next on a technical level. You should also include your advice for other students that work on these types of projects and on what way the experience can be

¹ **Jerry J. Spivey**, Lecture materials for undergraduate lab course, Louisiana State University, 2005.

improved.

As you review your executive summary, you should make sure that these five questions are answered:

- What did you do (tested what hypothesis)?
- Why did you do it (technological significance and broader impacts)?
- How did you do it?
- What were your important results (technical and learning)?
- What, if anything, was unique about your project?

Body of the Report (start a new page)

Introduction

When the introduction section is included (technical papers, full technical reports, etc.) it is used to identify the subject/problem, describe the purpose of the project, and outline the scope of the project or problem being described. It begins with general statements that capture a broad audience and gets more and more specific. A brief statement of how the current work is related to prior work can be included. The introduction should outline why the project or problem is important and it should outline the rest of the document in some fashion. You must make sure that the document is written for the intended audience; for example, what units are commonly used within the discipline of your audience?

Background

When the background section is included it is used to review relevant, prior research in order to set up the rest of the document. A distinction should be made between the prior work and the work being described. The background section should also be used to describe theories or approaches that are unfamiliar. Limit the background discussion to the most relevant details. Be sure to reference papers and books appropriately. Limit the number of references to materials that cannot be obtained easily. You must make sure that the document is written for the intended audience. **YOU MUST NOT PLAGIARIZE!!**

Experimental Methods

Experimental methods should be included in enough detail that the experiments can be reproduced by other people; the section should not, however, be written like a recipe. Schematics should be used to help illustrate descriptions. Relevant details about materials and components should be included. Unusual procedures should be explained in detail. References to prior/other work can be used to shorten this section; make sure that referenced materials are easily found. The conditions used during the experiment should also be listed (perhaps in table format). Anything that is relevant to the interpretation of results should be mentioned in some way. You can include the experimental procedure in recipe format but only as an appendix to the report.

Data and Results

The data and results section includes data and calculated results that answer the questions raised by the objectives of the investigation. The results reported here should prepare for the discussion and justify the conclusions of later sections of the report. The data and results are often presented best as graphs, but tables may also be used. For example, if the goal of the experiment is to determine the effect of air flow rate on a mass transfer coefficient, then a graph of mass transfer coefficient versus air flow rate would be provided. On the other hand, results such as distillate compositions vs. various column operating strategies might be presented in a table. You must make sure that the units are clearly indicated and that all variables are defined.

Calculations performed using MATHCAD, spreadsheets, etc. may be included as appendices,

but adequate commenting/variable definition must accompany programs. The results of these calculations should be included directly in the data and results section if appropriate.

Original (raw) data are usually reported in tables in Appendices, copied from the original lab notebook. Calibration curves and other graphs, which do not relate directly to the discussion and conclusions, can (and should) be reported in the Appendix.

Each graph or other figure should have a figure number and title. You must refer to the figure and/or table within the text (otherwise the reader may not be able to understand the implication of your figure). The axes of the graph should be clearly labeled, including units of measurement. Experimental points should be indicated individually (circle, triangle, or other identifying mark). In general, you should not use smoothed lines to connect experimental points. Lines on a graph either represent fits to the data by a correlating equation, or theoretical calculations for comparison with the data.

Discussion/Analysis

In the discussion and analysis section, the author is basically telling the reader what the results mean. Present whatever is necessary to explain what you did and anything that bears on the usefulness and/or validity of your results. Discuss what answers your results give to the questions raised by the objectives of the investigation. **Discuss the precision, accuracy and validity of your results, and agreement (or lack thereof) with theory. Use comparisons to published data to validate your results or put your results in context.** Any suggestions for future work should be made in this section.

You should make sure that the previous sections of the report provide the necessary supporting information to follow your discussion. Double check to make sure that you have described or at least referenced all procedures that are mentioned in your discussion section.

If this section is handled properly, the reader should inevitably be led to your definite conclusions. These appear in the Summary, but can appear here also if more detail is warranted.

Literature Cited

The literature cited includes all references from which material in the report was taken. The citations should be complete and include all information necessary for the reader to find the material. Book references should specify the author, title, publisher, copyright date and pertinent page numbers. Journal references should include the authors, title, and journal name, volume, page numbers, and year. Other situations are covered in many style manuals. YOU MUST NOT PLAGIARIZE!!

Appendices

The appendices can include your original data, and one set of sample calculations showing each type of computation involved, identifying all quantities (including units) clearly. Where not included in this Appendix, these items should be referenced back to your original lab notes. The

Appendix also includes any other computer programs and their results not previously given. The final page presents the nomenclature used in the report.

Computer programs, MatLab input files, Polymath input files, etc. must be listed and the printed results should be attached to the final report. These input files should be cut and pasted as text into the report. When submitting reports electronically you must make sure that the recipient can open and read your files; at The University of Akron all faculty can open Microsoft office files. Programs, tables and graphs from other programs can be “pasted” into the report (e.g., MATHCAD, MATLAB or VBA programs), as long as adequate commenting/variable definitions accompany the program.

Honors Abstracts Addendum:

Your abstract (200 words maximum) is to be prepared according to the following guidelines:

In your first few sentences, define your project indicating its purpose, *scope*, and limits. Then describe, as concisely and clearly as you can, what you did, *what you found*, and what made it worth doing. In this part you summarize your research *methods* and design, your major *findings* and conclusions, the significance of your investigation and so forth.²

If your project has involved creative work (art, music, dance, film, etc.), your abstract should describe the process and the product, and it should identify the form of documentation you have submitted with

² JRE Note: the *bold face* has been added for emphasis, but the frequency of appearance of “scope/methods” and “findings” is noteworthy. Too few abstracts report these, yet this is 90% of what an abstract should be. The consistency of this emphasis between the honors guidelines and Spivey’s executive summary (below) is also notable. To clarify, scope and methods should describe hypotheses tested, independent variables, controls, and dependent variables. Findings should be specific, not vague. All should be quantitative. “Quantitative” means numbers are involved. Consider the following example.

“Our hypothesis was that polymers could be produced by anionic polymerization with equivalent quality to conventional methods when a continuous micro channel reactor was used. Polymer quality was characterized by average molecular weight $\langle M \rangle$ and polydispersity index (PDI), as measured by size exclusion chromatography. A microchannel reactor was purchased with square channels of 790×590mm and 2 m in length. Isoprene was polymerized with sec butyl lithium as the initiator. Flow rates of initiator and monomer were controlled with syringe pumps. Flow rates were varied from 0.5-2.0 mL/hr. Monomer/initiator ratios were varied from 20/1 to 5/1. In a typical experiment, we obtained $\langle M \rangle = 1711$ with a PDI of 1.09. Results by conventional methods would yield $\langle M \rangle = 4000$ with a PDI of 1.06 when conducted in a batch stirred reactor for a time comparable to the residence time of the micro reactor. It was observed that the valves leaked at high flow rates and this might explain the inferior findings for $\langle M \rangle$. If these limitations could be overcome, it would be possible to continuously produce polymers in this manner with less waste and less labor than conventional methods.”

Note that this is 194 words, yet it covers the scope (range of independent variables), methods (hypothesis, independent variables, dependent variables, characterization of outcomes), findings ($\langle M \rangle = 1711 < 4000$, hypothesis not satisfied but PDI = 1.09 – 1.06 maybe close enough), and significance (less waste and labor). There is no room in 200 words for deadwood statements like “Independent variables were flow rate and monomer/initiator ratio.” Statements like this are obvious from the description above. Things that are obvious should not be stated within the 200 word budget. Note the prevalence of numbers in this abstract, because this is an engineering abstract. If an abstract about photography did not mention or describe any photographs, how would you feel about that? That’s exactly how you should feel about an engineering abstract without any numbers in it.

the written part of your project (photographs, videotapes, audiotapes, manuscripts, etc.).

The final version of the title for your project should include, as appropriate to your field of study, the subject words with which it would be located through a scholarly index.

The abstract must be perfect in spelling, punctuation, grammar, and syntax. Please type it **double-spaced** and forward a copy to dgannon@uakron.edu

Type abstract in paragraph form, double-spaced, **12 point font**, maximum of 200 words. Save as a Microsoft document and send by e-mail to the above address.